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OF

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URE'S DICTIONARY

OF

ARTS, MANUFACTURES, AND MINES

CONTAINING

A CLEAR EXPOSITION OF THEIR PRINCIPLES AND PRACTICE

EDITED BY ROBERT HUNT, F.R.S. F.S.S.

Keeper of Mining Records

Formerly Professor of Physics, Government School of Mines, &c. &c.

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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 *gruau* 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, and of a yellowish brown or orange colour. It forms the envelope of the shell of the fruit of the *Myristica moschata*, 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. Mace is used as a condiment in cookery, and the aromatic oil occasionally in medicine.—See NUTMEG.

MACLE is the name given to certain spots in minerals, of a deeper hue than the main substance, and differing from it. Clay-slates may be macled with Iron Pyrites;—or it may be that the macle spots are some peculiar form of the same mineral matter supposed to proceed from some disturbance of the particles in the act of crystallisation.

MACLES are twin crystals which are united, or which interpenetrate.

MADDER (*Garance*, Fr.; *Krapp*, *Färberröthe*, Germ.), a substance very extensively used in dyeing, is the root of the *Rubia tinctorum*, Linn. It is employed for the production of a variety of colours, such as red, pink, purple, black, and chocolate.

The *Erythrodanum* or *Ereuthodanum* of the Greeks, of which Pliny says that it was named *Rubia* in Latin, and that its roots were used for dyeing wool and leather red, was probably identical with the *Rubia tinctorum*, since the description of its appearance and uses given by ancient authors can hardly apply to any other plant. It was cultivated in Galilee, Caria, and near Ravenna in Italy, where it was planted either among the olive trees or in fields destined for that purpose. Another species of rubia, viz. the *R. manjista*, grows in the mountainous regions of Hindostan, and the roots of this and an allied plant, the *Oldenlandia umbellata*, called by the natives *chaya*, have been in use in that country since the most remote period, for the purpose of producing the red and chocolate figures seen in the chintz calicoes of the East Indies. (See CALICO-PRINTING.) The peculiar process by which the colour called Turkey red is imparted to cotton, was probably invented originally in India, but the dyeing material generally employed in this process was not madder, but the chaya root. From India the art of dyeing this colour seems to have been carried to Persia, Armenia, Syria, and Greece; where it was practised for many centuries before it became known in the western part of Europe. In those countries, however, the root of the *Rubia peregrina*, called in the Levant *Alizari*, was the material to which dyers had recourse for this purpose, and large quantities of it are at the present day imported into Europe from Smyrna, under the name of *Turkey roots*. In the middle ages, according to Beckmann, madder went by the name of *Varantia* or *Verantia*. The cultivation of madder was introduced into the province of Zealand, in Holland, in the reign of the Emperor Charles V., who encouraged it by particular privileges conferred on the inhabitants for the purpose. According to Macquer, however, it was to the Flemish refugees that the Dutch were first indebted for their knowledge of the method of preparing the plant. It is still grown very extensively in that part of Holland, and large quantities are annually exported thence into other countries. Until very recently indeed, the dyers of this country derived almost the whole of their supply of madder from Holland, and it was the discovery that Dutch madder was incapable of producing some of the finer colours more recently introduced, that first led to its being to some extent supplanted by madder grown in other countries. In the district of Avignon, in France, the cultivation of the plant commenced about the year 1666, under Colbert, but it was chiefly by the efforts of the Secretary of State, Bertin, towards the close of the last century, that it became firmly established there. The French dyers and printers are supplied with madder from Avignon and Alsace, and large quantities are also exported from France into England and other countries. Madder is also grown for the use of dyers in Silesia, Naples, and Spain. It was formerly more extensively cultivated in England than it is now, when it can be imported at a less expense than it can be raised. The *Rubia peregrina* grows wild in the south of England, but is not applied to any useful purpose.

The *Rubia tinctorum* is one of the least conspicuous and ornamental of our cultivated plants. In external appearance it bears great resemblance to the ordinary bed-straws or Galiums, with which it is also botanically allied. Some species of galium seem also to contain a red colouring matter, and one of them, the *G. verum*, is used in the Hebrides for dyeing. The *R. tinctorum* belongs to the class Tetrandria, order Monogynia, of the Linnæan, and the order Rubiaceæ, of the Natural system. It is a perennial plant, but has an herbaceous stem, which dies down every year. The main part of the root, which extends perpendicularly downwards to a considerable depth, is cylindrical, fleshy, tolerably smooth, and of a pale carrot colour. On cutting it across transversely, it is found to consist externally of a thin cortical layer, or epidermis, to which succeeds a thick, spongy mass of cellular tissue, filled with a yellow juice, and in the centre runs a thin tough string of woody fibre, of a rather paler yellow colour than the enveloping cellular tissue, which may easily be peeled off. The root when freshly cut has a yellow colour, but speedily acquires a reddish tinge on exposure to the air. Many side roots issue from the upper part or head of the parent root, and they extend just beneath the surface of the ground to a considerable distance. It in consequence propagates itself very rapidly, for these numerous side roots send forth many shoots, which, if carefully separated in the spring, soon after they are above ground, become so many plants. From the roots spring forth numerous square-jointed stalks, which creep along the ground to the length of from 5 to 8 feet. Round each joint are placed in a whorl from 4 to 6 lance-shaped leaves, about 3 inches in length, and almost an inch wide at the broadest part. The upper surface of the leaves is smooth, but their margin and keel, as well as the four angles of the stem, are armed with reflexed prickles, so as to cause the plant to adhere to any rough object with which it comes in contact. The flowers, which are yellow, are arranged in compound panicles, which rise in pairs opposite to each other from the axils of the leaves. The calyx is very small. The corolla is small, campanulate, and 5-cleft. The flower contains 4 stamens, and 1 style. The fruit or berry is at first red, but afterwards becomes black. It consists of two lobes, each of which contains a seed.

The *Rubia tinctorum* thrives best in a warm climate, and if grown in the north of Europe a warm sheltered situation should be chosen. A deep, dry soil, containing an abundance of humus, is best adapted for its cultivation. A rich loam, in which there is a large proportion of sand and but little clay, is preferable to the stiffer soils. As the plant requires to be left in the ground several years, it is not one which can be adapted to any system of rotation of crops, and its cultivation must be carried on independently. Land which has lain for a considerable time in grass is preferred to any other for the purpose. At all events it is well not to allow it to follow on root crops. The finest qualities of madder grow in calcareous soils. In the district called *Palud*, which produces the best quality of French madder, the soil contains about 90 per cent. of carbonate of lime, and is moreover capable of yielding several successive crops of the plant; whereas the land which grows the second quality called *rosée* is richer, but less calcareous, and can only be made to grow madder alternately with other crops. The land must be well dug up with the spade about the beginning of autumn, and before winter. The manure used must be well rotten, and mixed with earth in a compost some time before it is used. Good stable-dung, which has heated to a certain degree and been turned over two or three times before it is mixed with earth, is the best. The dung should be put in layers with the earth, and if the whole can be well watered with urine or the drainings of the yard, and then mixed up by the spade, the compost will be much superior to fresh dung alone. The manure having been dug or ploughed in, the land is left over winter, and in spring it is turned over again, in order to destroy all weeds, and make the soil uniform to the depth of two feet at least. After having been harrowed flat it is ready for planting. Madder is generally grown from suckers or shoots, rarely from seeds. The shoots are prepared by cutting in the previous autumn, from the secondary roots of old plants, pieces at least 5 inches long and of the thickness of a quill, each length containing several joints for the development of buds, and preserving them through the winter in a dry place by covering them over with litter or leaves. Before planting, the land is in some districts laid in beds, about 3 feet wide, with deep intervals dug out with the spade, and the layers are set by means of a dibble or narrow trowel in rows, each bed containing two rows about 16 inches apart, and the layers being at a distance of 4 to 6 inches from each other. In other districts, furrows about 3 or 4 inches deep and 1½ or 2 feet apart are made, and in these furrows the suckers are placed at a distance of 1 foot from one another, and the furrows are then filled up with soil by means of a rake. Should the weather be dry, the plants must be watered. A watering with diluted urine after sunset greatly assists their taking root. After 3 or 4 weeks they appear above the ground. When they have grown to the length of a finger they must be well weeded and earthed up with the hoe, and this process must be repeated 4 or 6 weeks later, taking care that the roots be well covered with earth, which very much promotes their growth. The stems and leaves should not be cut off, but allowed to die down, as winter approaches. Where the winter cold is very great the roots should in the course of November be covered up with earth to the depth of 2 or 3 inches, and an additional covering of litter is also advisable as a protection from the frost. Water must on no account be allowed to stand in the furrows between the rows during the winter. In spring the covering is removed, and the plant then sends up fresh stalks and leaves as in the first year. The same attention must be paid to weeding and earthing up during the second as the first year. A second winter and a third summer must elapse before the root is sufficiently mature to be taken up. The object of allowing the roots to remain for such a length of time in the ground seems to be to give time for the interior or woody part of the root to increase, for this part, though it is no richer in colouring matter than the outer or fleshy part of the root, yields a product of finer quality. In France, however, it is usual to gather the crop in 18 months after planting, that is, in the autumn of the second year.

In Germany the roots are sometimes even taken up at the end of the first year, and it is to the product thus obtained that the special name of *Röthe* is applied, the term *Krapp* being restricted to that which has been in the ground the usual length of time. The root is the only part of the plant generally used. The East Indian product called *munjeet* seems, however, to consist entirely of the stalks of the madder plant. It is much inferior in quality to ordinary madder, and is comparatively poor in colouring matter.

The time usually selected for taking up the roots is October or November. In doing so care must be taken to break and injure them as little as possible. The quantity of fresh roots obtained in France from one arpent of ground (of 48,000 square French feet) varies from four to six thousand pounds. In England an acre of ground will yield from 10 to 20 cwt., and in the south of Germany the produce of 1 morgen of land (equal to about 4075 square yards) amounts to 50 cwt. of dry roots. In warm climates the roots, as soon as they are taken out of the ground, are simply dried in the sun, and after having been separated from the earth &c., are broken into pieces and then brought to market. This kind of madder is called in the East *Alizari*, and in England *Madder roots.* It consists of short twisted pieces, a little thicker than a quill, reddish-brown, and rather rough externally. A transverse section of one of these pieces exhibits in the centre several concentric layers of pale yellowish-red woody fibre, surrounded by a thin reddish-brown layer of cellular tissue, the original volume of which has been much reduced by drying. Madder is also imported in this state from France, Naples, and Bombay.

In France and Holland the cultivator generally dries his roots, after shaking out the earth as much as possible, partially in stoves. He then takes them to the threshing-floor, and threshes them with the flail, partly for the purpose of separating the small radicles and epidermis of the root, and partly in order to divide the latter into pieces about 7 or 8 centimetres in length. They are then sieved or winnowed, in order to remove what has been detached by threshing. The particles which are separated in this process are ground by themselves, and constitute an inferior kind of madder called *Mull.* The remainder is then handed over to the madder manufacturer, who proceeds to dry it completely in stoves heated to about 100° F., by means of furnaces so constructed as to allow an occasional current of fresh air to pass through. It is afterwards taken to a large sieve with different compartments, moved by machinery. The compartment with the narrowest meshes serves to separate the portion of epidermis, earthy particles, and other refuse matter which had been left adhering to the roots after the threshing. The compartments with wider meshes are for the purpose of separating the smaller roots from the larger ones, the latter being considered the best. In France this operation is called *robage*. The roots are then subjected to the process of grinding, by means of vertical millstones, and afterwards passed through sieves of different sizes, until they are reduced to a state of fine powder. When the larger and better roots are ground by themselves, the madder is called in France *garance robée fine*, or *garance surfine*, and it is marked with the letters S F. The smaller roots yield an inferior madder, which is called *garance non robée*, or *mifine*, and is marked M F. When the different kinds of roots are not separated from one another, but all ground together, the product is called *garance petite robée*, *moins robée*, or *fine*, and is marked F F. By far the greater portion of the madder consumed in France consists of this quality, since it is found to be perfectly well adapted for all the purposes to which madder is usually applied. The letter O is applied to the lowest quality of madder or mull, which is obtained by grinding the epidermis and other portions of the root which are detached after the first stoving, and during the process called robage. The qualities C F and C F O consist of mixtures of M F and O. There is also another quality which receives the designation S F F, and which is obtained by grinding separately the internal ligneous part of the root, previously deprived of the outer or cortical portion. This quality is employed for dyeing fine colours on wool and silk, as well as for the preparation of madder lakes. Other marks, such as S F F F, E X S F F F, &c., are also occasionally employed by French manufacturers and dealers, to distinguish particular qualities. In Holland the product obtained by grinding together the whole roots, after the separation of the mull, is called *onber*, whilst the term *crop* is applied to the internal part of the root ground separately.

The Levant madder, usually called Turkey roots, is considered to be the finest quality imported into this country. It comes to us from Smyrna, and consists of the whole roots broken into small pieces and packed in bales. It is ground as it is without any attempt being made to separate the different portions of the root; and has then the appearance of a coarse dark reddish-brown powder. It is employed chiefly for the purpose of dyeing the finer purples on calico. Next to this comes the madder of Avignon, of which two varieties are distinguished in commerce, viz. *Paluds* and *rosée*. The first, which is the finest, owes its name to the district in which it is grown, consisting of a small tract of reclaimed marsh land in the neighbourhood of Avignon. Avignon madder is considered to be the best adapted for dyeing pink. It has the appearance, as imported into this country, of a fine, pale yellowish-brown or reddish-brown powder. The paler colour, as compared with that of ground *roots*, is owing to the partial separation of the external or cellular portion of the root during the process of grinding, as practised in France. The madders of Alsace, Holland and Naples, are richer in colouring matter than the two preceding kinds, but they yield less permanent dyes, and are therefore only employed for colours which require little treatment with soap, and other purifying agents after dyeing. Of late years, indeed, the employment of *garancine*, a preparation of madder, in the place of these lower descriptions, has become very general.

All kinds of madder have a peculiar, indescribable smell, and a taste between bitter and sweet. Their colour varies extremely, being sometimes yellow, sometimes orange, red, reddish-brown, or brown. They are all more or less hygroscopic, so that even when closely packed in casks in a state of powder, they slowly attract moisture, increase in weight, and at length lose their pulverulent condition, and form a firm, coherent mass. This change takes place to a greater extent with Alsace and Dutch madders, than with those of Avignon. Madder, which has undergone this change is called by the French *garance grappée*. It is probable that some process of fermentation goes on at the same time, for madder that is kept in casks in a dry place, and as much out of contact with the air as possible, is found constantly to improve in quality for a certain length of time, after which it again deteriorates. Some kinds of madder, especially those of Alsace and Holland, when mixed with water and left to stand a short time, give a thick coagulum or jelly, which does not take place to the same degree with Avignon madder. The madder of Avignon contains so much carbonate of lime as to effervesce with acids. The herbaceous parts of the plant, when given as fodder to cattle, are found to communicate a red colour to their bones, a circumstance which was first observed about a hundred years ago, and has been employed by physiologists to determine the manner and rate of growth of bone.

There exists no certain means of accurately ascertaining the intrinsic value of any sample of madder, except that of dyeing a certain quantity of mordanted calico with a weighed quantity of the sample, and comparing the depth and solidity of the colours with those produced by the same weight of another sample of known quality, and even this method may lead to uncertain results, if practised on too small a scale. The Paluds, which is the most esteemed of the Avignon madders, has a dark red hue, whereas the other kinds have naturally a yellow, reddish-yellow or brownish-yellow colour. Nevertheless, means have been devised of communicating to the latter the desired reddish tinge, which, therefore, no longer serves as a test. A method formerly employed to ascertain the comparative value of a number of samples of madder consisted in placing a small quantity of each sample on a slate, pressing the heaps flat with some hard body, and then taking them to a cellar or other damp place. After 10 or 12 hours they were examined, and that which had acquired the deepest colour, and increased the most in volume was considered the best. This method led, however, to so many frauds on the part of the dealer, for the purpose of producing the desired effect, that it is no longer resorted to. Madder is sometimes adulterated with sand, clay, brick-dust, ochre, saw-dust, bran, oak-bark, logwood and other dye-woods, sumac and quercitron bark. Some of these additions are difficult to detect. Such as contain tannin may be discovered by the usual tests, since madder contains naturally no tannin. If the material used for adulteration be of mineral nature, its presence may be discovered by incinerating a weighed quantity of the sample. If the quantity of ash which is left exceeds 10 per cent. of the material employed, adulteration may be suspected. The ash obtained by incinerating pure madder consists of the carbonates, sulphates, and phosphates of potash and soda, chloride of potassium, carbonate and phosphate of lime, phosphate of magnesia, oxide of iron and silica. If a considerable amount of any other mineral constituent is found, it is certainly due to adulteration.

There is probably no subject connected with the art of dyeing which has given rise to so much discussion as the composition of madder, and the chemical nature of the colouring matters to which it owes its valuable properties. The subject has engaged the attention of a number of chemists, whose labours, extending over a period of about fifty years, have thrown considerable light on it. Nevertheless, the conclusions at which they have severally arrived do not perfectly agree with one another, nor with the views entertained by the most intelligent of those practically engaged in madder dyeing. The older investigators supposed that madder contained two colouring matters, one of which was tawny, and the other red. Robiquet was the first chemist who asserted that it contained two distinct red colouring matters, both of which contributed to the production of the dyes for which madder is employed; and his views, though they were at the time of their promulgation strongly objected to by some of the most eminent French dyers and calico-printers, still offer probably the best means of explaining some of the phenomena occurring during the process of madder dyeing. The two red colouring matters discovered by Robiquet were named by him *Alizarine* and *Purpurine*, and these names they still retain. Several crystallised yellow colouring matters have been discovered by other chemists; but the only one which exists ready-formed in the madder of commerce is the *Rubiacine* of Schunck, and this substance may also be taken as the type of the whole class, the members of which possess very similar properties. Among the other organic substances obtained by different chemists from madder, two resinous colouring matters, sugar, a bitter principle, a peculiar extractive matter, pectin, a fermentative nitrogenous substance, and malic, citric, and oxalic acids, may be mentioned.

When madder is extracted with boiling water, a dark brown muddy liquid, having a taste between bitter and sweet, is obtained. On adding a small quantity of an acid to this liquid, a dark brown precipitate is produced, while the supernatant liquid becomes clear, and now appears of a bright yellow colour. The precipitate consists of alizarine, purpurine, rubiacine, the two resinous colouring matters, pectic acid, oxidised extractive matter, and a peculiar nitrogenous substance. The liquid filtered from this precipitate contains the bitter principle and the extractive matter of madder, as well as sugar and salts of potash, lime and magnesia. No starch, gum, or tannin can be detected in the watery extract. After the madder has been completely exhausted with boiling water, it appears of a dull red colour. It still contains a quantity of colouring matter, which cannot, however, be extracted with hot water, or even alkalies, since it exists in a state of combination with lime and other bases, forming compounds which are insoluble in those menstrua. If, however, the residue be treated with boiling dilute muriatic acid, the latter dissolves a quantity of lime, magnesia, alumina, and peroxide of iron, as well as some phosphate and oxalate of lime, which may be discovered in the filtered liquid; and if the remainder, after being well washed, be treated with caustic alkali, a dark red liquid is obtained, which gives with acids a dark reddish-brown precipitate consisting of alizarine, purpurine, rubiacine, resin, and pectic acid. That portion of the madder left after treatment with hot water, acids, and alkalies, consists almost entirely of woody fibre.

A short description of some of the substances just mentioned will not be out of place here, as it may assist in rendering the process of dyeing with madder more intelligible.

The most important of these substances is *alizarine*, since it forms the basis of all the finer and more permanent dyes produced by madder. The *matière colorante rouge* of Persoz and the *madder-red* of Runge also consist essentially of alizarine, mixed with some impurities. Robiquet first obtained it in the form of a crystalline sublimate, by extracting madder with cold water, allowing the liquid to gelatinise, treating the jelly with alcohol, evaporating the alcoholic liquid to dryness and heating the residue; and since the application of heat seemed to be an essential part of his process, it was for a long time doubted whether alizarine was contained as such in madder, and was not a product of decomposition of some other body. It was proved, however, by the experiments of Schunck that it does in reality pre-exist in the ordinary madder of commerce, though not in the fresh root when just taken out of the ground. It has the following properties:—It crystallises in long, transparent, lustrous, yellowish-red needles. These needles when heated to 212° F. lose their water of crystallisation and become opaque. At about 420° F. alizarine begins to sublime, and if carefully heated may be almost entirely volatilised, only a little charcoal being left behind. The sublimate obtained by collecting the vapours consists of long, brilliant, transparent, orange-coloured crystals, which are pure anhydrous alizarine. If madder, or any preparation or extract of madder, be heated to the same temperature, a sublimate of alizarine is also obtained, but the crystals are then generally contaminated with drops of empyreumatic oil, produced by the decomposition of other constituents of the root. This oily matter may, according to Robiquet, be removed by washing the crystals with a little cold alcohol. Alizarine is almost insoluble in cold water. It is only slightly soluble in boiling water, and is deposited, on the solution cooling, in yellow crystalline flocks. When the water contains large quantities of acid or salts in solution, it dissolves very little alizarine, even on boiling. The colour of the solution is yellowish when it is quite free from alkalies or alkaline earths. Alizarine dissolves much more readily in alcohol and ether than in water; the solutions have a deep yellow colour. Alizarine is decomposed by chlorine, and converted into a colourless product. It is also decomposed by boiling nitric acid, the product being a colourless, crystallised acid, *phthalic acid*, the same that is formed by the action of nitric acid on naphthaline. Alizarine dissolves in concentrated sulphuric acid, yielding a yellow solution, which may be heated to the boiling point without changing colour and without any decomposition of the alizarine, which is precipitated unchanged on the addition of water. Alizarine dissolves in caustic alkalies with a splendid purple or violet colour, which remains unchanged on exposure of the solutions to the air. The ammoniacal solution, however, loses its ammonia entirely on being left to stand in an open vessel, and deposits its alizarine in the form of shining prismatic crystals, or of a crystalline crust. The alkaline solutions give with solutions of lime and baryta salts precipitates of a beautiful purple colour, with alumina salts a red, with iron salts a purple precipitate, and with most of the salts of metallic oxides precipitates of various shades of purple. The affinity of alizarine for alumina is so great, that if the compound of the two bodies be treated with boiling caustic potash lye, it merely changes its colour from red to purple without being decomposed. Alizarine is not more soluble in boiling alum liquor than in boiling water. The chemical formula of anhydrous alizarine is probably $C_{14}H_5O_4$, and 100 parts contain therefore by calculation 69·42 of carbon, 4·13 of hydrogen, and 26·45 of oxygen.

If alizarine in a finely divided or, what is still better, in a freshly precipitated state, be suspended in distilled water, and a piece of calico printed with alumina and iron mordants of different strengths be plunged into it, the latter, on gradually heating the bath, become dyed. The process is necessarily a slow one, because alizarine is only slightly soluble in boiling water, and as the mordants can only combine with that portion actually in solution, a constant ebullition of the liquid must be kept up, in order to cause fresh portions of colouring matter to dissolve in the place of that portion taken up by the mordants. A very small proportional quantity of alizarine is required in order to dye very dark colours, but it is absolutely necessary that the bath should contain no trace of either acid or base, since the former would combine with the mordants, and the latter with the alizarine. When the process is complete the alumina mordant will be found to have acquired various shades of red, while the iron mordant will appear either black or of different shades of purple, according to the strength of the mordant employed. These colours are as brilliant and as permanent as those obtained from madder by means of a long and complicated process. Nevertheless, the red is generally found to have more of a purplish hue, and the black to be less intense than when madder or its preparations are employed. On the other hand, if one of the finer madder colours which are produced on calico, such as pink or lilac, be examined, the colours are found to contain, in combination with the mordants, almost pure alizarine. Hence it may be inferred, that alizarine alone is required for the production of these colours, and that the simple combination of this colouring matter with the mordants is the principal end which is to be attained by the dyer in producing them.

Purpurine, the other red colouring matter of madder, with which the *matière colorante rose* of Gaultier de Claubry and Persoz, and the *madder-purple* of Runge, are substantially identical, can hardly be distinguished by its appearance from alizarine, which it also resembles in most of its properties. It crystallises in small orange-coloured or red needles. When carefully heated it is almost entirely volatilised, yielding a sublimate of shining orange-coloured scales and needles. It is slightly soluble in boiling water, giving a pink solution. It is more soluble in alcohol than in water, the solution having a deep yellow colour. It dissolves in concentrated sulphuric acid, and is not decomposed on heating the solution, even to the boiling point. It is decomposed by boiling nitric acid, and yields, like alizarine, phthalic acid. It is distinguished from alizarine, by its solubility in alum liquor. When treated with a boiling solution of alum in water, it dissolves entirely, yielding a peculiar opalescent solution, which appears of a bright pink colour by transmitted light, and yellowish by reflected light. The solution deposits nothing on cooling, but on adding to it an excess of muriatic or sulphuric acid, it becomes colourless, and the purpurine falls down in yellow flocks. On this property depends the method of separating it from alizarine. The compounds of purpurine with bases are mostly purple. It dissolves in alkalies with a bright purplish-red or cherry-red colour. If the solution in caustic potash or soda be exposed to the air, its colour changes gradually to reddish-yellow, and the purpurine contained in it is decomposed, a characteristic which also serves to distinguish purpurine from alizarine, the alkaline solutions of which are not changed by the action of oxygen. The composition of purpurine approaches very near to that of alizarine, but its chemical formula is unknown. It communicates to calico, which has been printed with various mordants, colours similar to those imparted by alizarine, but the red is more fiery, and the black more intense than when alizarine is employed. On the other hand, the purple dyed by means of purpurine has a disagreeable reddish tinge, and presents an unpleasant contrast with the beautiful purple from alizarine. The name of this colouring matter is therefore very inappropriate, and is calculated to mislead. The colours dyed with purpurine are less stable than those dyed with alizarine, they are less able to resist the action of soap and other agents than the latter. Hence, very little purpurine is found in combination with the mordants, in such madder colours as have undergone a course of treatment with alkalies and acids, after having been dyed; indeed, the principal object of this treatment appears to be the removal of this and other substances, so as to leave compounds of alizarine only on the fabric. Purpurine seems to abound more in the lower, stronger qualities of madder than in the finer. To this cause, Robiquet chiefly ascribed the superiority of the latter in dyeing fast colours, and no better way of accounting for it has hitherto been suggested. Purpurine forms the basis of the red pigment called madder lake.

Rubiacine is the name which has been applied to a yellow crystallised colouring matter contained in madder. It coincides in most of its properties with the *madder-orange* of Runge. It crystallises in greenish-yellow lustrous scales and needles. When heated it is entirely volatilised, yielding a crystalline sublimate. It is only slightly soluble in boiling water, but more soluble in boiling alcohol, from which it crystallises on cooling. It dissolves in concentrated sulphuric acid, and is not decomposed on boiling the solution. It also dissolves in boiling nitric acid without being decomposed. It dissolves in caustic alkalies with a purple colour. Its compounds with earths and metallic oxides are mostly red. When treated with a boiling solution of pernitrate or perchloride of iron it dissolves entirely, yielding a brownish-red solution, which deposits nothing on cooling, but gives, on the addition of an excess of muriatic acid, a yellow flocculent precipitate, consisting of a peculiar acid, called *rubiacic acid.*

Two amorphous resinous colouring matters, forming brownish-red compounds with bases, have also been obtained from madder. Both are very little soluble in boiling water. One of them is a dark brown, brittle, resin-like substance, very easily soluble in alcohol, which melts at a temperature a little above 212° F. The other is a reddish-brown powder, less soluble in alcohol than the preceding. These two colouring matters, together with rubiacine, constitute probably the *tawny* or *dun colouring matter* of the older chemists. They do not contribute to the intensity of the colours dyed with madder, and exert a very prejudicial effect on the beauty of the dyes. If printed calico be dyed with a mixture of alizarine, and any one of these three colouring matters, the colours are found to be both weaker and less beautiful than when alizarine is employed alone. The red acquires an orange tinge, and the purple a reddish hue, whilst the black is less intense, and the parts of the calico which should remain white are found to have a yellowish colour. Hence it is of importance to the dyer that their effect should be counteracted as much as possible, by preventing them either from dissolving in the dye-bath or from attaching themselves to the fabric.

The other constituents of madder possess no interest in themselves, but may become of importance in consequence of the effects which they produce during the process of dyeing. The pectine, in the state in which it exists in the root, is probably an indifferent substance, but in consequence of the ease and rapidity with which it passes into pectic acid, it may in dyeing act very prejudicially by combining with the mordants and preventing them taking up colouring matter. The extractive matter of madder, when in an unaltered state, produces no injurious effects directly; but by the action of oxygen, especially at an elevated temperature, it acquires a brown colour and then contributes, together with the rubiacine and the resinous colouring matters, in deteriorating the colours and sullying the white parts of the fabric. The extractive matter, when in a state of purity, has the appearance of a yellow syrup like honey, which is easily soluble in water and alcohol. When pure it is not precipitated from its watery solution by any earthy or metallic salt, but if the solution be evaporated in contact with the air, it gradually becomes brown, and then gives an abundant brown precipitate with sugar of lead. When its watery solution is mixed with muriatic or sulphuric acid and boiled, it becomes green and deposits a dark green powder. Hence this extractive matter has, for the sake of distinction, been called *Chlorogenine*, and *Rubichloric Acid.* The bitter principle of madder will be referred to presently. The *Xanthine* of Kuhlmann, and the *madder-yellow* of Runge are mixtures of the extractive matter and the bitter principle. The sugar contained in madder is probably grape sugar. It has not hitherto been obtained in a crystallised state, but it yields by fermentation alcohol and carbonic acid, like ordinary sugar. The woody fibre which is left after madder has been treated with various solvents until nothing more is extracted, always retains a slight reddish or brownish tinge from the presence of some colouring matter which cannot be completely removed, and seems to adhere to it in the same way as it does to the cotton fibre of unmordanted calico.

There is a question connected with the chemical history of madder which must not be passed over in silence, since it is one which possesses great interest, and may at some future time become of great importance, viz. the question as to the state in which the colouring matters originally exist in the root. It has long been known, that when ground madder is kept tightly packed in casks for some time, it constantly improves in quality for several years, after which it again deteriorates; and it was always supposed that this effect was due to some process of slow fermentation going on in the interior of the mass, an opinion which seemed to be justified by the evident increase in weight and volume, and the agglomeration of the particles which took place at the same time. Nevertheless the earlier chemical examinations of madder threw no light whatever on this part of the subject, since the red colouring matters were found to be very stable compounds, not easily decomposed except by the action of very potent agents, so that when once formed it seemed improbable that they would be at all affected by any mere process of fermentation. Hence some chemists were led to the conclusion that the improvement which takes place in the quality of madder on keeping is caused by an actual formation of fresh colouring matter. A very simple experiment may indeed suffice to prove that the whole of the colouring matter does not exist ready formed, even in the article as used by the dyer. If ordinary madder be extracted with cold water, the extract after being filtered has generally an acid reaction, and cannot contain any of the colouring matters, since these are almost insoluble in cold water, especially when there is any acid present. Nevertheless the extract when gradually heated is found capable of dyeing in the same way as madder itself. If the extract be made tolerably strong, it possesses a deep yellow colour and a very bitter taste; but if it be allowed to stand in a warm place for a few hours, it gelatinises, and the insoluble jelly which is formed is found to possess the whole of the tinctorial power of the liquid, which has also lost its yellow colour and bitter taste. Hence, it may be inferred that the substance which imparts to the extract its bitter taste and yellow colour is capable also of giving rise to the formation of a certain quantity of colouring matter.

In 1837 a memoir was published by Decaisne, containing the results of an anatomical and physiological examination of the madder plant, results which were considered so important that a prize was awarded to the author by the Royal Academy of Sciences of Brussels. This investigation led the author to the conclusion, that the cells of the living plant contain no ready formed red colouring matter, but are filled with a transparent yellow juice, which on exposure to the atmosphere becomes reddish and opaque in consequence of the formation of red colouring matter. Hence he inferred that the insoluble red colouring matter was simply a product of oxidation of the soluble yellow one, and that, consequently, the more complete the exposure of the triturated root to the atmosphere, the greater would be its tinctorial power; and he even went so far as to assert that all the proximate principles obtained from the root were derived ultimately from one single substance contained in the whole plant. That the fresh roots, before being dried, do indeed contain no colouring matter capable of imparting to mordants colours of the usual appearance and intensity, may be proved by the following experiment: — If the roots, as soon as they are taken out of the ground, are cut into small pieces as quickly as possible, and then extracted with boiling spirits of wine, a yellow extract is obtained which, after being filtered and evaporated, leaves a brownish-yellow residue. Now this residue on being redissolved in water is found incapable of imparting to mordants any but the slightest shades of colour; and, on the other hand, the portion of the root left after extraction with spirits of wine, on being subjected to the same test as the extract, is found to possess as little tinctorial power as the latter. If, however, the roots, instead of being treated with spirits of wine, are macerated in water, the liquor on being gradually heated dyes the usual colours as well as ordinary madder. Hence it may be inferred that by means of alcohol the colour-producing body of the root may be separated from the agent which, under ordinary circumstances, is destined to effect its transformation into colouring matter, the one being soluble and the other insoluble in that menstruum. It was by this and other similar facts that Schunck was led to an examination of this part of the subject. He infers from his experiments that the colour-producing body of madder is identical with its so-called bitter principle, to which he has given the name of *Rubian*. This body, when pure, has the following properties: — It is an amorphous, shining, brittle substance like gum, dark brown and opaque in mass, but yellow and transparent in thin layers. Its solutions are of a deep yellow colour, and have an intensely bitter taste. It is easily soluble in water and alcohol. The watery solution turns of a blood-red colour, on the addition of caustic and carbonated alkalies, and gives dark red precipitate with lime and baryta water. The solution gives a copious light red precipitate with basic acetate of lead, but yields no precipitate with any other metallic salt. On trying to dye with rubian in the usual manner, the mordants assume only the faintest shades of colour. If, however, the watery solution be mixed with sulphuric or muriatic acid and boiled, it gradually deposits a quantity of insoluble yellow flocks, which after being separated by filtration and well washed, are found to dye the same colours as those obtained by means of madder. In fact, these flocks contain alizarine, to which they owe their tinctorial power, but they also contain a crystallised yellow colouring matter, similar to, but not identical with rubiacine, as well as two resinous colouring matters, which Schunck has named *Verantine* and *Rubiretine*, and which are probably identical with the resinous colouring matters before referred to as being obtained from ordinary madder. The liquid filtered from the flocks contains an uncrystallisable sugar, similar to that which is obtained from madder itself. Rubian is not decomposed by ordinary ferments, such as yeast and decomposing casein; but by extracting madder with cold water, and adding alcohol to the extract, a substance is precipitated in pale red flocks, which possesses in an eminent degree the power of effecting the decomposition of rubian. If a watery solution of the latter be mixed with some of the flocculent precipitate (after having been collected on a filter, and washed with alcohol), and then left to stand in a warm place for some hours, the mixture is converted into a light brown jelly, which is so thick that the vessel may be reversed without its falling out. This jelly when agitated with cold water communicates to the latter very little colour or taste, proving that the rubian has undergone complete decomposition by the action of the flocculent substance or ferment added to its solution. The cold water, however, extracts from the gelatinous mass a quantity of sugar, while the portion left undissolved contains alizarine, verantine, rubiretine, and a crystalline yellow colouring matter, besides a portion of undecomposed ferment. Rubian, therefore, by the action of strong mineral acids and of the peculiar ferment of madder, is decomposed, yielding sugar and a variety of colouring matters, the principal of which is alizarine. It appears, therefore, that these colouring matters are not originally contained as such in the root, but are formed by the decomposition of one parent substance, which alone is produced by the vital energies of the plant. In addition to this substance, the plant also contains another, which possesses the property of rapidly effecting the decomposition of the first. The two are, however, during the living state of the plant, prevented from acting on one another, either in consequence of their being contained in different cells, or because the vital energies of the plant resist the process of decomposition. During the drying and grinding of the root the decomposition of the colour-producing body commences and continues slowly during the period that the powder is kept before being used. It is finally completed during the process of dyeing itself, and hence no trace of colour-producing substance can be detected, either in the liquor or the residual madder, after the operation of dyeing is concluded. The presence of oxygen does not seem to be essential during this process of decomposition, as Decaisne supposed. Nevertheless, according to Schunck, rubian does in reality suffer a partial oxidation, when its watery solution mixed with some alkali or alkaline earth, is exposed to the action of the atmosphere, giving rise to a peculiar acid, called by him *rubianic acid.* When rubian is heated at a temperature considerably exceeding 212° F., it is converted without much change of appearance into a substance which yields by decomposition resinous colouring matters in the place of alizarine. The great excess of these colouring matters contained in the madder of commerce arises therefore most probably from the high temperature employed in drying the root.

Employment of madder in dyeing. — After the account which has just been given of the composition of madder, it may easily be conceived that the chemical and physical phenomena which occur during the various processes of madder dyeing, are of a rather complicated nature, and that many of these phenomena have not yet received a perfectly satisfactory explanation. Nevertheless the present state of our knowledge on this subject may enable us to give a consistent explanation of the facts presented to us by the experience of the dyer, and even to indicate what direction our labours must take if we wish to improve this branch of the arts.

In order to produce perfectly fast colours in madder dyeing, it is necessary that the madder should contain a large proportion of carbonate of lime, and if the madder is naturally deficient in that salt, the deficiency may be supplied either by using calcareous water in dyeing, or by adding a quantity of ground chalk. If madder be treated with dilute sulphuric or muriatic acid, so as to dissolve all the lime contained in it, and then washed with cold water until the excess of acid is removed, its tinctorial power will be found to be very much diminished, but may be entirely restored, and even increased, by the addition of a proper quantity of lime water or chalk. Hence too Avignon madder, which is grown in a highly calcareous soil, and contains so much carbonate of lime as to effervesce with acids, affords the most permanent colours; whilst Alsace madder requires the addition of carbonate of lime in order to produce the same effect. This fact was first pointed out by Hausmann, who, after having produced very fine reds at Rouen, 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 simple fact led to the production of a series of lengthy memoirs on the part of some of the French chemists and calico-printers, which fully confirmed the results of Hausmann, without, however, leading to a satisfactory explanation of them. The experiments of Robiquet prove that in dyeing with pure alizarine the least addition of lime is rather injurious than otherwise, as it merely weakens the colours without adding to their durability. Hence the beneficial effect of lime can only be accounted for by some action which it exerts on other constituents of the root. Bartholdi imagined that this action consisted simply in the decomposition of the sulphate of magnesia, which he found to be contained in ordinary madder. It was asserted by others, that the carbonate of lime served to neutralise some free acid, supposed by Kuhlmann to be malic acid, which was present in some madders, and which not only to a great degree prevented the colouring matters from dissolving in the dye-bath, but also combined with the mordants to the exclusion of the latter. Though later researches have failed to detect the existence of malic acid in madder, still it is certain that all watery extracts of madder contain pectic acid, which probably exists in the root originally as pectine; and that this acid, when in a free state, acts most injuriously in dyeing with alizarine, but ceases to do so as soon as it is combined with lime. Nevertheless, it seems that madder which is naturally deficient in lime, cannot be made to replace entirely such madder as has been grown in a calcareous soil, however great an excess of chalk be used in dyeing. Hence Robiquet was led to the conclusion, that the inferior kinds of madder, which are also the most deficient in lime, contain more purpurine and less alizarine than the superior kinds, and that the carbonate of lime serves partly to combine with the purpurine and prevent it from uniting with the mordants, and thus producing less permanent dyes. The experiments of Schunck have proved that not only pectic acid, but also rubiacine and the resinous colouring matters of madder, act detrimentally in dyeing with pure alizarine, by deteriorating the colours and sullying the white parts of the fabric, and that these effects are entirely neutralized by the addition of a little lime water to the dye-bath. If in dyeing with madder the whole of the colouring matters were in a free state, the resinous and yellow colouring matters would, according to Schunck, unite with the mordants, to the exclusion of the alizarine, yielding colours of little permanency and of a disagreeable hue; but on adding lime they combine with it, and the alizarine, being less electro-negative, then attaches itself to the mordants or weaker bases. A great excess of lime would of course have an injurious effect by combining also with the alizarine, and preventing it from exerting its tinctorial power. In practice a little less lime is added than is sufficient to take up the whole of the impurities with which the alizarine is associated, thus allowing a portion of the former to go to the mordants, to be subsequently removed by treatment with soap and other detergents. Lastly, it has been asserted by Köchlin and Persoz, that when lime is used in dyeing with madder the colours produced are not simply compounds of colouring matter with mordants, but contain also in chemical combination a certain quantity of lime, which adds very much to their stability. It is probable that all these causes contribute in producing the effect. The carbonates of magnesia and zinc, acetate and neutral phosphate of lime, and the protoxides of lead, zinc and manganese, act in a similar manner to carbonate of lime in madder dyeing, but are less efficient.

Dambourney and Beckman have asserted, that it is more advantageous to employ the fresh root of madder than that which has been submitted to desiccation, especially by means of stoves. But in its state of freshness, its volume becomes troublesome in the dye-bath, and uniform observation seems to prove that it ameliorates by age up to a certain point. Besides, it must be rendered susceptible of keeping and carrying easily.

In dyeing printed calicoes with madder the general course of proceeding is as follows:—The madder having been mixed in the dye-vessel with the proper quantity of water, and, if necessary, with chalk, the liquid is heated slowly by means of fire or steam, and the fabric is introduced and kept constantly moving, until the dyeing is finished. (See CALICO-PRINTING.) The temperature should be kept low at first, and should be gradually raised, without allowing it to fall, until it reaches the boiling-point; and the boiling may, if necessary, be continued for a short time. The chief object of the gradual heating seems to be to allow the ferment to exert its full power on the rubian or colour-producing body, for this process, like all processes of fermentation, is most active at a temperature of about 100° F., and is arrested at 212° F. In dyeing quickly, less permanent colours are also produced, in consequence, probably, of the colouring matters combining with the more superficial portions of the mordants, and not penetrating sufficiently into the interior of the vegetable fibre. The fastest colours are produced by dyeing at a moderate temperature, and not allowing the liquid to boil. By boiling, the madder becomes more thoroughly exhausted, and a greater depth of colour is attained, but the latter resists less perfectly the action of soap and other agents, than the same shade dyed at a lower temperature. The time occupied in dyeing varies according to the nature and intensity of the colours to be produced; but there is little advantage in allowing it in any case to exceed three hours, since the gain in colour acquired is more than counterbalanced by the loss of time and increased expenditure of fuel caused by a long continued ebullition. In dyeing ordinary madder colours, such as red, black, chocolate, and common purple, which do not require much treatment after dyeing, in order to give them the desired tone and intensity, strong but inferior qualities of madder may be used with advantage; and various other dye-stuffs, such as peachwood, quercitron bark, sumac, &c., are often added to the madder, in order to vary the shade and depth of colour. But for the finer colours, such as pink and fine purple, which after dyeing must be subjected to a long course of treatment with soap and acids before they assume the requisite beauty and delicacy of hue, it is necessary to employ the finest qualities of madder; for if dyed with inferior qualities they would resist only imperfectly the requisite after-treatment, and great care must be observed in regulating the temperature during dyeing. The addition of other dye-stuffs, in their case, would be not only useless, but positively injurious. The use of different kinds and qualities of madder in conjunction, is often found to be attended with benefit, arising probably from the circumstance of one kind supplying some material or other, such as ferment or carbonate of lime, in which the other is deficient.

The chemical processes which take place during the operation of dyeing may be shortly described as follows:—In the first place, the water of the dye-bath extracts the more soluble constituents of the madder, such as the sugar, extractive matter, and bitter principle. The latter substance is decomposed by the ferment, and the colouring matter thereby formed is added to that which already exists in the root. As the temperature rises, the less soluble constituents, such as the alizarine, purpurine, rubiacine, the resinous colouring matters, the pectine and pectic acid begin to dissolve, and as they dissolve they combine partly with the mordants of the fabric, partly with the lime and other bases contained in the root or added to the dye-bath, and thus permit the liquid to take up fresh quantities from the madder. If the quantity of madder was exactly proportioned to the quantity of fabric to be dyed, then it becomes, in this way, gradually exhausted of all available colouring matter. The extractive matter at the same time acquires a brown colour by the combined action of the heat and oxygen, and covers the whole surface of the fabric with a uniform brown tinge. When the dyeing is concluded, the liquor appears muddy and of a pale dirty red colour. It still contains a quantity of colouring matter in a state of combination with lime and other bases from the madder, or with portions of the mordant mechanically detached from the fabric. The residual madder at the bottom of the liquor also contains a quantity of colouring matter in a similar state of combination. By mixing the residue and the liquor with sulphuric or muriatic acid, boiling, and then washing with water, the various bases are removed, and the colouring matter is thus made available for dyeing. Occasionally, when a very great depth of colour is required, it is found advisable to let the goods pass through a second dyeing operation, instead of obtaining the requisite shade at once.

After the calico has been removed from the dye-bath and washed in water, it presents a very unsightly appearance. The alumina mordant has acquired a dirty brownish-red colour, and the iron mordant a black or brownish-purple, according to its strength, whilst the white portions are reddish-brown. In the case of ordinary colours, the fabric is now passed through a mixture of boiling bran and water, or through a weak solution of chloride of lime, or it is exposed for some time on the grass to the action of air and light, or it is subjected to several of these processes in succession, by which means the impurities adhering to the mordants or the fibre are, in a great measure, either removed or destroyed, the white portions recovering their purity, and the red, black, purple, and chocolate, appearing afterwards sufficiently bright for ordinary purposes. That the colours, however, even after being thus treated, still contain in combination with the mordants other substances in addition to the red colouring matters, may be proved by a very simple experiment. If a few yards of some calico, which has been treated as just described, be immersed in dilute muriatic acid in the cold, the mordants are removed, and the colours are destroyed; orange-coloured stains being left on the places where they were before fixed. After washing the calico with cold water, the orange-coloured matter may be dissolved in alkali, and the calico left entirely white. The solution, which is brownish-red, gives, with an excess of acid, a reddish-brown flocculent precipitate. This precipitate, after being collected on a filter and well washed with water, is found to be only partially soluble in boiling alcohol, a brown substance, consisting partly of pectic acid, being left undissolved. The yellow alcoholic solution leaves, on spontaneous evaporation, a brown crystalline residue, which is found on examination to contain alizarine, purpurine, a little rubiacine, or some similar compound, and a brown amorphous substance. The removal of these various impurities, associated with the alizarine, seems to be the principal object of the treatment to which madder colours are subjected, when it is desired to give them the highest degree of brilliancy of which they are susceptible. This course of treatment, as applied to printed calicoes, may be shortly described as follows:—The goods, after being very fully dyed, generally with the addition of chalk, and then washed, are passed for some time through a solution of soap, which is heated to a moderate temperature. By this means a great deal of colour is removed, as may be seen by the red tinge of the soap liquor, and the purity of the white portions is almost entirely restored. During this process the brown and yellow colouring matters are probably removed by double decomposition, the alkali of the soap combining with and dissolving them, while the fat acid takes their place on the fabric. After being washed the goods are passed through a weak solution of acid, mostly sulphuric or oxalic acid, or an acid tin salt, which causes the colours to assume an orange tinge. The point at which the action of this acid liquid is to be arrested can only be ascertained by practice. The next step in the process is, after washing the goods, to treat them again with soap liquor, which is gradually raised to the boiling point, and they are lastly subjected to the action of soap liquor in a close vessel under pressure. By exposing the goods on the grass for some time after the first soaping, the use of acid may be obviated, but the process then becomes much more tedious. In this way are produced those beautiful pinks and lilacs, which, for delicacy of hue, combined with great permanence, are not surpassed by any dyed colours known in the arts. Whether the fat acid of the soap employed forms an essential constituent of these colours is not certainly known, but it is probable that it contributes to their beauty and durability. It is certain, however, that they always contain fat acid. If a piece of calico which has gone through the processes just described be treated with muriatic acid, the colour is destroyed, and a yellow stain is left in its place. This yellow stain disappears on treating the calico, after washing with water, with alkali, yielding a solution of a beautiful purple colour. This solution gives again with an excess of acid a yellow flocculent precipitate, which, after filtration, dissolves almost entirely in boiling alcohol, and the solution on evaporation affords needle-shaped crystals of pure alizarine, mixed with white masses of fat acid. The latter, therefore, seems to occupy the place taken up by the impurities before the treatment with soap. This experiment serves also to prove that it is alizarine which forms the basis of the more permanent colours afforded by madder, though, on the other hand, as in dyeing the finer madder colours, it cannot be denied that the colouring matters which are removed by the treatment with soap and acids contribute to the effect produced in dyeing ordinary madder colours.

The same result is attained in dyeing Turkey red, but the process employed is somewhat different and much more complicated. (See Turkey Red.)

The attempts which have been made at various times to obtain an extract of madder, capable of being applied in making so-called steam colours for calico and other fabrics, have not been completely successful. A very beautiful pink has been produced by Gastard and Girardin, in France, by printing on calico, previously prepared with some mordant, an ammoniacal solution of an extract of madder, called *colorine*, but it is not much superior, either as regards its hue or its degree of permanency, to what can be obtained by easier processes from dyewoods and other materials.

Madder is not so much employed in woollen dyeing, especially in this country, as in cotton dyeing and printing. Only ordinary woollen goods are dyed red with madder, since the colour is not so bright as that obtained from cochineal or lac, though it is more permanent and cheaper. A mixture of alum and tartar is employed as a mordant. The addition of a little muriate of tin in dyeing, imparts to the colour a more scarlet tinge. The bath of madder, at the rate of from 8 to 16 ounces to the pound of cloth, is heated to such a degree as to be just bearable by the hand, and the goods are then dyed by the wince, without heating the bath more until the colouring matter is fixed. Vitalis prescribes as a mordant, one-4th of alum and one-16th of tartar; aud for dyeing one-3rd 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 one 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 to contain much yellow colouring matter. Sometimes a little archil is added to the madder, in order to give the dye a pink tinge; but the effect is not lasting. By passing the goods after dyeing through weak alkali, the colour acquires a blueish tinge. By adding other dye-stuffs, such as fustic, peachwood and logwood, to the madder in dyeing, various shades of brown, drab, &c., are obtained. Madder is also used in conjunction with woad and indigo in dyeing woollen goods blue, in order to impart to the colour a reddish tinge. (See Indigo.)

Silk is seldom dyed with madder, because cochineal affords brighter tints.

Preparations of Madder.—The numerous analytical investigations of madder, undertaken chiefly in consequence of the Société Industrielle de Mulhouse having offered in the year 1826 a premium for a means of discovering the real quantity of colouring matter in the root, and of determining the comparative value of different samples of madder, led to many attempts on the part of chemists to improve the quality of this dye-stuff by means of chemical agents, and thus render it more fit for the purposes to which it is applied. Robiquet and Persoz were the first to point out the advantages which result from submitting madder, previous to its being used, to the action of strong acids. They showed that, by acting on madder with strong sulphuric acid, and then carefully washing out the acid with water, a product was obtained, which not only possessed a greater tinctorial power than the original material, but also dyed much brighter colours. This important discovery, which was not, like so many others, arrived at by chance, but was purely the result of scientific investigation, did not at first receive, on the part of practical men, the appreciation which it deserved. The product obtained by the action of sulphuric acid on madder, which in the first instance was called *charbon sulfurique*, afterwards *garancine*, was first manufactured on a large scale by MM. Lagier and Thomas of Avignon, but so great were the prejudices entertained by dyers and calico-printers against its use at the commencement, that years elapsed before they could be overcome; indeed they were partly justified by the imperfect nature of the product itself. The persevering efforts to improve the method of manufacture, and adapt it to the wants of the consumer, were at last attended with success, so that at the present day garancine has come to be used to as great an extent as madder, and large quantities of it are now manufactured in France and other countries.

It was supposed by Robiquet, that by the action of sulphuric acid on madder the saccharine, mucilaginous, and extractive matters of the root were destroyed, and thus hindered from producing any injurious effects in dyeing, and that the woody fibre was at the same time charred, so as to prevent it from attracting and binding any of the colouring matter. This explanation is not entirely correct, since it is not necessary to carry the action so far as actually to carbonise any of the constituents of the root, and it is also doubtful whether the woody fibre ever attracts the useful colouring matters in any considerable degree. The account above given of the chemical constitution of madder, may easily lead us to the conclusion, that, during the action of the acid, the following processes take place :—1. The bitter principle or colour-producing body of the root is decomposed, yielding, among other products, a quantity of alizarine which did not previously exist. 2. The red colouring matters are rendered by the acid insoluble in water, and thus it becomes possible to wash out the extractive matter, sugar, &c., without the madder losing any of its tinctorial power. 3. The lime, magnesia, and other bases which are combined in the root with colouring matter, or would combine with it during the dyeing process, are removed by the acid, and thus prevented from exerting any injurious action. The subsequent addition of a suitable quantity of lime, soda, or other base, serves to neutralise the effect of the excessive amount of pectic acid and resinous colouring matters, which were set free by the action of the mineral acid.

The method of manufacturing garancine, as practised at the present day, may be shortly described as follows :—The ground madder is mixed with water, and the mixture is left to stand for some hours. During this time it is probable that the rubian is decomposed by the ferment of the root, otherwise a great loss would be experienced. More water is now added, in order to remove all the soluble matters, and is then run off. The liquid contains sugar, and is employed on the continent for the preparation of a kind of spirit, which on account of its peculiar smell and flavour cannot be consumed as a beverage, but is used in the arts for the preparation of varnishes and other purposes. A sufficient quantity of alcoholic spirit is thus obtained to pay for the whole cost of the process. The residue left after washing the madder may be employed for dyeing without any further preparation, and is then called *fleur de garance.* In order to convert it into garancine, it is mixed with sulphuric acid, and the mixture is heated and left to itself for some time. Water is then added in successive portions until the excess of acid is removed. The pectic acid of the root always retains a portion of the sulphuric acid in chemical combination ; and the compound being but little soluble in water would require for its removal a very long washing. The addition of a small quantity of carbonate of soda, by neutralising this double acid, serves to abridge the time of washing very considerably. The residue is then filtered on strainers, pressed, dried, and lastly ground into a fine powder. This powder has a dark reddish-brown colour, and a peculiar odour, different from that of madder, but no taste. It communicates hardly any colour to cold water. Dyeing with garancine is attended with the following advantages :—1. The whole tinctorial power of the madder is exerted at once, and garancine is therefore capable of dyeing more than the material from which it is made. 2. The colours produced by its means are much brighter than those dyed with madder, and the parts of the fabric destined to remain white attract hardly any colour, so that very little treatment is required after dyeing. 3. Much less attention is required in regard to the temperature of the dye-bath and its gradual elevation than with madder, and a continued ebullition produces no injurious effects, but only serves to exhaust the material of all its colouring matter. On the other hand, garancine colours are not so fast as madder colours, they do not resist so well the action of soap and acids, and hence garancine cannot be employed for the production of the more permanent colours, such as pink and fine purple. By the use of a product which was patented by Pincoffs and Schunck several years ago, and which is obtained by exposing garancine to the action of steam of high pressure, it is indeed possible to dye as beautiful and as permanent a purple as with madder, and its use is attended by a considerable saving of time as well as of dyeing material and soap, but it is not so well adapted for dyeing pink. As yet therefore we have not succeeded in obtaining a preparation which shall serve as a perfect substitute for madder, and the latter consequently continues to be employed for some purposes.

The residue left after dyeing with madder as well as the dyeing liquor still contain some colouring matter, in a state of combination, as mentioned above. By acting on it with sulphuric acid it affords a product similar to garancine, which is called *garanceux.* This product is, however, adapted only for dyeing red and black, as it does not afford a good purple. (See CALICO-PRINTING.) Numerous other methods of treating madder for the use of the dyer have been invented and patented of late years, but they are not sufficiently important to merit description within the limits of the present article.

Imports of Madder in 1857.

	Cwts.	Computed real value.
Madder Roots - - -	293,989	£766,361
Madder - - -	109,069	289,243
Garancine - - -	30,998	229,385

E. S.

MADDER LAKE. The red pigment usually called *madder lake*, which is much used by painters, is made by treating madder, which has been previously washed with water, with a boiling solution of alum, filtering the red liquid and adding a small quantity of carbonate of soda, taking care to leave an excess of alumina in solution, washing the red precipitate, which is a compound of colouring matter and alumina, with water and drying. Persoz gives the following method for obtaining a madder lake of great brilliancy:— One part of madder, which has been previously submitted to fermentation or else washed with a solution of sulphate of soda, is treated with ten times its weight of a boiling solution of alum, containing one part of alum, for fifteen or twenty minutes. The filtered liquid is mixed, as soon as its temperature has fallen to about 100° F., with a solution of carbonate of soda containing one-eighth or one-tenth of the weight of the alum employed. This quantity is insufficient to cause any precipitate at that temperature, but on boiling the liquid, the lake falls down in the shape of a red powder. The madder must be treated several times with boiling alum liquor, in order to extract the whole of the colouring matter soluble in that menstruum. It is evident that these lakes contain chiefly purpurine and very little alizarine, the latter being hardly soluble in alum liquor. See LAKE.

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 magistery of bismuth.

MAGISTRAL, in the language of the Spanish smelters of Mexico and South America, is the roasted and pulverised 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 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 silkworms are reared upon the great scale, or to the manager of the establishment. The word is derived from *magnans*, which signifies silkworms in the language of the country people. See SILK.

MAGNESIA (Eng. and Fr.; *Bittererde*, *Talkerde*, Germ.) (*Oxide of Magnesium*) is one of the 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 5150 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, popularly known as *Calcined 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. There is a heavy calcined magnesia prepared by burning the dense carbonate. Mr. Lockyer, shows, however, that a very dense and pure magnesia could be obtained by calcining the ordinary pure carbonate in large masses, and at very high temperatures.

MAGNESIA CARBONATE; 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 *bittern* of sea-salt evaporation works), a solution of carbonate of soda, or of carbonate of ammonia distilled from bones in iron cylinders. Mr. Hugh Lee Pattinson introduced the manufacture of carbonate of magnesia from the Dolomite rocks, availing himself of the different rates of solubility of the carbonates of lime and magnesia in water saturated with carbonic acid. (See DOLOMITE.) 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 acescency.

MAGNESIA, NATIVE HYDRATE OF. *Brucite*. This mineral consists of magnesia, 68·97, water, 31·03, according to analyses by Bruce. It accompanies other magnesia minerals in serpentine at Swinaness in Unst, one of the Shetland Isles, in the Ural Mountains, in France, and opposite to New York. — *Dana*.

MAGNESIA, SILICATES OF. Compounds of this character are abundant in the mineral kingdom. Meerschaum, French Chalk, Steatite, Talc, Serpentine, Asbestos, and many other minerals are silicates of magnesia. (See *these articles*.)

MAGNESIA, SULPHATE OF, (Epsom Salts,) 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 crystallise 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 bittern, 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.

MAGNESIAN LIMESTONE. See LIMESTONE.

MAGNESITE. *Carbonate of Magnesia, Rhomb Spar.* This native carbonate of magnesia, consisting of magnesia, 47·6, carbonic acid, 52·4, is found with serpentine and other magnesian rocks.

MAGNESIUM. The metal obtained from magnesia. It was first procured by Bussy, although previously shown to exist by Davy. It is now made by placing potassium or sodium in a platinum crucible, covering them with chloride of magnesium, fastening down the cover of the crucible, and exposing it to the heat of a spirit lamp. It has been recently prepared by Bunsen by the action of the voltaic current. Magnesium is a white metal, which tarnishes in damp air. See *Ure's Chemical Dictionary.*

MAGNET. A bar of steel, which, being imbued with a peculiar condition of electrical force, is possessed of polarity. The magnet has a special employment in the mariner's compass, as from the undeviating way in which — unless strong disturbing causes are in operation, — it points north and south. The magnet is used also in surveying instruments. The use of iron in shipbuilding has led to a very careful examination of the influence of iron on the ships' compasses. The late Dr. Scoresby, Professor Airy, and some others have been peculiarly distinguished in this important inquiry, and to their memoirs on the subject the reader is referred. Magnetic machines have been constructed for developing electricity, and employed for the deposition of metals. See ELECTROMETALLURGY.

MAGNET, NATIVE. See LOADSTONE AND IRON.

MAGNETISM. A peculiar condition of electrical force. The phenomena of magnetism which are rendered in any way available in the arts are detailed in special articles; as ELECTRO-TELEGRAPHY, &c. &c. All bodies must now be regarded as existing in one, of two, known conditions of magnetism. It is understood that magnetism is manifested as a *polar force*, as in a bar of iron. Every one is familiar with the fact, that a magnetised bar, if free to move, places itself in a certain direction, which we call north and south. Beside iron, nickel and two or three other metals possess this property. Bismuth, silver, glass, wood, and nearly all other substances exhibit a magnetic force of a different order, which is manifested in all these bodies by their placing themselves at right angles to a magnet, or to the line of magnetic force. This condition has received the name of DIA-MAGNETISM, *which see*.

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.

MAHOGANY. The wood of a tree (*Swietenia mahogoni*), which is a native of the West Indies. This wood appears to have been first brought to England in 1724.

SPANISH mahogany is imported from Cuba, St. Domingo, the Spanish Main, and several of the West India Islands, in logs about 26 inches square and 10 feet long. Its general character is well known, from its extensive use in cabinet work.

HONDURAS mahogany is generally lighter than the Spanish, and more open and irregular in its grain. This is imported in large logs, many of 4 feet square and 18 feet in length. Planks are sometimes obtained of 7 feet in width. According to Mr. Chief Justice Temple, "the cutting commences in the month of August. In April or

May, in which months the ground has become perfectly hard from the continued dry weather, the wood is carried upon trucks drawn by bullocks to the water side, and about the middle of June, when the rivers are swollen by the floods, the logs are floated down about 10 miles from the mouths of the different rivers, where they are confined by a heavy boom drawn across the stream. Here the owners select their respective logs from them into rafts, and so float them down to the sea. The mahogany is always trucked in the middle of the night, the cattle not being able to perform such laborious work during the heat of the day. It is a picturesque and striking scene, this midnight trucking. The lowing of the oxen, the creaking of the wheels, the shrill cries of the men, the resounding cracks of their whips, and the red glare of the pine torches, in the midst of the dense dark forest, produce an effect approaching to sublimity.

"An impression has latterly existed that almost all the mahogany in British Honduras has been cut. This, however, is a mistake. There is sufficient wood in the country, both on granted and ungranted land, to supply the European as well as the American markets for many years to come. A considerable quantity of mahogany has been, within the last few years, cut in the state of Honduras and on the Mosquito shore; but the mahogany works in the former country have been almost entirely abandoned, partly on account of the wood, which is accessible, being nearly all cut, and partly on account of the extra freight and insurance which are required when vessels are loaded on that coast. From the Mosquito shore very few cargoes have been lately sent, for the wood which grows there, although it is very large, is of inferior quality. The mahogany tree requires a rich dry soil. The best mahogany is found to the north of the river of Belize. In consequence of the nature of the soil in that district, in which there is a great quantity of limestone, the mahogany is longer coming to maturity, but, when fully grown, it is of a harder and firmer texture than that which is found in the southern portion of the settlement. There is no wood more durable than mahogany, and none that is so generally useful. It is stated in a little book called "The Mahogany Tree," that furniture is being made, in the royal dockyards, out of the beautiful mahogany found in breaking up the old line-of-battle ship the *Gibraltar*, which was built in Havana 100 years ago. The English and French governments purchase yearly a large amount of mahogany for their dockyards. During the last year the British government required 12,000 tons, paying 10*l*. 17*s*. 6*d*. per ton. The French government took 3000 tons at the same price. The royal yacht is built principally of Honduras mahogany. Private ship-builders are, however, reluctant to make use of mahogany for their vessels, as Lloyd's Committee exclude all ships of 12 years' standing, in which the floors, futtocks, top-timber, keelson, stem and stern post, transoms, knightheads, hawse timbers, apron, and dead wood are made of mahogany.

"Mahogany vessels of 10 years' standing they admit, but even these, I am informed, it is their intention very shortly to exclude. The reason which they assign is, that mahogany differs very much in quality, and it is impossible to know when a ship is built of good or bad wood. But this difference in quality depends entirely upon the district in which it has grown. If they restricted the shipbuilders to the northern wood, they might admit vessels of 12 years' standing without any risk. In the year 1846 the Honduras merchants presented a memorial to Lloyd's Committee, praying for a removal of the existing limitations to the general use of mahogany in the building of vessels of the highest class. Attached to this memorial were numerous certificates from persons well qualified to give an opinion on the subject, speaking in the highest terms of mahogany for shipbuilding. Captain E. Chappel, R. N., Secretary of the Royal Mail Steam-Packet Company says, 'Has seen the *Gibraltar*, 80-gun ship, which was broken up at Pembroke. *This ship is entirely of mahogany*; captured of the Spaniards in 1780, *all her timbers sound as when put into her*. Tables for the navy made of the timbers of the *Gibraltar*. The steamer *Forth*, built by Mr. Menzies of Leith, has as much mahogany put into her as could be obtained. The use of mahogany ought to be the *rule*, and not the exception.' The qualities of mahogany, which render it peculiarly fitted for shipbuilding, are its lightness and buoyancy, its freedom from dry rot, and its non-liability to shrink or warp. The price of mahogany varies according to the size, figure, and quality of the wood. One tree from the northern districts, which was cut into three logs, sold for 1800*l*. or 10*s*. per superficial foot of 1 inch; southern wood of small size and inferior quality has been sold at 3½*d*. a foot. The present prices in London for small-sized plain mahogany are from 5*d*. to 6*d*. per foot; for large-sized plain, from 7*d*. to 10*d*.; and for large, of good quality and figured, from 9*d*. to 1*s*. 6*d*.

"The yearly average quantity of mahogany exported from Honduras during the last ten years is about eight millions of feet, equal to 20,000 tons, or 200,000 tons in the whole ten years, requiring 160,000 trees."

African mahogany, *Swietenia senegalensis*, from Gambia, has been used of late years for curriers' tables, mangles, &c., and may be used for turning. It is denied by some authors as being a *Swietenia*; but, if not so, it is a very closely allied genus.

There are two or three varieties of the *Swietenia* in the East Indies, which are ornamental woods, but not mahogany.

The importance of the wood will be seen from the following statement of the *imports* of mahogany in 1857:—

	Tons.	Computed real value.
From Hanse Towns	232	£2,274
„ France	612	5,998
„ Cuba	5,538	54,272
„ Porto Rico	456	4,557
„ Hayti	5,575	67,318
„ United States	537	5,263
„ Mexico	4,903	48,049
„ Central America	1,402	13,740
„ New Granada	620	6,076
„ British West India Islands	1,251	12,260
„ Honduras, British settlements	19,857	203,577
„ other parts	66	646
	12,344	£424,030

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-spar; 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.

It is found in great quantities and of a remarkably fine character in the copper mines of the Ural mountains, and is in Russia manufactured into various kinds of furniture and highly ornamental articles. A very fine malachite has been obtained from the Burra-Burra mines in South Australia. It is found to exist in large quantities in Central Africa.

MALATES are saline compounds of the bases with Malic Acid.

MALIC ACID. (*Acid malique*, Fr.; *Aepfelsaure*, 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, whortleberries, cherries, and 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 it 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-crystallisation. 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 sulphide, 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-crystallisation.

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.

MALLEABLE IRON. See STEEL, HOMOGENOUS.

MALM ROCK. A local name for the sandstones of Surrey and Sussex, called also *fire stone*. See SANDSTONE.

MALTHA; *Bitume glutineux*, or mineral pitch. It dissolves in alcohol, as also in naphtha, and oil of turpentine. It seems to be inspissated petroleum.

MALTING. The process by which barley or other grain is prepared by artificial germination for the purpose of brewing. The changes produced in its constituents, and the requisite properties of good malt, having been already given at length in the article BEER (which see), we now proceed to describe the requisites of a malt-house, and the mode of operation.

The necessary apparatus for the production of malt is extremely simple; that is to say, first, a cistern or vessel for steeping the grain; secondly, a floor on which it may be thinly spread and allowed to vegetate; and, lastly, a kiln or stove in which the newly formed malt may be dried. Specific size, position, or arrangement is not needed; but in this country, from the large amount of duty levied on this manufacture, fiscal regulations of the most oppressive aud inquisitorial character interfere by the most arbitrary enactments at every stage, and influence the whole arrangement.

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 are enforced by 106 penalties, amounting in the aggregate to the incredible sum of 13,500*l.* How much of this is negatived 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 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 previous 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 $78\frac{1}{4}$ 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 guage 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, and 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.

Having thus seen the restrictions imposed by the legislature, we need only indicate that the capacities of the cistern, the couch, and the kiln should be adapted to contain respectively the whole quantity of barley or malt made at one steeping, and this should again have reference to the space allotted to the floor, which should allow of at least three steepings to be worked on it without interference in their different stages of growth and withering.

The process of malting consists of three successive operations: the steeping; the couching, sweating, flooring; and the kiln-drying.

The *steeping* is performed in large cisterns made of wood or stone, which being filled with clear water up to a certain height, a quantity of barley is shot into them, and well stirred about with rakes. The good grain is heavy, and subsides; the lighter grains, which float on the surface, are damaged, and should be skimmed off; for they would injure the quality of the malt, and the flavour of the beer made with it. They seldom amount to more than two per cent. More barley is successively emptied into the steep cistern, till the water stands only a few inches, about five, above its surface; when this is levelled very carefully, and every light seed is removed. The steep lasts from forty to sixty hours, according to circumstances; new barley requiring a longer period than old, and bigg requiring much less time than barley.

During this steep, some carbonic acid is evolved from the grains, and combines with the water, which, at the same time, acquires a yellowish tinge, and a strawy smell, from dissolving some of the extractive matter of the barley husks. The grain imbibes about one half its weight of water, and increases in size by about one fifth. By losing this extract, the husk becomes about one seventieth lighter in weight, and paler in colour.

The duration of the steep depends, in some measure, upon the temperature of the air, and is shorter in summer than winter. In general from 40 to 48 hours will be found sufficient for sound dry grain. Steeping has for its object to expand the farina of the barley with humidity, and thus prepare the seed for germination, in the same way as the moisture of the earth prepares for the growth of the radicle and plumula in seed sown in it. Too long continuance in the steep is injurious; because it prevents the germination at the proper time, and thereby exhausts a portion of the vegetative power: it causes also an abstraction of saccharine matter by the water. The maceration is known to be complete when the grain may be easily transfixed with a needle, and is swollen to its full size. The following is reckoned a good test:— If a barley-corn, when pressed between the thumb and fingers, continues entire in its husk, it is not sufficiently steeped; but, if it sheds its flour upon the fingers, it is ready. When the substance exudes in the form of a milky juice, the steep has been too long continued, and the barley is spoiled for germination.

In warm weather it sometimes happens that the water becomes acescent before the grain is thoroughly swelled. This accident, which is manifest to the taste and smell, must be immediately obviated by drawing off the foul water through the tap at the bottom of the cistern, and replacing it with fresh cold water. It does no harm to renew it two or three times at one steep.

The *couch*. — The water being drawn off, and occasionally a fresh quantity passed through, to wash away any slimy matter which may have been generated in warm weather, the barley is now laid upon the couch floor of stone flags, in square heaps from 12 to 16 inches high, and left in that position for 24 hours. At this period, the bulk of the grain being the greatest, it is usually gauged by the revenue officers, and the quantity then found multiplied by the decimal ·815 is that on which the duty is generally charged. The moisture now leaves the surface of the barley so completely, that it imparts no dampness to the hand. By degrees, however, it becomes warm; the temperature rising 10° above the atmosphere, while an agreeable fruity smell is evolved. At this time, if the hand be thrust into the heap, it not only feels warm, but it gets bedewed with moisture. At this sweating stage the germination begins: the fibrils of the radicle first sprout forth from the tip of every grain, and a white elevation appears, that soon separates into three or more radicles, which grow rapidly larger. About a day after this appearance the plumula peeps forth at the same point, proceeding thence beneath the husk to the other end of the seed, in the form of a green leaflet.

The greatest heat of the couch is usually about 96 hours after the barley has been taken out of the steep. In consequence, the radicles tend to increase in length with very great rapidity, and must be checked by artificial means, which constitute the chief art of the maltster. He now begins to spread the barley thinner on the floor, and turns it over several times in the course of a day, bringing the portions of the interior to the exterior surface; by which means the rootlets are kept short and bushy, and the germination uniform. The depth, which was originally 15 or 16 inches, is lowered a little at every turning over, till it be brought eventually down to three or four inches. Two turnings a day are generally required. The maltster will know when the grain requires turning by taking a handful, and if it smells faint, and the skin appears glossy and wet, it should at once be turned, and it will afterwards smell fresh, and the skin will be dry and not glossy. The omission of turning in due time will cause the roots to run out unequally, and some portions of the malt to be spent before the other is ready for the kiln. At this period of spreading or flooring, the temperature in England is about 62°, and in Scotland 5 or 6 degrees lower.

About a day after the radicles appear, the rudiments of the stem, or of the plumula, sprout forth, called by the English maltsters the *acrospire*. It issues from the same end of the seed as the radicle, but turns round, and proceeds within the husks towards the other end, and would there come forth as a green leaf, were its progress not arrested. The malting, however, is complete before the acrospire becomes a leaf.

The radicles, or rootlets, begin to fade or wither about the eleventh or twelfth day, and the grain on the floors may then be spread thicker to generate a little warmth and to mellow it; still frequently turning to keep off the glossy appearance until the moisture is spent, and also to prevent the acrospire growing too far, as it is sufficient if it has advanced two thirds the entire length of the grain.

The barley couch absorbs oxygen and emits carbonic acid, just as animals do in breathing, but to a very limited extent; for the grain loses only three per cent. of its weight upon the malt floor, and a part of this loss is due to waste particles. As the acrospire creeps along the surface of the seed, the farina within undergoes a remarkable alteration. The gluten and mucilage disappear in a great measure, the colour becomes whiter, and the substance becomes so friable that it crumbles into meal between the fingers. This is the great purpose of malting, and it is known to be accomplished when the plumula or acrospire has approached the end of the seed. Now the further growth must be completely stopped. Fourteen days may be reckoned the usual duration of the germinating stage of the malting operations in England; but in Scotland, where the temperature of the couch is lower, eighteen days, or even twenty-one, are sometimes required. The shorter the period within the above limits, the more advantageous is the process to the maltster, as he can turn over his capital the sooner, and his malt is also somewhat the better. Bigg is more rapid in its germination than barley, and requires to be still more carefully watched. In dry weather it is sometimes necessary to give additional water by sprinkling the barley upon the floor.

Occasionally the odour disengaged from the floor is offensive, resembling that of rotten apples. This is a bad prognostic, indicating either that the barley was of bad quality, or that the workmen, through careless shovelling, have crushed a number of the grains in turning them over. Hence, when the weather causes too quick germination, it is better to check it by spreading the heap out thinner, than by turning it too frequently over. On comparing different samples of barley, we shall find that the best develope the germ or acrospire quicker than the radicles, and thus occasion a greater production of the saccharine principle; this conversion advances along with the acrospire, and keeps pace with it, so that the portion of the seed to which it has not reached is still in its unaltered starchy state. It is never complete for any single barley-corn till the acrospire has come nearly to the end opposite to that from which it sprang; otherwise one part of the corn may be sugary, while the other is still insipid. If the grain were allowed to vegetate beyond this term, the radicles being fully one third of an inch long, the future stem would become visibly green in the exterior; it would shoot forth rapidly, the interior of the grain would become milky, with a complete exhaustion of all its useful constituents, and nothing but the husk would remain.

In France the brewers, who generally malt their barley themselves, seldom leave it on the floor more than 8 or 10 days, which, even taking into account the warmer climate of their country, is certainly too short a period, and hence they make inferior wort to the English brewer from the same quantity of malt.

At the end of the germination, the radicles have become 1½ longer than the barley, and are contorted so that the corns hook into one another, but the acrospire should not appear from under the husk. A moderate temperature of the air is best adapted to malting; therefore it cannot be carried on well during the heat of summer or the colds of winter. Malt-floors should be placed in substantial thick-walled buildings, without access of the sun, so that a uniform temperature of 59° or 60 may prevail inside. Some recommend them to be sunk a little under the surface of the ground, if the situation be dry.

The *kiln-drying*. — When the malt has become perceptibly dry to the hand upon the floor, it is taken to the kiln, and dried hard with artificial heat, to stop all further growth, and enable it to be kept, without change, for future use at any time. The malt-kiln, which is particularly described in the next page, is a round or a square chamber, covered with perforated earthenware tiles or plates of cast iron, whose area is heated by a stove or furnace, so that not merely the plates on which the malt is laid are warmed, but the air which passes up through the stratum of malt itself, with the effect of carrying off very rapidly the moisture from the grains. The layer of malt should be about 3 or 4 inches thick, and evenly spread, and its heat should be steadily kept at from the 90th to the 100th degree of Fahrenheit's scale, till the moisture be mostly exhaled from it. During this time the malt must be turned over at first frequently, and latterly every three or four hours. When it is nearly dry, its temperature should be raised to from 145° to 165° F., and it must be kept at this heat till it has assumed the desired shade of colour, which is commonly a brownish yellow or a yellowish brown. The fire is now allowed to die out, and the malt is left on the plates till it has become completely cool; a result promoted by the stream of cool air, which now rises up through the bars of the grate; or the thoroughly dry browned malt may, by damping the fire, be taken hot from the plates, and cooled upon the floor of an adjoining apartment. The prepared malt must be kept in a dry loft, where it can be occasionally turned over till it is used. The period of kiln-drying should not be hurried. Many persons employ two days in this operation.

According to the colour and the degree of drying, malt is distributed into three sorts; pale, yellow, and brown. The first is produced when the highest heat to which it has been subjected is from 90° to 100° F.; the amber yellow, when it has suffered a heat of 122°; and the brown when it has been treated as above described. The black malt used by the porter brewer to colour his beer has suffered a much higher heat, and is partially charred. The temperature of the kiln should, in all cases, be most gradually raised, and most equably maintained. If the heat be too great at the beginning, the husk gets hard dried, and hinders the evaporation of the water from the interior substance; and should the interior be dried by a stronger heat, the husk will probably split, and the farina become of a horny texture, very refractory in the mash-tun. In general, it is preferable to brown malt rather by a long-continued moderate heat, than by a more violent heat of shorter duration, which is apt to carbonise a portion of the mucilaginous sugar, and to damage the article. In this way the sweet is sometimes converted into a bitter principle.

During the kiln-drying, the roots and acrospire of the barley become brittle, and fall off; and are separated by a wire sieve whose meshes are too small to allow the malt itself to pass through.

A quantity of good barley which weighs 100 pounds, being judiciously malted, will weigh, after drying and sifting, 80 pounds. Since the raw grain, dried by itself at the same temperature as the malt, would lose 12 per cent. of its weight in water, the malt process dissipates out of these remaining 88 pounds, only 8 pounds, or 8 per cent. of the raw barley. This loss consists of—

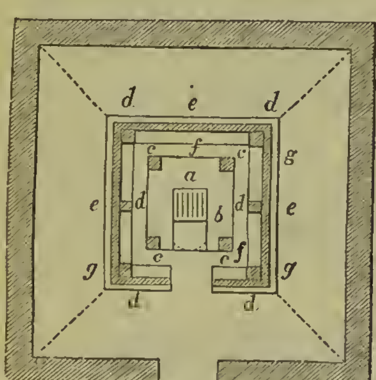
$1\frac{1}{2}$	per cent.	dissolved out in the steep water,
3	„	dissipated in the kiln,
3	„	by the removal of the fibrils,
$0\frac{1}{2}$	„	of waste.

The bulk of good malt exceeds that of the barley from which it was made by about 8 or 9 per cent.

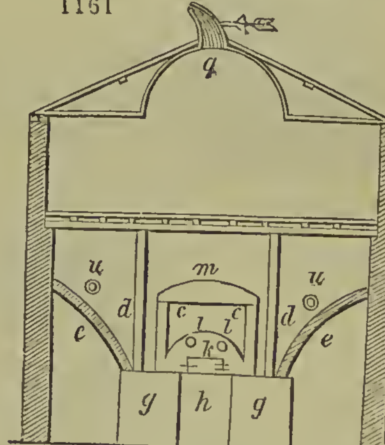
MALT KILN. (*Darre*, Germ.) The requisite conditions of a good malt kiln are, that the temperature should be under perfect control; the malt not exposed too near the direct action of the fire; and the vapour from the heated grain rapidly carried off.

Figs. 1160, 1161, 1162, 1163 exhibit the construction of a well-contrived *malt kiln*. *Fig.* 1160 is the ground plan; *fig.* 1161 is the vertical section; and *figs.* 1162 and 1163 a horizontal and vertical section in the line of the malt-plates. The same letters denote the same parts in each of the figures. A cast-iron cupola-shaped oven is sup-

1160

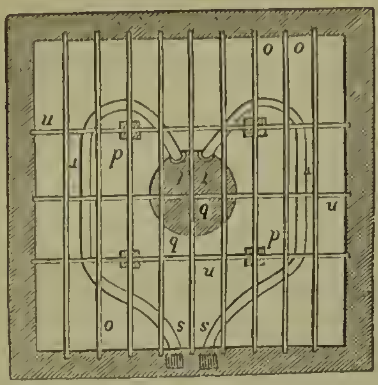


1161

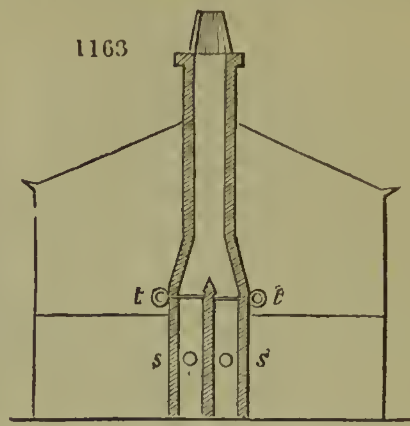


ported in the middle upon a wall of brickwork four feet high; and beneath it are the grate and its ash-pit. The smoke passes off through two equidistant pipes into the chimney. The oven is surrounded with four pillars, on whose top a stone lintel is laid: *a* is the grate, 9 inches below the sole of the oven *b*; *c c c c* are the four nine-inch strong pillars of brickwork which bear the lintel *m*; *d d d d d* are strong nine-inch pillars, which support the girder and joists upon which perforated plates repose; *e* denotes a vaulted arch on each of the four sides of the oven; *f* is the space between the kiln and the side arch, into which a workman may enter to inspect and clean the kiln; *g g*, the walls on either side of the kiln, upon which the arches rest; *h*, the space for the ashes to fall; *k*, the fire-door of the kiln; *l l*, junction pieces to connect the pipes *r r* with the kiln; the mode of attaching them is shown in *fig.* 1162. These smoke-pipes lie about three feet under the iron plates, and at the same distance from the side walls; they are supported upon iron props, which are made fast to the arches. In *fig.* 108, *u* shows their section; at *s s*, *fig.* 1162, they enter the chimney, which is

1162



1163



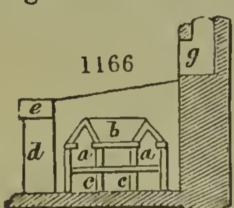
provided with two register or damper plates, to regulate the draught through the pipes. These registers are represented by *t t*, *fig.* 1163, which shows a perpendicular section of the chimney. *m*, *fig.* 1161, is the lintel, which causes the heated air to spread laterally, instead of ascending in one mass in the middle, and prevents any combustible particles from falling upon the iron cupola. *n n* are the main girders of iron for the iron beams *o o*, upon which the perforated plates *p* lie; *q*, *fig.* 1161, is the vapour pipe in the middle of the roof, which allows the steam of the drying malt to escape. The kiln may be heated either with coal or wood.

The size of this kiln is about 20 feet square; but it may be made proportionally either smaller or greater. The perforated floor should be large enough to receive the contents of one steep or couch.

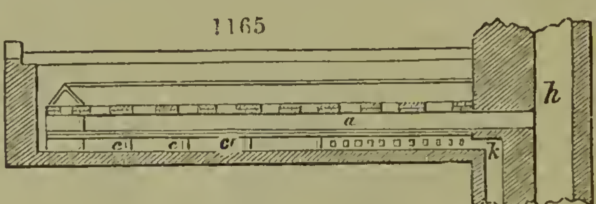
The perforated plate might be conveniently heated by steam pipes, laid zigzag, or in parallel lines under it; or a wire-gauze web might be stretched upon such pipes. The wooden joists of a common floor would answer perfectly to support this steam-range, and the heat of the pipes would cause an abundant circulation of air. For drying the pale malt of the ale brewer, this plan is particularly well adapted.

The improved malt kiln of Pistorius is represented *fig.* 1164, in a top view; *fig.* 1165, in a longitudinal view and section; and *fig.* 1166, in transverse section. *a*, *a*, are two

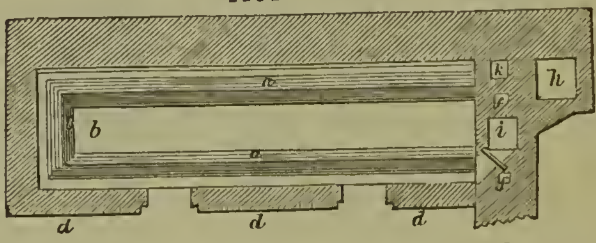
1166



1165



1164



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.* 1165, 1166). These flues are built above a grating *c c*, which commences at *c′*; in front of *c′* 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; *f f* 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 a smoke-pipe, from which the smoke passes into the anterior flue *d*, 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 a 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.

The following is an account of the total number of quarters of malt made in the United Kingdom, from the 1st day of October 1856, to the 1st day of October 1857, distinguishing the quantity made, and the quantity used by brewers, and by victuallers and by retail brewers, in each country.

	Quarters of malt made.			Quarters of Malt used.		
	Charged with Duty.	Free of Duty for Distillery purposes and Exportation per Act 18 & 19 Vict. c. 94.	Total.	By Brewers and Victuallers.	By Retail Brewers.	Total.
England - -	4,645,074	89,265	4,734,339	3,748,415	394,172	4,142,587
Scotland - -	152,396	489,087	641,483	153,565	-	153,565
Ireland - -	216,666	118,782	335,448	260,491	- -	260,491
United Kingdom	5,014,136	697,134	5,711,270	4,162,471	394,172	4,556,643

The quantities of malt charged with duties of excise in the United Kingdom, quantities exported on drawback, and retained for home consumption.

Years.	Charged with Excise Duty.	Exported on Drawback.	Retained for Home Consumption.
	Bushels.	Bushels.	Bushels.
1842	35,851,394	- -	35,851,394
1843	35,693,890	- -	35,693,890
1844	37,187,186	- -	37,187,186
1845	36,545,990	- -	36,545,990
1846	42,097,085	- -	42,097,085
1847	35,307,815	- -	35,307,815
1848	37,545,912	- -	37,545,912
1849	38,935,460	- -	38,935,460
1850	40,744,752	- -	40,744,752
1851	40,337,412	20,690	40,316,722
1852	41,072,486	51,160	41,021,326
1853	42,039,748	161,962	41,877,786
1854	36,819,360	199,655	36,619,705
1855	33,887,234	106,709	33,780,525
1856	36,980,041	212,374	36,767,667

R. W. H.

MAMMEE. A tree growing in Honduras. Its dried leaves are very powerfully narcotic; the bark is, however, stated to possess some tonic properties. The flowers of the tree are used in flavouring a *liqueur* made in some parts of the West Indies called *crème des créoles*. — *Temple*.

MANCHINEEL. A large tree of a very poisonous character, growing in South America, and in some parts of the West Indies. The wood is of a yellow-brown colour, beautifully clouded, and very close and hard. It is sometimes used instead of mahogany.

MANDIOCA. Cassava starch. See Starch.

MANGANESE (Eng. and Fr.; *Mangan*, *Braunsteinmetal*, Germ.) is a greyish-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 oxidised, 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 lampblack 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, ORES OF. 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 primary formations.

1. *Pyrolusite*, or grey manganese ore, has a metallic lustre, a steel-grey 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. Manganese, 63·3; oxygen, 36·7.

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. Manganese, 69·68; oxygen, 30·32. *Hausmannite* is a rare variety of this ore.

3. *Manganite* 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 manganese, 62·68; oxygen, 27·22; water, 10·10.

Manganese blende, or sulphide of manganese, has a metallic aspect; is black, or dark steel-grey; 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, 37·90; manganese, 62·10.

Dialogite; carbonate of manganese. 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 ferro-cyanide of potassium. Carbonic acid, 38·20; protoxide of manganese, 61·80.

Rhodonite, or hydrosilicate of manganese, is a brownish-red-looking substance, which yields a yellowish-brown powder, and water by calcination; is acted on by muriatic acid, but affords no chlorine. It consists of silica, 45; protoxide of manganese, 54·1.

Wad, or *Bog manganese*, 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 a dark 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. The localities of wad are particularly Cornwall and Devonshire, the Hartz, and Piedmont. Wad from Devonshire gave oxide of manganese, 79·12; oxygen, 8·82; water, 10·06.

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.

The restoration of manganese to the state of peroxide, for the chemical arts in which it is so extensively consumed, has been long a desideratum in manufactures.

For some of the uses of manganese in the arts, see BLEACHING and CHLOROMETRY.

Imports of manganese in 1858: —

	Tons.	£
Hanse Towns	262	2096
Holland	23,280	186,240
France	239	1,912
Other parts	390	3,120
	24,171	193,368

Our *exports* in the same year being of —

Manganese	2	19

MANGANESE, OXIDES OF. 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 sulphide of ammonia a flesh-red precipitate, but with caustic alkalies 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 oxidisement of the protoxide in the air. It is black; when finely pulverised, 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. *Manganesic acid* forms green-coloured salts, but has not hitherto been insulated from the bases. It consists of 53·55 metal, 46·45 oxygen.

5. *Hypermanganesic acid* consists of 49·70 metal and 50·30 oxygen. See *Ure's Dictionary of Chemistry.*

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 CHLOROMETRY.

MANGLE. (*Calandre*, Fr.; *Mangel*, Germ.) This is a well known machine for smoothing 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. Warcup, 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.

MANGROVE. Several tropical trees yield woods to which this name has been applied. Colonel G. A. Lloyd informs us, that "the timbers are very much valued for ship-building, and a large quantity comes from Crab Island and Porto Rico."

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. See CASSAVA; TAPIOCA.

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.

MANURE. 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 skilful 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 tenor 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 Liebig himself speaks of the mineral theory in this edition of his letters on chemistry. Thus 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." Messrs Lawes and Gilbert published the following paper in reply to Liebig. It is of so important a nature that, acting on the advice of the best authority in this country, it has been retained.

"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 ammonial 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 farmyard 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 applyiug farmyard manure it will do so, it is evident that if we supply to different plots of this *exhausted land* the constituents of farmyard 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 farmyard 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 farmyard 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 eause, unless we inelude the frequent faulty methods of application.

"It is, then, by this *synthetic* rather than by the aualytic 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 seleeted 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 farmyard 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, aud 20 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 mueh occupied also with the subject of the feeding of auimals, viz. bullocks, sheep, and pigs; as well as in investigating the funetional actions of the growing plant in relation to the soil and atmosphere; and in connection with each of these subjects much laboratory labour has eonstantly 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 eorn 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 mueh then for the rationale and general plau of the experiments themselves, and we now propose to call attention to some of the results which they have afforded us.

"It is to 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 aeeumulate 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 develope 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. bush.	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 farmyard 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 - Superphosphate of lime, 350lbs. Phosphate of potass, 364 lbs. -	16	1	980	1160
Plot 15. Maximum produce of 9 plots with artificial mineral manures - - Superphosphate of lime, 350 lbs. Phosphate of magnesia, 168 lbs. " potass, 150 lbs. - Silicate do. 112 lbs. -	17	3¼	1096	1240
Mean of the 9 plots with artificial mineral manures - - - - - - -	16	3¾	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 130 lbs. of rape-cake respectively -	18	1¾	1078	1201
Plot 18. With complex mineral manure, 65 lbs. of sulphate of ammonia, and 150 lbs. of rape-cake	22	3¼	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 farmyard manure 22 bushels. The *ashes* of farmyard 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 two 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 of 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 farmyard 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 farmyard manure gives 32 bushels in 1845, and only 22 in 1844.

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 1.				
Plot 3. No manure	23	0¾	1441	2712
„ 2. 14 tons of farmyard manure	32	0½	1967	3915
Section 2.				
„ 5*a*. No manure	22	2¼	1431	2684
„ 5*b*. 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. / Muriate of ammonia, 168 lbs. } top-dressed at once	33	1½	2131	4058
„ 10. { Sulphate of ammonia, 168 lbs. / Muriate of ammonia, 168 lbs. } top-dressed at 4 times	31	3¼	1980	4266

"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 22¼ 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 5*a*') being, as just said, unmanured, and the other ('plot 5*b*') 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 potass. To each of these plots 1½ cwt. of sulphate and 1½ 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 1¼ bushel that given by farmyard 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 farmyard 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, but that 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' — he 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 and Pecks.		Total Corn per Acre in lbs.	Straw per Acre and lbs.
	bush.	pecks.	lbs.	lbs.
Section 1.				
Plot 3. No manure - - - - - -	17	3¾	1207	1513
„ 2. 14 tons of farmyard manure - -	27	0¼	1826	2454
Section 2.				
„ 10*b*. No manure - - - -	17	2½	1216	1455
„ 10*a*. Sulphate of ammonia, 224 lbs. - -	27	1½	1850	2244
Section 3.				
„ 5*a*¹. Ash of 3 loads of wheat straw - -	19	0½	- -	1541
„ 5*a*². Ash of 3 loads of wheat straw, and top-dressed with 224 lbs. of sulphate of ammonia - - - - -	27	0	- -	2309
Section 4.				
„ 6*a*. Liebig's wheat-manure, 448 lbs. - -	20	1½	1400	1676
„ 6*b*. Liebig's wheat-manure, 448 lbs., with 112 lbs. each of sulphate and muriate of ammonia - - - - -	29	0¾	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 10*b* — 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 17½ 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 farmyard manure, and the produce is 27¼ 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 farmyard 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, $5a^1$) 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 $5a^2$) 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 $5a^1$ by 7⅞ bushels of corn and 768 lbs. of straw, instead of by 9⅝ 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 20¼ 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 29¼ 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 farmyard manure, was only 9¼ 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 alkalies 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 amount 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 Alkalies.			
	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 had 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 8¼ tons of bulb! varying however exceedingly year by year, according to the season. We see, too, that by the addition to superphosphate of lime of a large quantity of the alkalies, 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 neutralised by alkalies 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 alkalies, 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 alkalies in which the ash of the turnip so peculiarly abounds, than would have been lost to 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 alkalies 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.

"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 6½ to 7½ 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 alkalies 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 nitrogenised 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."

MANURE, ARTIFICIAL. Agricultural writers usually divide manures into two classes, natural and artificial.

The first division includes farmyard manure, liquid manure, and the various composts that are occasionally made by farmers from excrementitious matters, earth, lime, and all sorts of refuse matters found or produced on the farm.

In the second division we find guano, bone dust, nitrate of soda, sulphate of ammonia; also the waste of slaughter-houses, night-soil, the refuse of glue-makers, wool waste, and other refuse materials of certain factories; and likewise superphosphate of lime, blood manure, and a great variety of saline mixtures, which are now extensively manufactured in manure works, for the purpose of supplying farmers with special chemical fertilisers, such as wheat-, barley-, oat-, potato-, flax-manure, &c. The term artificial manure thus includes a great variety of different materials, and is frequently applied to products which, like guano, are in point of fact much more natural than farmyard manure, in the successful preparation of which a certain amount of skill is required on the part of the farmer. The evident anomaly of considering guano, bones, blood, and nitrate of soda (Chili saltpetre) as artificial manures, has led some agricultural writers to describe them under natural manures. Again, others apply the term artificial only to compound saline manuring mixtures, such as wheat and grass manures, or to manures the preparation of which necessitates a certain acquaintance with chemical principles and the use of chemical agents. All this confusion can be avoided entirely, if manures, instead of being divided into natural and artificial, were separated into home-made manures, that is, manures produced from the natural resources of the farm, and into imported manures, that is, fertilisers which are introduced on the farm from foreign sources.

The term "artificial," more appropriately, is given to all simple or compound fertilisers in the production of which human art has been instrumental. In this signification we shall use the term artificial manure.

Not many years ago farmyard manure was universally considered the only efficient fertiliser to restore the fertility of land, impaired by a succession of crops. Recent agricultural experience, however, has shown that, in a great measure, artificial manures may be employed with advantage instead of yard manure, nay, that in several respects artificial manures are preferable to ordinary dung. Indeed the present advanced state of British agriculture is intimately connected with the success with which artificial manures have been introduced into the ordinary routine on the farm.

The variety of artificials in present use amongst English farmers is very great. Some, like well prepared samples of superphosphate, are unquestionably manures distinguished for high fertilising properties; others are less efficacious, or of a doubtful character; and not a few hardly repay the cost of carriage beyond a distance of 10 miles. The fact that in almost every market-town artificial manures are sold, which, if not altogether worthless, offer, to say the least, no profitable investment to the occupier of land, shows plainly that the principles which ought to regulate the manufacture of artificial manures are not so generally understood as it is desirable they should be. In comparison with other branches of industrial art, the manufacture of manures is comparatively simple, and involves no very expensive machinery beyond steam power for the pulverisation of the raw materials; nor does it necessitate extensive practical experience, or the possession of a large stock of chemical knowledge, on the part of the manufacturer. The limits of this article preclude the detailed description of all the artificial manures that find their way at present into the manure market; nor does it appear to us necessary to mention in detail the various proportions in which the numerous refuse materials used by manure-makers may be blended together into efficacious fertilisers, for a manufacturer who is thoroughly acquainted with the nature of artificial manures, and the legitimate uses to which they ought to be applied, will find little or no difficulty when working up into artificial manures the raw materials or refuse matters for the acquirement of which a particular locality may offer peculiar advantages. A right conception of the relative commercial and agricultural value of the different constituents that enter into the composition of manures is the chief desideratum for the manufacturer of artificial manures. We therefore propose to refer, in the following pages, briefly to the more important principles which ought to be kept steadily in view in establishments erected for the supply of artificial fertilisers.

The high esteem in which good farmyard manure is held by practical men, its uniformly beneficial effect upon almost every kind of crop, and the economical advantages with which it is usually applied to the land, have induced many to regard farmyard manure as the model which the manufacturer of artificial manure should endeavour to imitate. But this proposition is wrong in principle, as will be shown presently, and its adoption in manure works has led to disappointment and ruin. It would be foreign to our object to give in this place a full account of the peculiar merits that belong to yard manure, and to compare them with those exhibited by artificial manures. Each has its peculiar merits and disadvantages, upon which we need not dwell in this article. It will help us, however, in properly comprehending what is really required in a good artificial manure, if we inquire briefly into the composition of good yard manure. We therefore subjoin an analysis made some time ago by Dr. Voelcker of well rotted farmyard manure.

Composition of Farmyard Rotted Dung (*Horses', Cows', and Pigs'*), *in* 100 *Parts.*

Water		75·42
Soluble organic matter*		3·71
Soluble inorganic matter (ash):—		
Soluble silica	·254	
Phosphate of lime	·382	
Lime	·117	
Magnesia	·047	
Potash	·446	
Soda	·023	
Chloride of sodium	·037	
Sulphuric acid	·058	
Carbonic acid and loss	·106	
		1·47
Insoluble organic matter †		12·82
Insoluble inorganic matter (ash):—		
Soluble silica	1·424	
Insoluble silica	1·010	
Oxides of iron and alumina, with phosphates	·947	
Containing phosphoric acid	(·274)	
Equal to bone earth	(·573)	
Lime	1·667	
Magnesia	·091	
Potash	·045	
Soda	·038	
Sulphuric acid	·063	
Carbonic acid and loss	1·295	
		6·58
		100·00

Farmyard manure contains all the constituents which our cultivated crops require to come to perfection, and is suited for every description of agricultural produce. As far as the inorganic fertilising substances are concerned, we find in farmyard manure potash, soda, lime, magnesia, oxide of iron, phosphoric acid, sulphuric acid, hydrochloric and carbonic acid, in short all the minerals that are found in the ashes of agricultural crops.

Of organic fertilising substances, we find in farmyard manure some which are readily soluble in water, and containing a large portion of nitrogen; and others insoluble in water, and containing, comparatively speaking, a small proportion of nitrogen. The former readily yield ammonia, the latter principally give rise to the formation of humic acids, and similar organic compounds. These organic acids constitute the mixture of organic matters, which in practice pass under the name of humus.

Farmyard manure thus is a perfect manure, for experience and analysis alike

*	Containing nitrogen	·297
	Equal to ammonia	·36
†	Containing nitrogen	·309
	Equal to ammonia	·375
	Whole manure containing ammonia in free state	·046
	" " " form of salts	·057

show that it contains all the fertilising constituents required by plants, in states of combination which appear to be especially favourable to the luxuriant growth of our crops.

On most farms the supply of common yard manure is inadequate to meet the demands of the modern system of high farming. Hence the endeavour of enterprising men to supply this deficiency by converting various refuse materials into substitutes for farmyard manure. Artificial manures, likely to approach farmyard manure in their action, should contain all the elements in the latter, and in a state of combination, in which they are neither too soluble nor too insoluble; for it is evident that a plant can grow luxuriantly, and come to perfect maturity, only when all the elements necessary for its existence are presented to it in a state in which they can be assimilated by the plant.

But the question arises, Is it desirable to produce by art perfect substitutes for common dung? We think not, for the following reasons: —

In the first place well rotted dung contains in round numbers two thirds of its weight of water, and only one third of its weight of dry matter. A large bulk therefore contains, comparatively speaking, but a small proportion of fertilising matters. In every 3 tons of manure we have to pay carriage for 2 tons of water, and it may be safely asserted that no manure, however efficacious it may be in a dry condition, will be found an economic substitute for farmyard manure, if it cannot be produced in a much drier condition than common yard manure.

Again, several of the constituents which greatly preponderate in farmyard manure are present in most soils in abundant quantities; they need not, therefore, be supplied to the land in the form of manure; or, should they be wanting in the soil, they can be readily obtained almost everywhere at a cheap rate. If, therefore, these inexpensive and more widely distributed substances are dispensed with in compounding a manure, and those are selected which occur in soils only in minute quantities, a very valuable and efficacious fertiliser is obtained, which possesses the great advantage of containing in a small bulk all the essential fertilising substances of a large mass of home-made dung.

That the effect which every description of manure is capable of producing depends on its composition is self-evident; and as the different constituents which generally enter into the composition of manures produce different effects upon vegetation, it is of primary importance to the manufacturer of manure that he should be acquainted with the special mode of action of each fertilising constituent.

We shall therefore make some observations on the practical effects, and the comparative value, of the various constituents that enter into the composition of manures.

To guard against misapprehension, we would observe that, in one sense, all the fertilising agents are alike valuable; for they are all indispensable for the healthy condition of our cultivated crops, and consequently the absence of one is attended with serious consequences, though all others may be present in abundance. Thus the deficiency of lime in the land is attended with as much injury to the plant as that of phosphoric acid. In this sense lime is as valuable as phosphoric acid; but inasmuch as lime is generally found in most soils in abundant quantities, or, if deficient, can be applied to the land economically in the form of slaked lime, marl, shell sand, &c., its presence in an artificial manure is by no means a recommendation to it.

The principal constituents of Manures are: —

1. Nitrogen (in the shape of ammonia, nitric acid, and nitrogenised organic matters).
2. Phosphoric acid (bone-earth and soluble phosphates).
3. Potash (carbonate and silicate of potash).
4. Soda (common salt).
5. Lime and magnesia (carbonate and sulphate of lime and magnesia).
6. Soluble silica.
7. Humus, forming organic matters (vegetable remains of all kinds).
8. Sulphuric acid (sulphate of lime).
9. Chlorine (common salt).
10. Oxide of iron, alumina, silica (clay, earth, and sand).

We have here mentioned these constituents in the order which expresses their comparative commercial value.

1. *Nitrogen.* — This element may be incorporated with artificial manures in the shape of ammoniacal salts or nitrates, or nitrogenised organic matters.

The cheapest ammoniacal salt is sulphate of ammonia; the cheapest nitrate is Chili saltpetre, or nitrate of soda; hence sulphate of ammonia and nitrate of soda are exclusively employed by manure manufacturers for the preparation of nitrogenised manures, when no organic refuse matters containing nitrogen, such as horn-shavings, bone-dust, woollen rags, blood, glue refuse, &c., are available.

Nitrogen in any of these forms exercises a most powerful action in manure, especially when applied to plants at an early stage of their growth; at a later period of development the application of ammoniacal salts or nitrate of soda appears much less effective, and sometimes even useless. For this reason nitrogenised manures, such as guano, soot, specially prepared wheat manures, &c., ought to be applied either in autumn or in spring, immediately after the young blade has made its appearance above ground.

Ammoniacal salts, nitrate of soda, and decomposed nitrogenised organic matters have a most marked effect upon the leaves of plants, they induce a rapid and luxuriant development of leaves, and may therefore be called leaf-producing or forcing manures. Grass, wheat, oats, and other cereals, when grown upon soils containing abundance of available mineral elements, are strikingly benefited by a nitrogenised manure; but on account of their special action they ought to be used with caution in the case of corn-crops, and always more sparingly on light than on heavy land; otherwise, fine straw, but little and an inferior sample of grain, will be obtained.

As a general rule, ammoniacal salts or nitrate of soda should not be used by farmers in a concentrated state, and exceptionally only. However useful sulphate of ammonia or nitrate of soda may be in a particular case, it ought to be remembered that generally such manures produce beneficial effects only in conjunction with mineral matters. If, therefore, a proper amount of available mineral substances does not exist in the soil, it has to be supplied in the manure. Ammoniacal salts, nitrate of soda, animal matters, &c., are therefore almost always blended together with phosphates, common salt, gypsum, &c., by manufacturers of manures.

Whilst we thus fully recognise the importance of the presence of ammonia, ammoniacal salts, nitrates, or animal matters furnishing ammonia on decomposition in manures, especially in manures for white crops, we cannot agree with those who estimate the entire value of manuring substances by the proportion of nitrogen which they contain.

In a purely commercial sense, nitrogen in the shape of ammonia or nitric acid, or animal nitrogenised matters, is the most valuable fertilising constituent, for it fetches a higher price in the market than any other manuring constituent.

2. *Phosphoric acid.* — Next in importance follows phosphoric acid. This acid exists largely in the grain of wheat, oats, barley, in leguminous seeds, likewise in turnips, mangolds, carrots, in clover, meadow-hay, and, in short, in every kind of agricultural produce. Whether we grow, therefore, a cereal crop or a fallow crop, there must be phosphoric acid in sufficient quantity in the soil, or if insufficient it must be added to the land in the shape of manure.

The proportion of phosphoric acid in even good soils is very small, and as the agricultural produce in almost every case removes from the soil more of phosphoric acid than of any other soil-constituent, the want of available phosphoric acid makes itself known very soon. This is especially the case with quick-growing crops, such as turnips, mangolds, &c. The whole period of vegetation of these green crops extends only over four or five months, and the fibrous roots of these crops are unable to penetrate like wheat the soil to any considerable depth. For these reasons phosphoric acid in some form or the other has to be abundantly supplied to root-crops; and experience has shown that no description of fertilising matter benefits so much roots as superphosphate and similar manures, which contain phosphate of lime in a state in which it is readily assimilated by plants.

In artificial manures phosphoric acid commonly occurs in the shape of bone-dust, boiled bones, bone-shavings (refuse of knife-handle makers, turners of ivory, button-makers, &c.), or in the state of bi-phosphate of lime, purposely manufactured from bone-materials or from phosphatic minerals.

The phosphate of lime which occurs in fresh bones, practically speaking, is insoluble in water. In water charged with carbonic acid, and still more so in water containing some ammonia, it is more soluble than in pure water. On fermenting bone-dust in heaps it becomes a much more effective manure. Such fermented bone-dust is added with much benefit to general artificial manures.

All really good artificial manures should contain a fair proportion of phosphate — say from 25 to 40 per cent., according to the uses for which the manure is intended. Generally speaking, manures for turnips, and root-crops in general, should be rich in phosphates, especially soluble phosphates (bi-phosphate of lime); such manures need not contain more than 1 to 1½ per cent. of ammonia, and, when used on land in a tolerably good agricultural condition, ammonia can be altogether omitted in the manure without fear of deteriorating the efficacy of the manure.

3. *Potash.* — Salts of potash unquestionably are valuable fertilising constituents, for potash enters largely into the composition of the ashes of all crops. Root-crops especially require much potash; hence these crops are much benefited by wood ashes, burnt clay, liquid manure, and other fertilisers containing much potash.

The commercial resources of potash are limited, and salts of potash without exception far too expensive to be employed largely in the manufacture of artificial manures. Potash consequently is rarely found in artificial manures. Fortunately potash exists abundantly in most soils containing a fair proportion of clay. Its want in artificial manures therefore is not perceived, at least not in the same degree in which the deficiency of phosphates in a manure would be felt.

4. *Soda.*—Salts of soda are much less efficacious fertilising matters than salts of potash. There are few soils which do not contain naturally enough soda, in one form or the other, to satisfy the wants of the crops which are raised upon them. However, common salt is largely employed in the manufacture of artificial manures; if it does no good, it certainly does no harm, and in this country is one of the cheapest diluents which can be employed for reducing the expenses of concentrated fertilising mixtures to a price at which they can be sold to farmers. In Continental districts common salt proves more efficacious as a manure than in England, where the neighbourhood of the sea provides the majority of soils with plenty of salt, which by the winds is carried landwards with the spray of the sea to very considerable distances.

Salt, however, even in England, is usefully applied to mangolds, and enters largely into the composition of most artificial manures expressly prepared for this crop.

5. *Lime and Magnesia.*—All plants require lime and magnesia in smaller or larger quantities. Many soils contain lime in superabundance; in others it is deficient. To the latter soils it must be added. This can be done by lime-compost, by slaked lime, by marl, shell-sand, or gypsum. All these calcareous manures are cheap almost everywhere, for lime and magnesia are among the most widely distributed, and most abundant mineral substances.

The addition of chalk, marl, and even gypsum, to artificial manures, should therefore be avoided as much as possible.

At the best, carbonate and sulphate of lime in artificial manures must be regarded as diluents.

6. *Soluble Silica.*—The artificial supply of soluble silica to the land, as far as our present experience goes, has done no good whatever to cereals, the straw of which soluble silica is supposed to strengthen.

In the absence of reliable practical experiments with soluble silica, we cannot venture to recommend the use of silicate of soda, or soluble silica to manure manufacturers.

7. *Organic substances, Humus.*—The importance of organic matters free from nitrogen, as fertilising agents, is very trifling. Formerly the value of a manure was estimated by the amount of organic matter it contained, and little or no difference was made whether the organic matter contained nitrogen or not. Under good cultivation, the organic matter in the soil regularly increases from year to year; there exists therefore no necessity of supplying it in the shape of manure.

In artificial manures we should certainly exclude all substances that merely add to the bulk, without enhancing the real fertilising value of the manure. Peat, saw-dust, and similar organic matters, &c., are useful to the manure-maker only as diluents and absorbents of moisture.

8. *Sulphuric acid*, is another constituent of manure, which possesses little value. In artificial manures sulphuric acid chiefly occurs as gypsum.

9. *Chlorine.*—Exists in manures principally as salt.

10. *Oxide of iron, Alumina, Silica.*—These constituents exist sometimes in manures in the shape of burnt-clay, earth, brick-dust, and sand.

It is hardly necessary to remark that good artificial manures should contain as little as possible of these matters.

It will appear from the preceding observations, that nitrogen in the shape of ammoniacal salts, nitric acid or decomposed animal matters, and phosphoric acid are the most valuable fertilising constituents.

The manufacturers of artificial manures should therefore endeavour:

1. To produce manures containing as little water as possible.
2. To incorporate as much of nitrogenised organic matters, or ammoniacal salts, or nitrates and phosphates, in general manuring mixtures, as is possible at the price at which artificial manures are usually sold.
3. To avoid as much as possible gypsum, salt, peat-mould, chalk, and other substances that chiefly add to the bulk, without increasing the efficacy, of the manures.

He should also endeavour to produce uniform finely pulverised articles, that run readily through the manure drill.

It likewise devolves on the manufacturer of manures to render more effective, that is to say, more rapid and energetic in their action, refuse materials which may remain inactive in the soil for years before they enter into decomposition, and to reduce by chemical means into a more convenient state for assimilation, raw materials, which like coprolites, apatite, &c., produce little or no beneficial effects upon vegetation, even when added to the land in a finely powdered condition.

At the present time, two classes of artificial manures may be distinguished: 1, general manures, *i.e.* manures which profess to suit equally well every kind of agricultural produce; and 2, special manures, *i.e.* manures specially prepared for a particular crop only.

The requirements of different crops, or perhaps, more correctly speaking, the conditions that regulate the assimilation of food, vary so much, that we doubt the policy of manure-makers to prepare *general* artificial manures. At the same time, we doubt the necessity of preparing artificial manures for every description of crop. Special manures are extremely useful to farmers, if they are prepared by intelligent manufacturers, who possess sufficient chemical knowledge to take advantage of every improvement that is made in manufacturing chemistry, and at the same time know sufficient of agriculture to understand what is really wanted in a soil. In other words, except a manufacturer is a good practical chemist, and a tolerably good farmer, he will not be able properly to adapt the composition of special fertilizers to the nature of the soil, and the peculiar mode of treatment which the land has received on the part of the farmer.

However, nearly all special artificial manures, generally speaking, may be arranged under two heads. They are either: 1. Nitrogenized Manures, or, 2. Phosphatic Manures.

The first may be used with almost equal advantage for wheat, barley, oats, for rye, and on good land likewise for grass.

The second are chiefly used for root-crops.

Nitrogenized artificial manures frequently are nothing more than guano, diluted with gypsum, salt, peat-mould, earth, &c. In fact, guano is the cheapest ammoniacal manure; for which reason it is so largely employed for compounding low-priced wheat manures, grass manures, &c. &c.

Good manures for cereals may be made by blending together fine bone-dust, or bone-dust dissolved in sulphuric acid, sulphate of ammonia, salt, and gypsum. These manures will be the better the more sulphate of ammonia they contain.

Turnip-manures, and artificial manures for root-crops in general, consist principally of dissolved bones, or dissolved coprolites and other mineral phosphates. They are, in fact, superphosphates of various degrees of concentration. The more soluble phosphate a root-manure contains, the better is it adapted to the purpose for which it is used.

Most samples of superphosphate contain little or no ammonia, or nitrogenized organic matters. See PHOSPHATES.

Others sold under the name of nitro- or ammonia-phosphate, in addition to soluble and insoluble phosphate contain some ammonia and organic matters.

Blood manure is a superphosphate, in the preparation of which some blood is used.

In preparing superphosphate from bones, it is essential that they should be reduced to fine dust. This is moistened with about ⅓ its weight of water, after which another third to one half of brown sulphuric acid is added. The pasty mass is allowed to cool, in the mixing vessel, or when large quantities are prepared, the semi-liquid mass in the mixer is run out still hot, fresh quantities of bone-dust, water, and acid are put in the mixer, and after 5 or 10 minutes the contents allowed to run out, and a fresh quantity prepared as before. The successive mixings are all kept together in one heap for 1 or 2 months; the heap is then turned over, and if necessary, the partially dissolved bones are passed through a riddle.

In a similar manner, coprolites, bone-ash, apatite and other phosphatic minerals are treated with acid. It ought to be observed, however, that the quantity of brown sulphuric acid necessary for dissolving coprolites must be at least ¾ of the weight of coprolite powder, for coprolites contain much carbonate of lime, which neutralises sulphuric acid. Even 75 per cent. of brown acid are not always sufficient to dissolve completely coprolite powder, and as the proportion of carbonate of lime in coprolites and phosphatic minerals varies considerably, it cannot be stated definitely what amount of oil of vitriol should be used in every case. The safest plan, therefore, for the manufacturer is, to ascertain from time to time whether the proportion of acid which he has used has converted nearly the whole of the insoluble phosphates in coprolites into soluble phosphates, and if necessary to add more acid. In the case of bone-dust, it does not matter if the whole of the bone-earth is not rendered soluble; bones even partially acted upon by oil of vitriol, become sufficiently soluble in the soil to prove efficacious for the turnip crop. But the case is different, if mineral phosphates, such as apatite or coprolite powder are employed in the manufacture of superphosphate. Insoluble phosphates in the shape of coprolite powder are not worth anything in an artificial manure, for they are too insoluble to be taken up by the turnip-crop. It is therefore essential to employ a quantity of acid, which is amply sufficient to convert the whole of the insoluble phosphate of lime in coprolites into soluble, as biphosphate of lime. See COPROLITES.—A. V.

MAPLE or PLANE. (*Erable*, Fr.; *Ahorn*, Germ.) *Acer Campestre*, the English or field maple. The wood of this tree is compact and finely veined; it is used in France and other parts of the continent for furniture, and it makes excellent charcoal.

Acer platanoides. The Norway maple. This wood is soft, but being finely grained is capable of receiving a good polish, and looks well.

Acer pseudo-platanus. Sycamore, great maple, or false plane. The wood is of a compact grain, and does not warp or become worm-eaten.

Acer saccharinum. Sugar maple. This tree is extensively cultivated in America for the sugar which is extracted from it. The wood is frequently used for furniture, having a silky lustre when polished.

Acer striatum. Striped barked maple. This tree is grown in America, and as the wood is finely grained and white, it is much used as a substitute for holly by furniture makers.

The Russian maple is thought to be the wood of a birch tree. It differs in many respects from the American maple, but is sometimes used as a substitute for it.

The bird's eye maple is the American variety, the best being obtained from Prince Edward's Island. The mottled maple is a commoner variety.

MARBLE. This title embraces such of the primary, transition, and purer compact limestones of the 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; 1, 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 transition districts. The greater part of the close-grained coloured marbles belong also to the same geological localities; and become so rare in the more recent 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.

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 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 grey 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 marbles at Oxford consist of Parian marble, as does also the Medicean Venus. *Pentelic marble*, from Mount Penteles, 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 *Cipilino 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 Musuem. *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 Luni*, on the coast of Tuscany, was preferred by the Greek sculptors to both the Parian and Pentelic. *White marble of Carrara*, between Specia and Lucca, is of a fine white colour, but often traversed by grey 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 grey. 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 strewed over with grains of saud. 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 kiud 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 grey 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 greyish-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 particularise.

Modern Marbles. — 1. British. Black marble is found at Ashford, Matlock, and Bonsaldale in Derbyshire; and in the south part of Devonshire. The variegated marbles of Devonshire are generally reddish, brownish, and greyish, 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-grey 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 grey in the neighbourhood of Moneyash, the light grey 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 fine variety of white marble is found in beds at Assynt in Sutherlandshire. A beautiful ash-grey 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 Belephetrich 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 sahlite, 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 petrifactions. 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 Louthlougher, 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 extract is given under the article Marble, *Rees's Cyclopædia*.

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 grey 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 grey, quarried at Maguregą for altars and tombs. Near Mergozza a white marble with grey 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 *polveroso* of Pistoya 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 *brocatello 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 Luggezzana, 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 grey 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-grey, and rose-coloured spots. That of Bergamo consists of black and grey 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, with which the marble must be worked 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 (see Putty Powder). 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.

MARCASITE, or white iron pyrites, is of a pale bronze-yellow, or iron-grey colour, with a metallic lustre. It is a bisulphide of iron, composed of iron 46·7, sulphur 63·3. Specific gravity 4·678 to 4·847.

This mineral was formerly much used for various ornaments, as shoe and knee-buckles, pins, bracelets, setting of watch-cases, &c., and although the taste for it has considerably declined now, probably owing in some degree to its abundance, immense quantities are still cut and manufactured at Geneva and in the French Jura.

The marcasite of commerce is generally small, rarely attaining the size of a stone of two carats. It takes a good polish, and is cut in facets like rose diamonds. In this state it possesses all the bright blue of polished steel, without the tendency of the latter to become oxidized by exposure to the action of the atmosphere. It is principally procured from Germany and the Jura.—H. W. B.

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. Formerly so called because it could be obtained from sea-water. See HYDROCHLORIC ACID and MURIATIC ACID.

MARINE SALT. See SALT.

MARL (*Marne*, 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.

MARL STONE. One of the members of the Lias formation. See LIAS.

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 *marqueteur* puts gold, silver, copper, tortoise-shell, mother-of-pearl, ivory, horn, &c. under contribution. These substances being reduced to laminæ of proper thinness, are cut out into the desired form 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. See PARQUETERY. For the methods of dyeing the woods, &c., see WOOD.

MARTIAL signifies belonging to iron; from Mars, the mythological name of this metal. It is rarely employed.

MASSICOT is the yellow oxide of lead. The old name of litharge. See LITHARGE.

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. See LUCIFER MATCHES.

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.

MEASURES, WEIGHTS, and COINS—METRICAL. The phrase "metrical measures" may appear 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 teu-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 $3\frac{1}{3}$ inches, or more accurately by $3\frac{10}{27}$ 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 International Association for the introduction of a uniform decimal system of weights, measures and coins, have published a lecture delivered at Belfast, by the Reverend John Scott Porter, "On the Metrical System of Weights and Measures," which so fully explains the advantages of the system that we feel it is not possible to explain the whole question more satisfactorily thau by trausferring a large portion of that paper to our pages.

"I begin with a retrospective glance at the early history of weights and measures. Their introduction is coeval with the dawn of civilisation. Society may exist without them, but not civilised society. The Laplanders, the Bushmen, the Esquimaux, the Red Indians, have neither weights nor measures; but the business of a city could not go on for a week without them. Hence we find mention of them at a very early period in the world's history. The dimensions of the ark were given to Noah in cubits (Gen. vi. 15): and Abraham weighed to Ephron the Hittite the silver which was the price of the field and cave of Machpelah, iu shekels (Gen. xxiii. 16). The *ammah*, like the Latin word *cubitus* (a cubit), by which it is translated, signifies the fore-arm, from the elbow downwards to the point of the fingers, 'the cubit of a man,' as it is called in Deut. iii. 11. The shekel, like our own English *pound* (from *pondus*) denotes etymologically 'a weight;' but among the Hebrews, the 'shekel of the sanctuary' was defined to be of the weight of twenty *gerahs*, that is of twenty *beans*, for so the word *gerah* literally signifies.* Let us not despise these rude attempts to fix a common and natural standard of measures and weights. Our own system was originally founded on the very same principle. Silver among ourselves is sold by the ounce, consisting of 480 grains; and the *grain* was at first what its name implies, a pickle of dried corn taken from the middle of the ear. More bulky commodities are often sold by the *stone*: a term which explains itself, and bespeaks the rudeness or primeval times. In measures of length, we have the *barley-corn*, now never used, except by boot and shoemakers, who call it a size, and in works of arithmetic, in which it is preserved for the sole purpose, as it would seem, of presenting an additional puzzle to the hapless children who are condemned to drudge at our dreary and unaccountable system of counting; we have the *hand* and the *foot*, taken of course from the corresponding parts of the human form; we have the yard, anciently termed the *ell* (*ulna*), that is to say, the arm. The word ell is no longer used to signify the arm in our common speech; but it is retained in the compound *el-bow*, which means the bow or bend of the arm. And the depths of the ocean are sounded in *fathoms*, that is to say, the expanse of the outstretched arms. These are very rough standards of comparison; they fluctuate in size and bulk; in fact, they are seldom exactly equivalent in any two individuals. Their employment for the purposes of trade would open a door to continual frauds, and give rise to perpetual bickerings, which it is the very object of a system of weights and measures to prevent. Accordingly, means were early taken to reduce them to some definitely ascertained magnitude, which should be general, at least for each neighbourhood. At first, the plans employed for this purpose were almost as rude as the errors which they were designed to correct. In France, for example, every province under the old monarchy had its own system of weights, and its own system of measures, both for lengths, surfaces, and capacities, quite independent of all the rest. Sometimes these standards, thus differing from each other, went by different names in the different provinces, which occasioned considerable inconvenience to traders. Sometimes the standards used in different provinces, and differing from each other in magnitude, passed by the same name, which led to still greater perplexity. In two, at least of the largest and most populous provinces of France, it was the custom, which had the force of law, that the standard of length in each seigneurie, or manor, should be the arm of the seigneur for the time being. In these districts, the death of a short seigneur, if succeeded by a son of six feet in height and with an arm proportioned to his height, would ruin half the traders who happened to have outstanding contracts, and make the fortunes of the remainder. All this has now been rectified; and there is no country in the world that at present enjoys the benefit of a system of weights and measures more philosophical in its conception, more elegant in the relation of its different members, and more convenient in its application to all the purposes of civilised man, than that now employed in the French empire and the adjoining parts of the Continent of Europe.

"In England, the necessity of a fixed and uniform standard was felt and acknowledged at a very early period. In the Anglo-Saxon times, so early as the reign of King Edgar, about 100 years before the Norman Conquest, a law was made requiring that a set of weights and measures should be kept at Winchester, then the capital of the kingdom, by which those employed in other places should be regulated. The troublesome and distracted state of the nation in after times probably occasioned this law to be neglected. At all events, great irregularities existed, and were complained of in the time of King Henry I., the son of the Conqueror, at least, as regarded the unit of length; and, to obviate them, he made a law that the length of his own arm should be the standard yard for his dominions. This provision also failed to produce the needful uniformity. In Magna Charta, which was signed in the reign of Henry's great-grandson, King John, it was stipulated, by the 41st section, that there should be only one weight and one measure throughout the whole realm. In later times, it was enacted by Parliament that a standard yard, a standard pound, and a standard gallon, all made of brass, under the direction of commissioners appointed for the purpose, should be kept in the custody of the Speaker of the House of Commons; that compared copies of them should be lodged in several important towns; and that all local weights and measures should be conformed to them. The originals were

* The Hebrew system of weights was binary and decimal, agreeably to the principles of the Metrical System, though not carried to the same extent.
10 gerahs = 1 bekah, or drachma; 2 bekahs = 1 shekel, or didrachma; 50 shekels = 1 maneh of the sanctuary; 100 shekels = 1 common maneh or pound. See Gen. xxiv. 22; Exodus xxx. 13, xxxviii. 26; Lev. xxvii. 25; Numb. iii. 47, xviii. 16; 1 Kings x. 17, compared with 2 Chron. ix. 16; Ezek. xlv. 12. Buxtorf and Böckh.

lost by the fire which consumed the House of Commons in the autumn of 1834; but certified copies, which were made with equal care and accuracy still exist.

"It is to be remarked that three important portions of our method are quite independent of each other. I allude to the measures of weight, length, and capacity. The pound has nothing to do with the yard, nor the yard with the gallon. There are thus three distinct and separate standards; whereas, if a more rational method had been followed, one would have been sufficient, from which all the rest could easily have been derived.

"All these standards are purely artificial and arbitrary; there is nothing in nature that corresponds to any one of them, or from which they can, in any simple or elegant manner, be derived.

"The divisions of our scale, or rather of our manifold scales, are arbitrary, capricious, perplexing, and, in most cases, inconvenient to a degree that foreigners, accustomed to a simple aud elegant system, find it difficult to comprehend. This is the circumstance which makes the study of commercial arithmetic so difficult and disgusting.

"Let me illustrate this by a specimen of the subdivision of some of the larger units of the scale, showing the multipliers which are to be used in bringing them to a lower denomination. Of course, in bringing lower to higher denominations, the multipliers become divisors in inverted order. In subdividing money, that is to say, the denominations in which accounts are kept, for the coins are far more numerous, and their subdivisions go upon a different principle altogether, the multipliers are successively 20, 12, and 4. In subdividing a mile in Ireland, the multipliers are 8, 40, 7, 3, 12, and 3; in England they are 8, 40, 5½, 3, 12, and 3. In subdividing a ton, the multipliers are 20, 4, 28, and 16; for a ton of stones, they are 21, 4, and 28; for another sort of ton the multipliers are 20, 4, 30, and 16. In subdividing a yard a carpenter uses as multipliers 3, 12, and 8, but a draper 4 and 4. A grocer subdivides his pound, using as multipliers 16 and 16; a goldsmith his by 12, 20, and 24; and an apothecary his by 12, 8, 3, and 20. Moreover, these pounds are of different weights: the goldsmith's pound and the apothecary's consist of 5,760 grains; the grocer's, of 7000. In the measure of surfaces, the statute acre is successively reduced to its lower denominations by the multipliers 4, 40, and 30¼; the perch by 30¼, 9, and 144. To take one out of many of the ways of calculating capacity, we may select the authorised division of the quarter of corn. It is to be reduced into its lower component parts by multiplying by 8, 4, 2, 4, 2, and 4. And, as to the divisions of the bushel and the gallon, they are so various and so perplexing that I could not venture to set them forth without exposing myself to the chance, or rather to the certainty, of falling into some mistake, which, though it would confirm my argument, for my argument is that our present system leads unavoidably into mistakes, might make myself ridiculous.

"While the pound, the yard, and the gallon are required by law to be of a fixed and regulated magnitude, so many local customs prevail, as to their multiples and submultiples, that it is very difficult, from a "price current list," to ascertain the comparative value of the same commodities at various places in our own nation. Suppose, for example, I have got a quantity of wheat on hand, which I am anxious to dispose of to the best advantage, and I look over the "prices current" in all the newspapers I can find in the commercial news-room. In one place, it is quoted at so much per *cwt.*; in another, at per *barrel*; in another, at per *quarter*; in another, at per *bushel*; in another, at per *load*; in another, at per *bag*; in another, at per *weight*; in another, at per *boll*; in another, at per *coomb*; in another, at per *hobbet*; in another, at per *winch*; in another, at per *windle*; in another, at per *strike*; in another, at per *measure*; in another, at per *stone*. Thus, there are fifteen different denominations to be compared with each other, before the most desirable market for the sale or the purchase of wheat can be discovered. At Hertford, it is sold by the load, which is equal to 5 bushels; at Hitchin, by the load of *about* 5 bushels; at Bedford, by the load of 3 bushels; at Dorking, by the load of 5 quarters; at Bishop's Stortford, by the load of 40 bushels, five nominal values for the one denomination, the load, expressed as so many quarters, or so many bushels. What, then, is the amount of a quarter? Why, in general, it is equal to 8 bushels by measure; but, in London, it is generally a *weight* of 480 lbs.; and I have just been informed by a gentleman present, who being engaged in the grain trade is practically acquainted with the fact, that in London grain is still sold, occasionally, by the measured quarter of 8 bushels: the quarter has thus two different values in one and the same city, and that the capital of the commerce of the world. In like manner, the bushel is, in many places, not a measure, but a weight; and, in different places, it signifies different weights. The following is its value in various towns and places in England: — 168 lbs.; 73½ lbs.; 62 lbs.; 80 lbs.; 75 lbs.; 72 lbs.;

60 lbs.; 70 lbs.; 65 lbs.; 63 lbs.; 64 lbs.; 5 quarters; 144 quarts; and 488 lbs.; — while, in the highly enlightened and commercial town of Manchester, a bushel of English wheat is 60 lbs., but a bushel of American wheat is 70 lbs. On the other hand, in five important markets in the United Kingdom, corn is sold by the bushel, containing or made up to a certain specified weight. In these places the grain must be measured first and weighed afterwards, and the deficiency, if any, made good. Here we have the bushel fluctuating from 5 quarters to the eighth part of a quarter, the quarter itself being an unsettled quantity; and, where its value is given in pounds weight, it varies from 60 lbs. to 488 lbs. So, a bag is, at Bridgenorth, 11 scores, whatever may be meant by a score (I suppose it means 20 lbs.). In an adjoining town, the bag is 11 scores and 4 lbs. In another place, it is 12 scores; in another, 12 scores 10 lbs.; in another, 2 bushels; but which of the many bushels is intended, the return saith not. In like manner, a weight is 14 stones, 36 stones, 40 stones. It is useless to follow this line of illustration further. I may, however, remark, that similar variations exist in the system of linear measure, of land measure, of the weights and measures of oats, of barley, of butter, of potatoes, of coals, of wool and flax; and, in fact, of almost every article that is in common use among us. Even in the same town, the same name does not express the same quantity. In Belfast, a stone of oats is 14 lbs.; a stone of flax is $16\frac{3}{4}$ lbs. A stone elsewhere means 8 lbs., 14 lbs., 18 lbs., 16 lbs., or 24 lbs., according to circumstances. Flax is sold in Downpatrick by the stone of 24 lbs. Can any man tell me, without hesitation or circumlocution, what is meant by an acre? I fancy there are few who know the answer to that simple question. It means *seven different quantities of land*, varying from the statute acre of 4840 square yards, to the Cheshire acre of 10,240, which is nearly half as large again as our Irish plantation acre of 7840 square yards.

"Now, a moment's consideration will satisfy us that the first thing to be determined is the unity of length; for from it the measures of surface, of capacity, and of weight, can easily be deduced; and, according to the first of the conditions above stated, we must look for a unit that has its basis in nature, and is not peculiar to one locality, or to one tribe of mankind. Various standards of this kind have been suggested. In the year 1679, Locke recommended and employed the third part of a pendulum vibrating seconds as the unit of linear measure. But pendulums require to be made of different lengths, to vibrate seconds at different points on the earth's surface; and it is a matter of great difficulty to determine the exact length of the second's pendulum, either at the equator or at any particular latitude. Although this proposal has been before the world for nearly 200 years, no one pendulum has ever yet been mentioned as beating time with such accuracy that it would be right to adopt it as a standard of length. A similar objection applies to another suggestion, which is, that we should employ, as the origin of our linear system, the space through which a heavy body falls *in vacuo* in a second of time. It is evident that this suggestion involves all the difficulties connected with the pendulum, and some others besides. First, we should require to have a pendulum swinging seconds with great exactness to mark the time: and if we had such a pendulum, it is very difficult to procure a perfect vacuum of the size needful for the experiment. It is not easy to determine the space described by the falling body by observation merely. Sir John Herschel says it is impossible (*Treatise on Astronomy*, p. 126). The space through which a falling body would descend *in vacuo* in a second of time, is known approximately by calculations founded on the length of the pendulum itself; and here, still more than in the case of the pendulum, the varying force of gravity at different latitudes would give units of varying length at each point. The only proposal that remains for discussion, which it is needful to consider, is that for taking as the unit of linear measure some definite portion of the dimensions of the earth itself. It is confessedly difficult to make any exact measurement of the earth, or of any required portion of its surface; but the thing can be done with a very close approach to correctness, and when this has been accomplished with as great accuracy as can be attained, the subdivision of any one of the great magnitudes thus reached, will give a unit of length as accurate as can reasonably be desired. I am sure I speak in the presence of many who are well aware that there is no such thing as an exact measurement of any one object in the universe. All that we can do is to reduce the amount of error within the narrowest possible limits; and this is most easily effected by the subdivision of the dimensions of a very large body, which has itself been measured with the utmost possible exactness. Now, the earth itself is the largest body that we can touch: the magnitudes and distances of the heavenly bodies, though in many cases much greater than that of the earth, are determined, primarily, from the dimensions of our planet. Accordingly, it has been proposed to deduce our standard of length either from the dimensions of the earth's polar diameter, or from the extent of its surface, measured or computed from the North Pole to the Equator. The latter is, assuredly, preferable, because from it the diameter of the earth is calculated; and, in such cases, it is better to employ the original than the derivative magnitude. The French Government deserves the credit of having first put this suggestion into practice. An arc of the meridian, embracing upwards of nine degrees of latitude, and extending from Dunkirk, in France, to the sea-shore near Barcelona, in Spain, was measured, in 1792-4, with the utmost care, by Messieurs Méchain and Delambre; and from this was deduced the length of an arc extending from the North Pole to the Equator. The one 10,000,000th part of this arc was denominated the mètre; a bar of platinum was constructed, representing this length as accurately as possible; and this bar, or others directly or indirectly copied from it, is the standard unit of length throughout France, and in many other countries which have herein followed her example. It is equal to 39·371 English inches, and is about $\frac{1}{4}$th of an inch longer than a pendulum vibrating seconds at the level of the sea in London. The mètre is divided decimally downwards, into décimètres, centimètres, and millimètres

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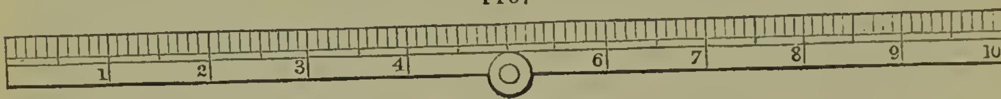

(*Fig.* 1167); and multiplied decimally upwards into décamètres, hectomètres, kilomètres, and myriamètres; the latter being, as is implied by its name, equal to 10,000 mètres of the scale.

"A décimètre, as its name implies, is the tenth part of a mètre. In like manner a centimètre is the hundredth part, and a millimètre is the thousandth part of a mètre. Those who find it difficult to pronounce these names, and prefer words of one syllable, may use the terms *hand*, *size*, and *streep*. The only objection is, that the longer names are perfectly precise and unambiguous, whereas the shorter terms, if used at all, are employed with a considerable degree of freedom and latitude in their signification. Thus, when a horse-dealer asserts that a horse is so many *hands* high, he does not profess to give its height with perfect exactness. The fact is, that the horse's height is so many *décimètres, more or less.* In like manner, the divisions of a shoemaker's size stick, each of which he calls a *size*, correspond pretty nearly with céntimètres, so much so that in actual practice his sizes often are centimètres, although he does not profess to use them as exact céntimètres. The term *streep* is used for millimètre in Holland. It is to be observed, however, that the term *mètre*, besides the perfect exactness of its signification as a linear measure, is a common English word known to every child.

"A square formed upon a line of ten mètres is the unit of superficial or land measure; and a cube which has a décimètre (or one-tenth of a mètre) for its measuring line, is called a *litre* — the unit of capacity. Each of these is increased or diminished by multiples or submultiples of ten; but for the convenience of those who prefer halves and quarters to tenths, each may be, and often is, divided in this manner, though all arithmetical calculations are performed decimally. The fundamental unit of weight is the kilogramme, which is the weight of a litre of distilled water, at its greatest density, which is a little above the freezing point. The thousandth part of a kilogramme is called a gramme; this is extremely useful in chemical investigations, and in weighing minute objects of every kind. In the shops, the kilogramme is most frequently employed; and on the quays, the ton, which is 1000 kilogrammes. These three principal weights have a clear and simple relation, not only to each other, but to the mètre, the unit of length. The mètre, as I have already shown, contains 10 décimètres, the décimètre 10 centimètres, the centimètre 10 millimètres; and, as multiplication by 10 in linear measures produces multiplication by 1000 in the corresponding solids, the cubic mètre contains 1000 cubic décimètres, the cubic décimètre, also called the *litre*, contains 1000 cubic centimètres, and the cubic centimètre 1000 cubic millimètres; whence the mètre, cubed and filled with water, gives the ton, the décimètre the kilogramme, the centimètre the gramme, and the millimètre the milligramme. The kilogramme is also called by abbreviation *the kilo*, and is something more than 2lb. avoirdupois. The half-kilo is also in constant use, and is in some countries very properly called a *pound*, because the term *pound*, which is of Latin derivation, has often been used for any weight approaching the half-kilo, such as the English pounds Troy and Avoirdupois, which have kept their name, however they might vary from time to time in their real weight. No less than 150 different pounds were used in different parts of Europe before they were supplanted by the half-kilogramme. The kilogramme has never varied. I must add, that while I approve most highly of the metrical system of weights and measures, I agree with the opinion expressed by Professor Hennessey in his excellent pamphlet on this subject,— one of the best that I have seen,—that the nomenclature is an unfortunate adjunct; and when the system is introduced into this country, as I hope it will be, I trust care will be taken to employ terms less removed from the language of daily life.

"The advantage which a well-contrived system of weights, measures, and coins, common to all nations, would produce to merchants, manufacturers, agriculturists, and travellers, is too obvious to require to be pointed out."

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.

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. We cannot do better than show the great importance of this subject to a maritime nation like Great Britain, by stating, that these provisions, when sound, are an absolute preventive of sea-scurvy.

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.

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. 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 (*Ure*). 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. Now the method of Appert, as improved by Gamble, is to render the albumen of the meat or the 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 is 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.

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.

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 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 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.—*Ure.*

MEDALS. For their composition, see BRONZE and COPPER.

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 gouged 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, when deficient in relief, it is sunk deeper. It will of course be borne in mind that, what will be relievo in the medal, is intaglio in the die. The inscription is introduced by means of small letter-punches. Then follows the hardening of the die, 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, observe, 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. See MINT, MINTING.

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, 0·8 to 1·0, when moist, nearly 2·0; affords water by calcination; fuses with difficulty before the blowpipe into a white enamel; and is acted upon by acids. It consists, when pure, of silica, 60·9; magnesia, 26·1; water, 12·0. An analysis by Berthier gives, silica, 50, magnesia, 25, water 25. It occurs in veins or kidney-shaped nodules, among rocks of serpentine, chiefly at Kiltschik in Asia Minor; also in the island of Negropont, Eskihi-shir in Anatolia, Brussa at the foot of Mount Olympus, at Baldissero in Piedmont, &c.

When first dug up, it is soft, and lathers like soap; on which account, and from its absorbing grease, it is used by the Tartars in washing their linen. The well-known Turkey tobacco-pipes are carved from it. 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.

MELAMINE. $C^6H^6N^6$. An alkali produced from melam under the influence of boiling potash. It is isomeric with cyanamide, from which it may be produced by the action of heat.—G. G. W.

MELLITE. (Eng. and Fr.; *Honigstein*, Germ.) See HONEYSTONE.

MELLITIC ACID, which is associated with alumina in the preceding mineral, crystallises 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 carbonised at a red heat, without the production of any inflammable oil.

MELLONE (Syn. MELLANE) is a new compound of carbon and azote, discovered by M. Liebig, by heating bi-sulpho-cyanide of mercury. The mellone remains at the bottom of the retort under the form of a yellow powder. For Mellitic acid, &c., see Ure's *Dictionary of Chemistry*.

MELTING POTS. CRUCIBLES. The best crucibles are formed from a pure fire clay, mixed with finely ground *cement* of old crucibles and a portion of black lead or graphite. Some pounded coke may be mixed with the plumbago. The clay should be prepared in a similar way as for making pottery ware; the vessels after being formed must be slowly dried, and then properly baked in the kiln. Crucibles formed of a mixture of 8 parts in bulk of Stourbridge clay and cement, 5 of coke, and 4 of graphite, have been found to stand 20 meltings of 76 pounds of iron each, in the Royal Berlin Foundry. Such crucibles resisted the greatest possible heat that could be produced, in which even wrought iron was melted, equal to 150° or 155° Wedgewood; and bore sudden cooling without cracking. Another composition for brass-founding crucibles is the following:—$\frac{1}{2}$ Stourbridge clay; $\frac{1}{4}$ burned clay cement; $\frac{1}{8}$ coke powder; $\frac{1}{8}$ pipe clay. The pasty mass must be compressed in moulds. The Hessian crucibles from Great Almerode and Epterode are made from a fire-clay which contains a little iron, but no lime; it is incorporated with silicious sand. The dough is compressed in a mould, dried and strongly kilned. They stand saline and leaden fluxes in docimastic operations very well; are rather porous on account of the coarseness of the sand, but are thereby less apt to crack from sudden heating or cooling. They melt under the fusing point of bar iron. Beaufay in Paris has lately succeeded in making a tolerable imitation of the Hessian crucibles with a fire-clay found near Namur in the Ardennes.

Berthier has published the following elaborate analyses of several kinds of crucibles:—

	Hessian.	Beaufay.	English for Cast Steel.	St. Etienne for Cast Steel.	Glass Pots at Nemours	Bohemian Glass Pots.	Glass Pots of Creusot.
Silica - -	70·9	64·6	63·7	65·2	67·4	68·0	68·0
Alumina -	24·8	33·4	20·7	25·0	32·0	29·0	28·0
Oxide of iron - -	3·8	1·0	4·0	7·2	0·8	2·2	2·0
Magnesia -	trace	- -	- -	trace	trace	0·5	trace
Water - -	- -	- -	10·3*	- -	- -	- -	1·0

Wurzur states the composition of the sand and clay in the Hessian crucibles as follows:—

Clay; silica 10·1; alumina 65·4; oxides of iron and maganese 1·2; lime 0·3; water 23

Sand; „ 95·6; „ 2·1; „ „ 1·5; „ 0·8

The composition of some of the best varieties of fire-clay, as deduced from the analyses of Berthier and Salvetat, is given in the following table:—

Dried at 212°	Great Almerode Hessian Crucible Clay.		Beaufay's Department of Ardennes.	Brierley Hill, near Stourbridge.		Schierdorf, near Passau.
	Berthier.	Salvetat.	Berthier.	Berthier.	Salvetat.	Salvetat.
Hygrometric water - - -	- -	0·43	- -	- -	- -	0·50
Combined water -	15·2	14·00	19·0	10·3	17·34	16·50
Silica - - -	46·5	47·50	52·0	63·7	45·25	45·79
Alumina - -	34·9	34·37	27·0	20·7	28·77	28·10
Oxide of iron -	3·0	1·24	2·0	4·0	7·72	6·55
Lime - - -	- -	0·50	- -	- -	0·47	2·00
Magnesia - -	- -	1·00	- -	- -	- -	- -
Alkalies - -	- -	trace	- -	- -	- -	- -

Quoted from Knapp's Technology.

Mr. C. Cowper has analysed the clays used at Birmingham for glass pots. His results were as follows:—

	In the dry state.		In the ordinary state.	
	Best Stourbridge Pot Clay.	Clay from Monmouth.	Best Stourbridge Pot Clay.	Clay from Monmouth.
Silica - - -	70·6	80·1	63·3	75·3
Alumina - - -	25·9	17·9	23·3	16·8
Oxide of iron - -	2·0	1·0	1·8	1·0
Carbonate of lime -	1·5	1·0	1·3	0·9
Do. magnesia	trace	- -	trace	- -
Water - - -	- -	- -	10·3	6·0
Total - -	100·0	100·0	100·0	100·0

* This crucible had been analysed before being baked in the kiln.

Black-lead crucibles are made of two parts of graphite and one of fire-clay; mixed with water into a paste, pressed in moulds, and well dried; but not baked hard in the kiln. They bear a higher heat than the Hessian crucibles, as well as sudden changes of temperature; have a smooth surface, and are therefore preferred by the melters of gold and silver. This compound forms excellent small or portable furnaces.

The crucibles from Passau or Ipser are made from one part plastic clay from Schildorf, and from two to three parts of an impure graphite, which according to Berthier's analysis consists of—

Carbon	34
Silica	41
Alumina	15
Oxide of iron	8
Magnesia, water	2
	100

Mr. Anstey describes his patent process for making crucibles as follows. Take two parts of fine ground raw Stourbridge clay, and one part of the hardest gas coke, previously pulverised, and sifted through a sieve of one-eighth of an inch mesh (if the coke is ground too fine, the pots are very apt to crack). Mix the ingredients together with the proper quantity of water, and tread the mass well. The pot is moulded by hand upon a wooden block, supported on a spindle which turns in a hole in the bench; there is a gauge to regulate the thickness of the melting pot, and a cap of linen or cotton placed wet upon the core before the clay is applied, to prevent the clay from sticking partially to the core, in the taking off; the cap adheres to the pot only while wet, and may be removed without trouble or hazard when dry. He employs a wooden bat to assist in moulding the pot; when moulded, it is carefully dried at a gentle heat. A pot dried as above, when wanted for use, is first warmed by the fire-side, and is then laid in the furnace with the mouth downwards (the red cokes being previously damped with cold ones in order to lessen the heat); more coke is then thrown in till the pot is covered, and it is now brought gradually to a red heat. The pot is next turned and fixed in a proper position in the furnace, without being allowed to cool, and is then charged with cold iron, so that the metal, when melted, shall have its surface a little below the mouth of the pot. The iron is melted in about an hour and a half, and no flux or addition of any kind is made use of. A pot will last for fourteen or even eighteen successive meltings, provided it is not allowed to cool in the intervals; but if it cool, it will probably crack. These pots it is said can bear a greater heat than others without softening, and will, consequently, deliver the metal in a more fluid state than the best Birmingham pots will.

Berthier has examined the crucibles of different districts, his results are as follows:

	Silica.	Alumina.	Oxide of Iron.	Magnesia.
Crucibles from Gros Almerode - -	70·9	24·8	3·8	
„ Paris - - -	64·6	34·4	1·0	
„ Savcignies (Beaufay's) -	72·3	19·5	3·9	
„ English (for steel) -	71·0	23·0	4·0	
„ St. Etienne (for steel) -	65·2	25·0	7·2	
Glass Pots from Nemours - -	67·4	32·0	0·8	
„ Bohemia - -	68·0	29·0	2·2	0·5

The Cornish crucible has been long known, and valued for all assaying purposes. They are prepared in large quantities for the ordinary assays made in the county and are exported in considerable numbers. The base of these crucibles is the Poole and Stourbridge clay, which is mixed with a certain proportion of sand obtained from St. Agnes, and ground pots.

Dr. Percy has favoured us with his analysis of the Cornish crucible:—

Silica . - - - - -	72·29
Alumina - - - - -	25·32
Peroxide of iron - - - -	1·07
Lime - - - - - -	0·38
Magnesia - - - - -	trace
Potash - - - - - -	1·14

MENACHANITE. 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 662° F. it boils and distils off in an elastic vapour of spec. grav. 6·976, 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. (See AMALGAM.) 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. *Argental 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 crystallised in a variety of forms. It has been found in the territory of Deux-Ponts, at Rozenau 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. In the rich silver mines of Arqueros, near Coquimbo, this mineral occurs, having the composition, silver 86·49, mercury 13·51. This is the *arquerite* of *Domeyko*. 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. *Sulphide of mercury*, commonly called Cinnabar, is a red mineral of various shades; burning at the blowpipe with a blue flame, volatilising 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. Its chief localities are Idria, in Carniola, and Almaden, in Spain. It is found also in fine crystals in the coal formation at Wolfstein, in Rhenish Bavaria; in Saxony, in the Harz; in Carinthia, Styria, Bohemia, Hungary, and Tuscany; in the Ural and Altai; in China and Japan; and in great abundance in California, Mexico, and Peru.

A *bituminous sulphide 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 analysed by Dr. Ure for the German Mines Company. At Idria and Almaden the sulphides are extremely rich in mercury.

4. *Chloride of mercury*, or the *Muriated mercury*, commonly called Horn mercury. This mineral, which is very rare, occurs in very small crystals of a pearl-grey or greenish-grey 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 *zechstein*, in Germany, or among the accompanying bituminous schists, as at Idria in Carniola; and, lastly, they form masses in the zechstein itself. The German "Zechstein" or "Mine Stone," is the equivalent of the Permian limestone of England. (See PERMIAN.) 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 lignite, 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 aud in the native form. They are more or less penetrated with the ore, forming sometimes numerous beds of very great thickness. Mercury is, generally speaking, a metal sparingly distributed in nature, and its mines are few.

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 metrical 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: 1st, that the Greeks imported red cinnabar from Almaden 700 years before the Christian era; and 2nd, 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 ouly 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 *Ingénieur des Mines*, who published, in a 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. "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 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 *Almadenejo*, after having been the property of the religious knights of *Calatrava*, who had assisted in expelling the Moors, were farmed off to the celebrated *Fugger* merchants of Augsbourg; 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 cinnabar ore annually produced in Idria, yields, when very rich, 50 per cent. of this metal. This ore is a sulphide 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 2341 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.

The metallurgic treatment of the quicksilver ores is tolerably simple. In general, when the sulphuret of mercury, the most common ore, has been pulverised, 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 recognised. 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. We 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 shown in *fig.* 1168, which presents a vertical section in the line *a b* of the ground plan, *fig.* 1169. In the ground plan, the roof *e e*, of the furnace (*fig.* 1168) is supposed to be lifted off, in order to show the disposition of the four ranges of cucurbits upon the grate *c f*, *figs.* 1169, 1170, which receives the pit-coal employed as fuel. Under this grate extends an ash-pit. *d*, *fig.* 1170, 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.* 1168) 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.* 1169, 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 sulphide 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.

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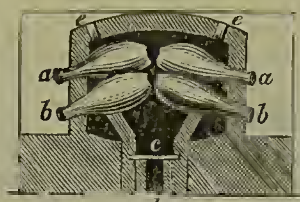

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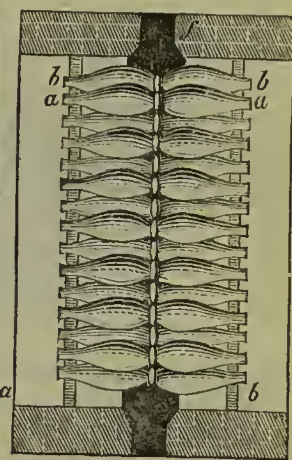

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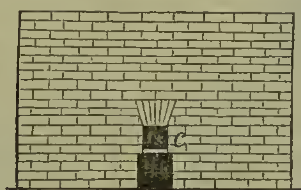
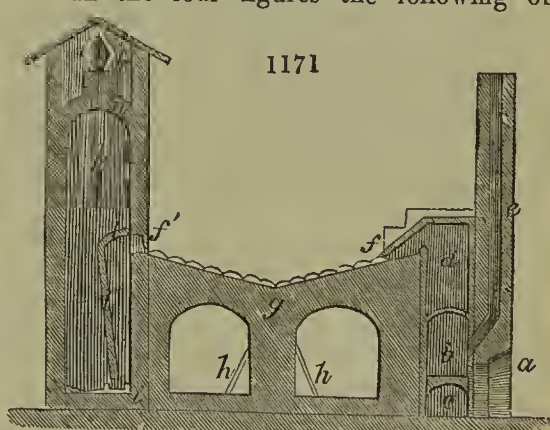


d

2. *Aludel furnaces of Almaden.*—*Figs.* 1171 and 1172 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.* 1171 and 1174 present two vertical sections; *figs.* 1172 and 1173 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 sulphide of mercury. Six ranges of aludels or stoneware tubes *f f*, 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 gutters *t*, *v*, a little inclined towards the intermediate wall *m*. In each range the aludel placed at the line *t m v*, *fig.* 1172, that is to say at the lowest point, *g*, *figs.* 1171, 1174, is pierced with a hole. Thereby the mercury which had been volatilised in *d*, if it be already condensed by the cooling in the series of aludels *f g*, may pass into the corresponding gutter, next into the hole *m*, *fig.* 1172, and after that into the wooden pipes *h h'*, *fig.* 1171, which conduct it across the masonry of the terrace into cisterns filled with water; see *q*, *fig.* 1173, which is the plan of *fig.* 1174.

1171



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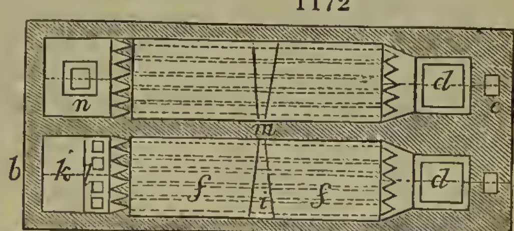

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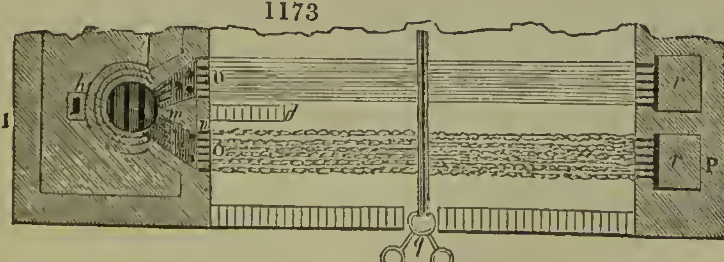
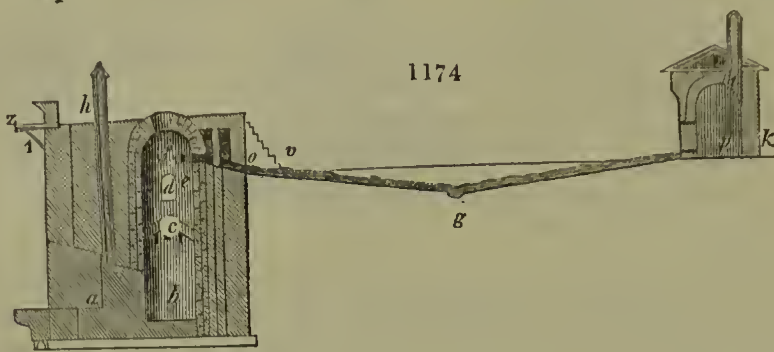


The portion of mercury not condensed in the range of aludels, *f g*, which is the most considerable, goes in the state of vapour, into a chamber *h*; but in passing under a partition *l l*, a certain portion is deposited in a cistern *i*, filled with water. The greater part of the vapours diffused in the chamber *h'* is thereby condensed, and the mercury

1174



falls down upon the two inclined planes which form its bottom. What may still exist as vapour passes into an upper chamber *h'* 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.

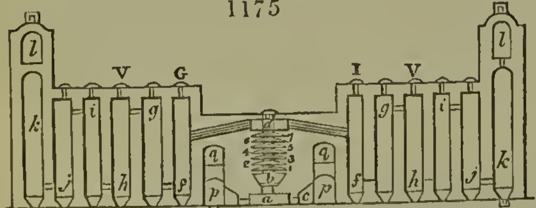
Details of the aludel apparatus.—25 are set in each of the 12 ranges, seen in *figs.* 1173, 1174, constituting 300 pear-shaped stoneware vessels, open at both ends, being merely thrust into one another, and luted with loam. *a*, is the door of the fire-place; *c*, the perforated arches upon which the ore is piled in the chamber *e*, through the door *d*, and an orifice at top; the latter being closed during the distillation; *f f* 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.* 1173. *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, *fig.* 1174.

3. *Great apparatus of Idria.*—Before entering into details of this laboratory, it will not be useless to state 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 metalliferous rocks, which is the most abundant and the poorest species of ore, affording only one per cent. of mercury; *b*, the massive sulphide 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.

1175



The general aspect of the apparatus is indicated by *figs.* 1175, 1176, and 1177. *Fig.* 1177 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.* 1175, 1176, *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.* 1175 and 1178; *c c*, brick tunnels, by which the smoke of the fuel and the vapours of mercury pass, on the one side, into successive chambers *f k*.

f g h i j k l are passages which permit the circulation of the vapours from the furnace *a b c d*, to the chimneys *l l*. *Figs.* 1175 and 1176 exhibit clearly the distribution of these openings on each side of the same furnace, and in each half of the apparatus, which is

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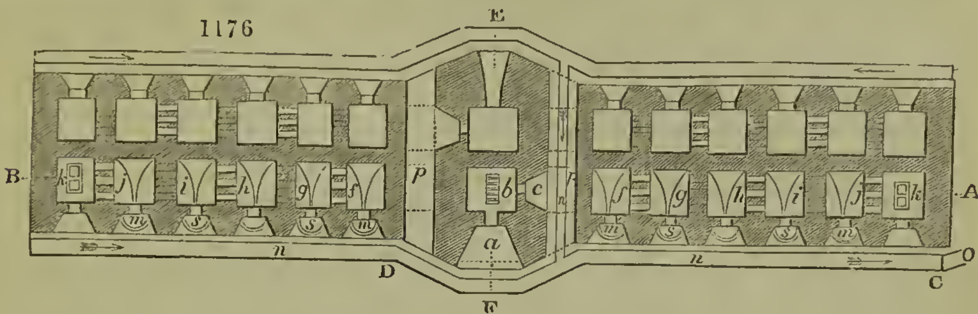


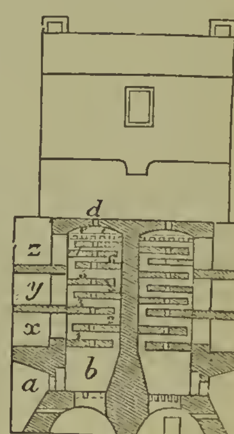
double, as *fig.* 1176 shows; the spaces without letters being in every respect similar to the spaces mentioned below. *Fig.* 1176 is double the scale of *fig.* 1175.

m m', *fig.* 1176, 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.* 1175, 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.* 1177, vaults which permit access to the tunnels *e' e''*, *fig.* 1178.

1177

s s' and *t t'*, *fig.* 1177, 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.* 1175. These openings are hermetically shut, like the preceding. V V', *fig.* 1175, 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.* 1178, are floors which correspond to the doors *u u'*, of the vaults 1 to 7, *fig.* 1177. These floors are reached by stairs set up in the different parts of the building which contains the whole apparatus.

1178



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 vaporise; 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 to 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 (of 110 lbs. each) 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.

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 combines, by virtue of a superior affinity with the lime, to the exclusion of the quicksilver, to form sulphides of lime and calcium, both of which being fixed *hepars*, remain in the retort, while the mercury is volatilised 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 sulphide of iron are formed.

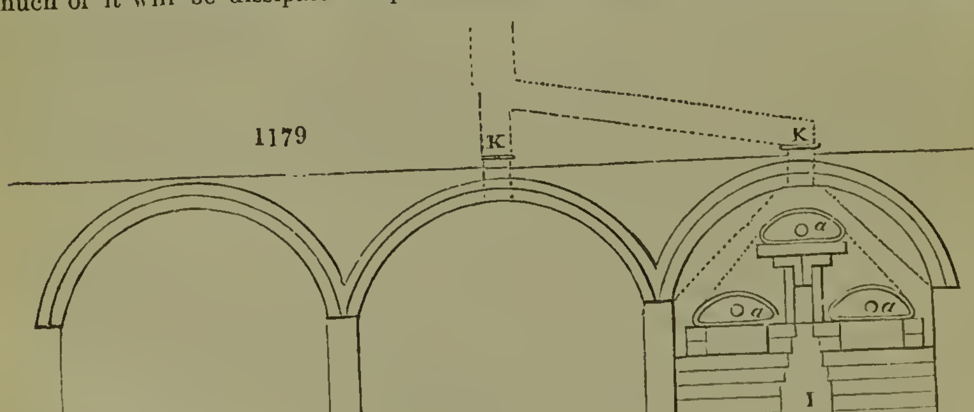
The annual production of the Bavarian Rhine provinces has been estimated at from 400 to 550 quintals ; that of Almaden, at 22,000 quintals ; and that of Idria, at about 1500 quintals.

All the plans hitherto prescribed for distilling the ore along with quicklime are remarkably rude. In that practised at Landsberg near 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 economised 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 3½ 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 1½ 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.

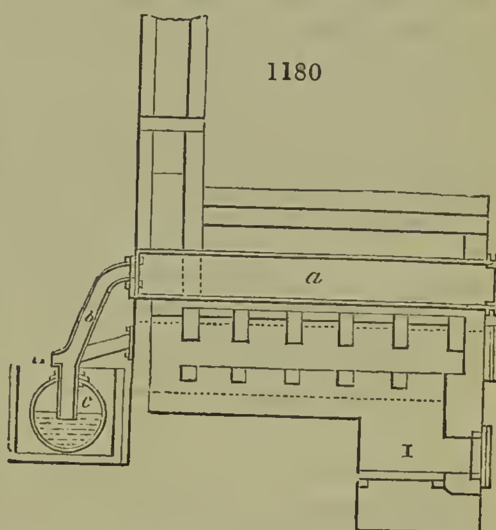
1179



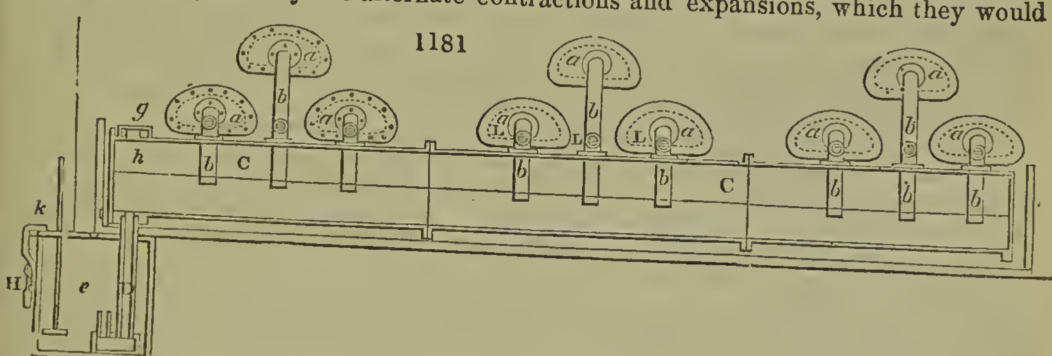
Figs. 1179, 1180, 1181 represent a cheap and powerful apparatus contrived by Dr. Ure at the request of the German Mines Company of London, and which was mounted at Landsberg, near Obermoschel, in the Bavarian Rhein-Kreis.

Fig. 1179 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 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.

In the section, *fig.* 1180, *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 L, 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.* 1181. 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 was found to act perfectly well. 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, Dr. Ure recommends 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.

Dr. Tobin gives an interesting account of the mercurial mines in California, in a letter from which we abstract the following.

"That part of California where I have been residing, and that which I have just visited, consists of three long ranges of trap 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 trap 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 a German miner, an experienced and practical man, who, if he stays here will eventually put the mine into some kind of order. Its greatest depth is about 150 feet, and the weekly extraction of ores varies from 100 to 150 tons. I have now 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 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 blacksmith has superseded me. Before the year was half out, he got tired of attempting to compete with my furnaces, and left in disgust.

The cylinders produced - - - - (but were stopped in November on account of expense of working)	251,616	lbs of mercury.
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 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."

Mr. Russell Bartlett, the United States Commissioner on the Mexican and United States Boundary Question, who visited California in 1853, states that the quantity of quicksilver produced annually at New Almaden, exceeds 1,000,000 lbs. During the year 1853 the total exports from San Francisco amounted to 1,350,000 lbs. valued at 683,189 dollars. All this, together with the large amount used in California, was the product of the New Almaden mine in the Santa Clara county, 12 miles from the town of San José, which is 54 miles from the city of San Francisco. The working of the mine was begun in the year 1846–7, by an English company, but for some reasons was not profitable. In 1849–50 it fell into American hands. The following shows to what points the quicksilver was exported in 1853:—Hong Kong, 423,150 lbs.; Shanghae, 60,900 lbs.; Canton, 27,450 lbs.; Whampoa, 22,500 lbs.; Calcutta, 3,750 lbs.; Mazatlan, 210,825 lbs.; Mazatlan and San Blas, 19,125 lbs.; San Blas, 145,652 lbs.; Callao, 135,000 lbs.; Valparaiso, 148,275 lbs.; New York, 138,375 lbs.; Philadelphia, 75,000 lbs. The ore is cinnabar of a bright vermilion colour. Its specific gravity is 3·622. The analysis compared with that of the Old Almaden ore, furnished the following results to Mr. Bealey (*Quarterly Journal of Chemical Society*, vol. iv.):—

	New Almaden.	Old Almaden.
Mercury	69·90	37·79
Sulphur	11·29	16·22
Iron	1·23	10·36
Lime	1·40	35·12 silica and alumina.
Alumina	0·61	
Magnesia	0·49	
Silica	14·41	
Loss	·67	·51
	100·00	100·00

The process by which the fluid metal is extracted is one of great simplicity. There are 6 furnaces, near which the ore is deposited from the mine, and separated according to its quality; the larger masses are first broken up, and then all is piled up under sheds near the furnace doors. The ore is next heaped on the furnaces, and a steady though not a strong fire is applied; as the ore becomes heated the quicksilver is sublimed, and being condensed it falls by its own weight, and is conducted by pipes which lead along the bottom of the furnace to small pots or reservoirs imbedded in the earth, each containing from 1 to 2 gallons of the metal. The furnaces are kept going night and day, while large drops or minute streams of the pure metal are constantly trickling down into the receivers; from these it is carried to the storehouse and deposited in large cast-iron tanks or vats, the largest of which is capable of containing 20 tons of quicksilver. Seven or eight days are required to fill the furnaces, extract the quicksilver, and remove the residuum. The miners and those who merely handle the cinnabar are not injured thereby; but those who work about the furnaces and inhale the fumes of the metal are seriously affected. Salivation is common, and the attendants on the furnaces are compelled to desist from their labour every 3 or 4 weeks, when a fresh set of hands is put on. The horses and mules are also salivated, and from 20 to 30 of them die every year from the effects of the mercury.

The following more detailed account of the apparatus for smelting is given by Mr. Ruschenberger: — A kind of reverberatory furnace 3 feet by 5, is arranged at the extremity of a series of chambers, of nearly, if not exactly of the same dimensions, namely, 7 feet long, 4 wide, and 5 high. There are 8 or 10 of these chambers in each series; they are built of brick, plastered inside, and secured by iron rods, armed at the end with screws and nuts as a protection against the expansion by heat. The tops are of boiler iron luted with ashes and salt. The first chamber is for a wood fire. The second is the ore chamber, which is separated from the first by a net-work partition of brick. The flame of the fire passes through the square holes of this partition, and plays upon the ore in the ore chamber, which when fully charged contains 10,000 lbs. of cinnabar; next to the ore chamber is the first condensing chamber which communicates with it by a square hole at the right upper corner; and the communication of this first with the second condensing chamber is by a square hole at the left lower corner. An opening at the right upper corner of the partition, between the second and third condensing chamber, communicates with the latter. The openings between the chambers are at the top, and to the right, and at the bottom, and to the left alternately; so that the vapours from the ore chamber are forced to describe a spiral in their passage through the 8 condensers. The vapour and smoke pass from the last condensing chamber through a square wooden box, 8 or 10 feet long in which there is a continuous shower of cold water, and finally escape into the open air by tall wooden flues. The floor or bottom of each condensing chamber is above 2 feet above the ground, and is arranged with gutters for collecting the condensed mercury and conveying it out into an open conduit along which it flows into an iron receptacle from which it is poured into the iron flasks through a brush to cleanse it of the scum of oxide formed on the surface on standing. 70 pounds weight are poured into each flask. There are 14 of these furnaces and ranges of condensers, with passages of 8 or 10 feet in width between them. A shed is constructed above the whole at a sufficient elevation to permit free circulation of the air.

According to Dumas, the following mines yield annually as follows: — Almaden in Spain, from 2,700,000 to 3,456,000 lbs. avoirdupois; Idria, 648,000 to 1,080,000 lbs.; Hungary and Transylvania, 75,600 to 97,200 lbs.; Deux Points, 43,000 to 54,000 lbs.; Palatinate, 19,440 to 21,600 lbs.; Huancavelica, 324,000 lbs.

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 condensible 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 ores. 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 mercury, 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, which see.

The *imports* of mercury during four years have been as follows: —

	1855. lbs.	1856. lbs.	1857. lbs.	1858. lbs.
Spain	2,809,752	536,371	42,334	154,174
United States	294,278	- -	376,579	164,536
Chili	111,173			
Australia	1,164			
Hanse Towns	- -	- -	5,445	
Hanover	- -	2,016		
Austrian Italy	- -	- -	49,241	1,191
Mexico	- -	38,437		
Other parts	850	- -	1,494	822
	3,217,217	576,824	475,093	320,723

H.M.N.

MERCURY, CHLORIDE OF; PROTOCHLORIDE (*Deutochlorure de mercure*, Fr.; *Aetzendes quecksilber sublimat*, Germ.), is made by subliming a mixture of equal parts of persulphate of mercury and sea-salt, in a stoneware cucurbit. The sublimate rises in vapour, and incrusts the globular glass capital with a white mass of small prismatic needles. It is a very deadly poison. Raw white of egg swallowed in profusion is the best antidote. See CORROSIVE SUBLIMATE.

MERCURY, FULMINATING. For this compound of mercury with fulminic acid, see FULMINATING MERCURY.

MERCURY, PERIODIDE OF, 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, SUBCHLORIDE OF; *Calomel*. (*Protochlorure de mercure*, Fr.; *Versüsstes quecksilber*, Germ.) See CALOMEL.

MERINO. For the following we are indebted to the *History of the Woollen Trade of Bradford*, by John James.

George the Third, ever desirous of the welfare of his people, though ofttimes mistaken in the means for accomplishing his wishes, amongst other improvements projected by him in agriculture and husbandry, imported in 1786 a few merino sheep from Spain, for the purpose of improving the wool of England. Unquestionably this variety of sheep sprung from the English flock which Edward III. permitted to be exported to Spain, where by assiduous care and crossing, the fleece had become the finest in its staple of any in the world. His Majesty made from time to time considerable accession to his original flock, which throve well and increased very fast, so that in a few years, by distribution and sale, they had come into the hands of the most eminent sheep breeding gentlemen in the kingdom. Among these the late Lord Western stood the most distinguished for his breeding and culture of merino sheep. His flock had its origin in a gift from His Majesty of 40 ewes, selected from 500 merinoes sent by the Cortes of Spain to the king for distribution among his subjects. His lordship's chief care in his improvement of the fleece, was to adapt it for the finest articles of worsted, and he certainly succeeded well in his object. Many other sheep breeders in the kingdom also devoted much attention with great success to the breeding of merino sheep, so that at this period (1826) large quantities of such wool were produced in the country.

Contemporaneous with these efforts made in England, the propagation of the merino sheep, which had been obtained from Spain, was carried on to a great extent in Saxony, where the ruling monarch, like our own, took much interest in the enterprise. The government of Saxony was amply rewarded for the pains which had been taken to spread the breeds so as to become a portion of the public wealth. Hence from this source arose the large supply which enabled Saxony to send to this country large quantities of wool, chiefly for the making of fine woollen cloth, as it, on the whole, ranged in staple shorter than English or Spanish merino. Nor were the French idle in availing themselves of the excellent properties of the Spanish sheep by transplanting them to their soil, and manufacturing from the wool fine stuffs to which they gave the name of merinoes.

From the merino wool produced in France and Germany, were manufactured fine descriptions of stuffs named after the sheep. A Bradford spinner in 1826, being desirous of extending his export trade in Germany, instituted inquiries respecting the stuffs made there, and received in answer the following information: — No worsted yarn of any amount was made on the Continent, except by hand. As the laws prohibiting the exportation of English machinery still remained in force, the continental nations could not obtain our improved frames, and either their handicraftsmen were unable to construct them with sufficient skill, or their capitalists were disinclined to embark in the enterprise. Much yarn was spun by hand in the neighbourhood of Hamburgh. Then, as to the weaving of stuffs, a few merinoes were made at Leipsic, and some of them from English yarn spun to No. 46. At Waldenberg, Eisenach, and Langensalza, Berlin, Altona, and Erfurt, merinoes were made. For some of these English yarn was used, but the German manufacturers preferred, most likely for its durability, their own yarn. Whilst the French and Germans were weaving merino pieces, a fabric bearing the same name, but widely differing in structure, arose in the English market, and imparted a most beneficial impulse to the stuff trade of the West Riding.

A brief narration of the origin of English merinoes will at this point, find an appropriate place. The wearing of worsted stuffs, after many changes of fashion, had again become very common amongst people of every degree in England. But it was perceived as the taste for fabrics of fine texture increased, that plainbacks and other worsted articles of that kind were not sufficiently delicate in structure for the higher classes. This idea having been mentioned by one of the partners in the house of Messrs. Todd, Morrison, and Co., warehousemen, London, to Messrs. Mann of Bradford, merchants, the latter began to reflect on the best method of supplying the void. It occurred to them that a plainback made with the finest yarn, and spun from merino and other fine wools, would answer the object.

Accordingly they employed Messrs. Garnett of Bradford to spin yarn and manufacture such a stuff, who accomplished the task to the full satisfaction of their employers. Some beautiful pieces were the result; three quarters wide, made from 40's to 52's weft, and 32's to 34's warp; in every respect they resembled cashmere, except in being finer. From the period of their introduction, these stuffs pleased the public taste, and were rapidly sold at high prices. They were originally sold at from 75*s.* to 80*s.* the piece; but when the article became known, many manufacturers entered into competition, and making lower sorts, reduced the pieces from 40*s.* to 50*s.* the piece according to qualities.

About a year after the full introduction of the three-quarters merino into the market, it was found that, owing to the narrowness of the piece, it did not cut up conveniently or economically for dresses; and the six-quarter variety of merino was brought into the market, where it for many years had a large demand, bringing as much in some instances as 120*s.* a piece.

METALS (*Metaux*, Fr.; *Metalle*, Germ.) are by far the most numerous class of undecomposed bodies in chemical arrangements. They amount to 45; of which 7 form, with oxygen, bodies possessed of alkaline properties: these are, 1. potassium; 2. sodium; 3. lithium, bases of the alkalies; 4. barium; 5. strontium; 6. calcium; 7. magnesium, bases of the alkaline earths, for even magnesia, the last and feeblest base, tinges turmeric brown, and red cabbage green. The next seven metals form with oxygen the earths proper; they are, 8. yttrium; 9. glucinum; 10. aluminium; 11. zirconium; 12. thorium; 13. erbium; 14. terbium. 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: 15. antimony; 16. arsenic; 17. bismuth; 18. cadmium; 19. cerium; 20. chromium; 21. cobalt; 22. copper; 23. gold; 24. iridium; 25. iron; 26. lead; 27. manganese; 28. mercury; 29. molybdenum; 30. nickel; 31. osmium; 32. palladium; 33. platinum; 34. rhodium; 35. silver; 36. tantalum; 37. tellurium; 38. tin; 39. titanium; 40. tungstenium; 41. vanadium; 42. uranium; 43. zinc; 44. niobium; 45. pelopium.

1. They are all, more or less, remarkable for a peculiar lustre, called the *metallic lustre*. 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, and bodies which are 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 possess 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.

Becquerel 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 zirconium ; aluminium ; 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 phenomenon 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 *seleniurets* ; with boron, into *borurets* (the termination *ide*, as *carbide*, *sulphide*, &c., is now more usually adopted); 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.

MESSENGER. A hawser, or small cable, about sixty fathoms long, wound round the capstan, and having its two ends lashed together. See CABLE.

METAL LEAF. Commonly applied to the Dutch leaf to distinguish it from gold leaf. There was of metal leaf, not gold, *imported*, in 1857 and 1858:

	1857.	1858.
In packets of 250 leaves —	260,433	310,920
From Hanse Towns - - - - - -	92,781	43,637
„ Holland - - - - - -	48,222	30,251
„ Belgium - - - - - -	22,650	
„ France - - - - - -	4,002	987
„ Other parts - - - - -		
	428,088	385,795

Computed real value 32,107*l.*, in 1857 ; 28,935*l.* in 1858.

METALLOGRAPHY. A process invented by M. Abate, and published by him in 1851. It consists of printing from engraved wood-blocks upon metallic surfaces, so as to produce imitations of figures and ornaments inlaid in wood. This effect he obtained by using, as a printing menstruum to wet the block with, solutions of such metallic or earthy salts as are decomposed when brought into contact with certain metals, and produce, through an electro-chemical action, an adhesive precipitate of a coloured metallic oxide, or any other chemical change upon the metal. There are here two principles at work : the one is the chemical action just referred to ; the other—the formation and key-stone to the invention—rests in the porousness of the printing object, which causes the absorption of the wetting fluid. The application of the invention to printing upon vegetable substances instead of metallic surfaces, required the introduction into the process of some other principle, to produce that chemical change which in metallography is spontaneous. The following is M. Abate's description of his process:—

Suppose a sheet of veneering-wood to be the object from which impressions are to be taken ; the wood is exposed for a few minutes to the cold evaporation of hydrochloric or sulphuric acid, or is slightly wetted with either of those acids diluted, and the acid is wiped off from the surface. Afterwards it is laid upon a piece of calico, or paper, or common wood, and by a stroke of the press an impression is taken, but which is quite invisible ; now by exposing this impression immediately to the action of a strong heat, a most perfect and beautiful representation of the printing wood instantaneously appears. In the same way, with the same plate of wood, without any other acid preparation, a number of impressions, about twenty or more, are taken ; then as the acid begins to be exhausted and the impressions faint, the acidification of the plate must be repeated as above, and so on progressively, as the wood is not in the least injured by the working of the process for any number of impressions. All these impressions show a general wood-like tint, most natural for the light-coloured woods, such as oak, walnut, maple, &c., but for other woods that have a peculiar colour, such as mahogany, rosewood, &c., the impression must be taken, if a true imitation be required, on a stuff dyed with the right colour of the wood.

It must be remarked, that the impressions as above made show an inversion of tints in reference to the original wood, so that the light are dark, and *vice versâ*, which, however, does not interfere with the effect. The reason of it is, that all the varieties of tints which appear in the same wood are the effect of the varying closeness of its fibres in its different parts, so that where the fibres are close the colour is dark, and light where they are loose; but in the above process, as the absorption of the acid is greater in proportion to the looseness of its fibres, the effect must necessarily be the reverse of the above. However, when it is required to produce the true effect of the printing wood, the process is altered as follows:—The surface upon which the impression is to be taken is wetted with dilute acid, and an impression is taken with the veneering-wood previously wetted with diluted ammonia; it is evident that in this case, the alkali neutralising the acid, the effect resulting from the subsequent action of heat will be a true representation of the printing surface. M. Abate gives this variation of the process the name of THERMOGRAPHY, or the art of printing by heat; but this term has been already applied to another process. See THERMOGRAPHY.

METALLURGY. (*Erzkunde*, Germ.) The art of extracting metals from their ores. Under the heads of the different metals respectively, the metallurgical processes to which they are subjected are given; still there are a few general details, principally relating to continental processes which are included with advantage in the present article. A full description of the processes of preparing the minerals for the operations of the metallurgist will be found under the head of ORES, DRESSING OF.

It has been deemed advisable to comprehend in this article all the processes, not mentioned elsewhere, which involve the action of fire in any way. Therefore the processes of roasting ores, although they may be subsequently submitted to some washing operations, are dealt with.

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 oxidising 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 in the labour; two most important circumstances, on account of the great masses operated upon.

Three principal methods may be distinguished: 1, the roasting in heaps 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.

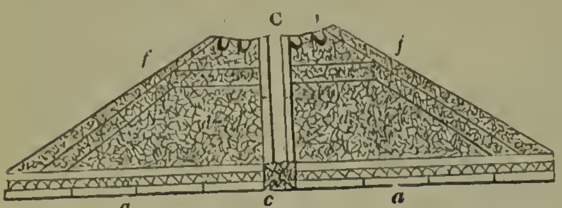
1. The roasting in the open air, and in heaps more or less considerable, is practised upon iron ores, and such as are pyritous or bituminous. The operation consists in general in spreading over the plane area, often bottomed with beaten clay, billets of wood arranged like the bars of a gridiron, and sometimes laid crosswise over one another, so as to form a uniform flat bed. Sometimes wood charcoal is added, so as to fill up the interstices, and to prevent the ore from falling between the other pieces of fuel. Coal is also employed in moderately small lumps; and even occasionally turf. The ore either simply broken into pieces, or sometimes under the form of *schlich* (fine pyritous sand), is piled up over the fuel; usually alternate beds of fuel and ore are formed.

The fire, kindled in general at the lower part, but sometimes, however, at the middle, gradually spreads, 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 equably 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. 1182, 1183, 1184 represent the roasting in mounds, as practised near Goslar in the Harz, and at Chessy in the department of the Rhone. *Fig.* 1182, is a vertical

1182



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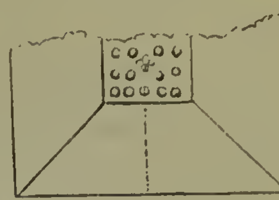
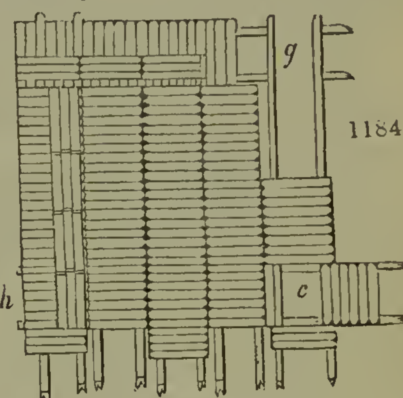


section in the line *h c* of *figs.* 1183 and 1184. In *fig.* 1183 there is shown in plan, only a little more than one half of the quadrangular truncated pyramid, which constitutes the heap. *Fig.* 1184 shows a little more than one fourth of a bed of wood, arranged at the bottom of the pyramid, as shown by *a a*, *fig.* 1182, and *c g h*, *fig.* 1184. c is a wooden chimney, formed within the heap of ore, at whose bottom *c* 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.* 1184, 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.* 1182.



Burning wood is thrown in by the chimney c. The charcoal and the wood take fire; the sulphurous ores *d e f* are heated to such a high temperature as to vaporise the sulphur. In the Lower Harz, 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 sand 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 or four little walls, 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 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 going, 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 connection 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*, or pyritic sands, and in general of all matters which are to have several fires; a circumstance indispensable to a due separation of the sulphur, arsenic, &c.

3. The furnaces employed for roasting the ores and *matts* 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 sulphide of copper and pyrites, with a 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 sulphide of iron. For it sometimes runs into one mass, or at least into lumps agglutinated together in certain parts of the furnace, and the operation is either altogether stopped, 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.

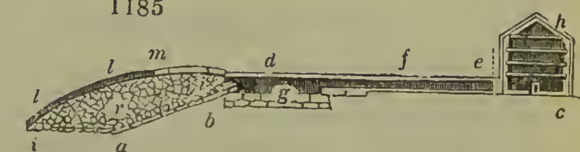
In the Pyrenees, the roasting of iron ores is executed in a circular furnace, so disposed that the fuel is contained and burned in a kind of interior oven, above which lie the pieces of ore to be calcined. Sometimes the vault of this oven which sustains the ore, is formed of bricks, leaving between them openings for the passage of the flame and 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 iron pyrites, or from pyritous minerals, different furnaces may be employed, among which that used in Hungary deserves notice. It is a rectangular parallelopiped 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 *fig.* 1184, 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.* 1185, 1186 represent a furnace which has been long employed 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.* 1185 is a vertical section, in the line *k d n o* of *fig.* 1186, 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 *a b* of a hillock *a b c*, lumps *r* of iron pyrites are piled upon the pieces of wood *i i* for roasting. A conduit *d f e* 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 *h* it is constructed in boards. At the beginning of this conduit there is a recipient *g*. The chamber *h* 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 i*, whenever these are fairly kindled, they are covered with small ore, and then with rammed earth *l l*. Towards the point *m*, for the 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 laded 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.

1185



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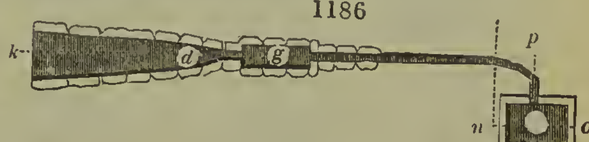

The reverberatory furnace affords one of the best means of ustulation, where it is requisite to employ the simultaneous action of heat and atmospherical air to destroy certain combinations, and to decompose the sulphides, arsenides, &c. It is likewise evident that the facility thus offered of stirring 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, and 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 oxidising, and very fit for burning the sulphur, and oxidising 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 by 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 sulphide 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 workmen 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 chimney that the heating may be effected with the greatest economy.

The reverberatory furnace is always employed to roast ores of the 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 lower than the other. Above the vault there is a space

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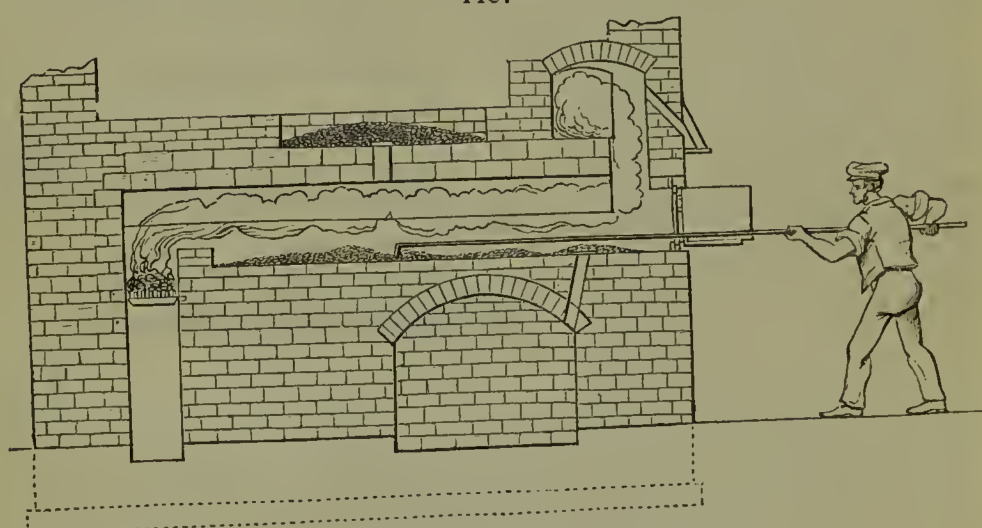

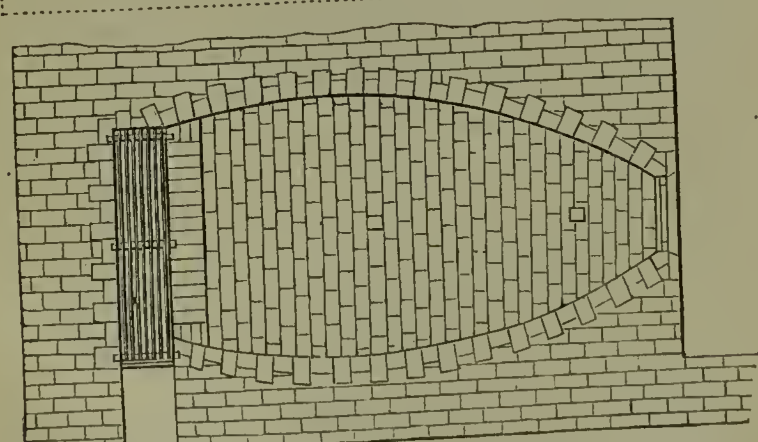

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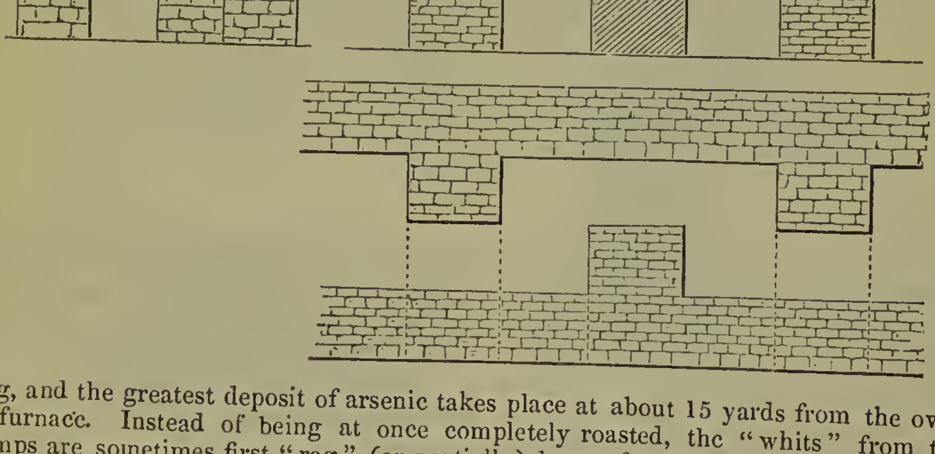
or chamber in which the ore is deposited, and which communicates with the laboratory by a vertical passage; which serves to allow the ore to be pushed down, when it is dried and a little heated. The flame and the smoke which escape from the sole or laboratory pass into condensing chambers, before entering into the chimney, 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 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 Schlaekenwald in Bohemia, and at Ehrenfriedensdorf in Saxony, the arsenical pyrites of Geyer (in Saxony), &c., the chambers of condensation for the arsenious acid are much more extensive than in furnaces commonly used for roasting galena, copper, or even silver ores.

Most of the tin ores in Cornwall have to be roasted, or calcined, before they are fit for the smelting house, although in some mines the admixture with other minerals is so trifling, that this operation is considered unnecessary. The furnace (*figs.* 1187, 1188) in which the roasting is carried on, is about 10 feet long, 5 feet 6 inches wide in the middle, and 3 feet wide near the mouth. The fireplace, it will be observed, is situated at the back, the flames playing through the oven and ascending the chimney, which is above the furnace door. The man is represented in *fig.* 1187, as stirring the ore with a long iron rake. The ore, before it is submitted to the action of the fire, is thoroughly dried in a circular pit, placed immediately above the oven, into which it is let down through the opening when it is considered to be ready for calcining. Beneath the oven and connected with it by an opening through which the ore when sufficiently roasted is made to pass, is an arched opening about 4 feet wide, termed the "wrinkle." Here the ore is collected, whilst another charge is being placed in the furnace. About 7 cwt. or 8 cwt. of ore is the quantity usually roasted at one time. Whilst undergoing this operation, dense fumes of arsenic and sulphur escape with the smoke from the fire, and pass through large flues, divided into several chambers (*fig.* 1189) where the former is collected. The flue is often 70 yards

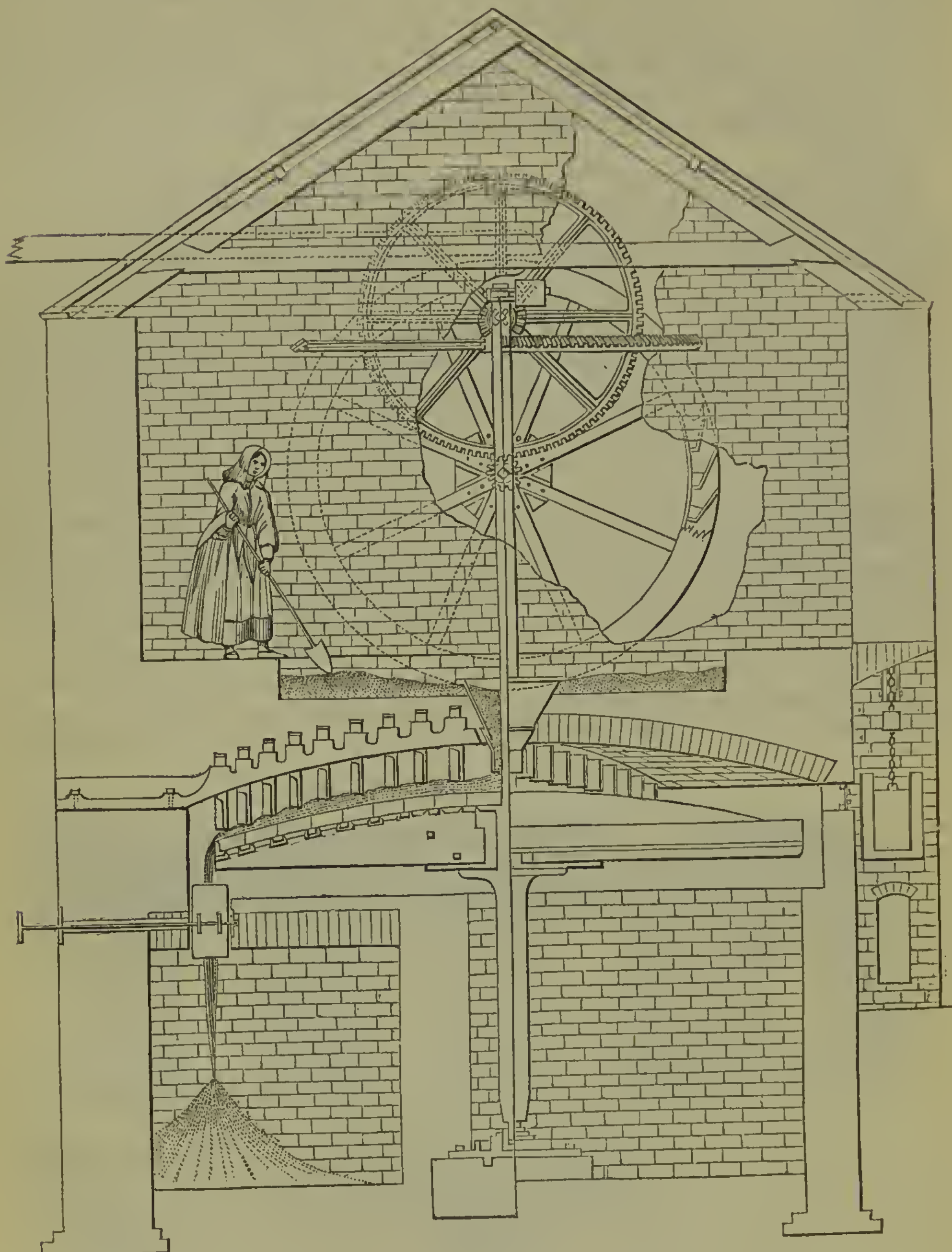
1189



long, and the greatest deposit of arsenic takes place at about 15 yards from the oven or furnace. Instead of being at once completely roasted, the "whits" from the stamps are sometimes first "rag" (or partially) burnt, for about six or eight hours. The object of this partial burning is to save time and expense, nearly three-fourths of it being thrown away after dressing it from the first burning.

Fig. 1190. The machine called originally "Brunton's Patent Calciner," for calcining tin ore, is gradually coming into use in Cornwall, and is adopted in many of the larger mines. Its operation may be thus briefly described: — A revolving circular table, usually 8 feet, or 10 feet in diameter, turned by a water-wheel, receives through the hopper the tin stuff to be roasted or calcined. The frame of the table is made of cast-iron, with bands, or rings, of wrought-iron, on which rests the fire-bricks composing the surface of the table. The flames from each of the two fire-

1190



places pass over the ore as it lies on the table, which slowly revolves, at the rate of about once in every quarter of an hour. In the top of the dome, over the table, are fixed three cast-iron frames called the "spider," from which depend numerous iron coulters, or teeth, which stir up the tin stuff, as it is carried round under them. The coulters on one of the arms of the "spider" are fixed obliquely, so as to turn the ore downwards from one to the other — the last one at the circumference of the table, projecting the ore (by this time fully calcined) over the edge, into one of the two "wrinkles" beneath. A simple apparatus called the "butterfly," moved by a handle outside the building, diverts the stream of roasted tin stuff, as it falls from the table, either into one or the other as may be required. Unlike the operation of roasting in the oven previously described, the calciner requires little or no attention; the only care requisite being to see that the hopper is fully supplied, and the roasted ore removed when necessary from the wrinkles.

For this description of the burning house and of the calciner, we are indebted to Mr. James Henderson's communication to the Institution of Civil Engineers.

We have been favoured with the following notes on the action of Brunton's calciners, employed at Fabrica la Constanto, Spain, which are of great value, as are also the additional suggestions.

Diameter of revolving bed, 14 feet.

Revolution of bed per hour from 3 to 4, or about 1 foot of the circumference per minute.

Ores introduced by hopper, at the rate of 1 quintal to every revolution of table.

Quantity of ore calcined per day of 10 hours, 30 to 35 quintals.

Salt consumed, generally 6 per cent. of weight of ore.

Fuel consumed per 10 hours, 1200 to 1400 lbs. of pine wood.

Power employed to revolve table, half horse.

Remarks. — The furnace is charged with ore and salt by means of iron hoppers placed immediately over the centre of each of the hearths. For the supply of each hopper, a heap of about 14 quintals of ore, with 5 or 6 per cent. of salt is prepared from time to time upon a small platform on the top of the furnaces, and a few shovelfulls thrown in occasionally as required, taking care, however, always to have enough ore in the hopper to prevent the ascension of acid vapours, &c. from the furnace. The time the mineral remains in the furnace, and the quantity calcined per hour, must depend on the rapidity of motion of the revolving hearth, and the angle at which the iron stirrers are fixed.

The average amount passed through each furnace in 24 hours is about 84 quintals, or 3½ quintals per hour. For every revolution of the bed, nearly 1 quintal is discharged from the furnace.

Compared with the German Röstöfen, the mechanical furnaces are less efficient for the calcination of silver ores, particularly when the ores operated on are very damp and contain much sulphur; in which case the excessive production of lumps becomes a serious inconvenience to contend with.

But in the treatment of the silver ores of Steindelencina, they possess the advantage of calcining a large quantity of ore in a given time, and require no further attendance than is necessary for supplying them with ore and fuel. The supply of fuel is, however, subject to great neglect. The management of the fires is nevertheless a matter of much importance, for should they be forgotten, and the heat get much reduced, the mineral, from continuing to pass at the same rate through the furnace, cannot be properly calcined.

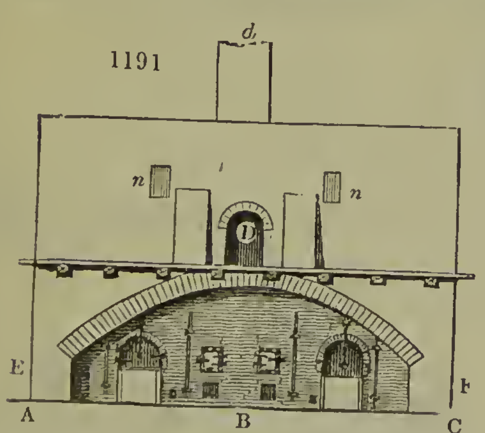
To prevent the fires getting low, and to raise them after being neglected, the workmen often load the grate with fuel, the result of which is to overheat the ore and cause a great waste of wood.

Some measure is evidently necessary to regulate the supply of fuel to the grate.

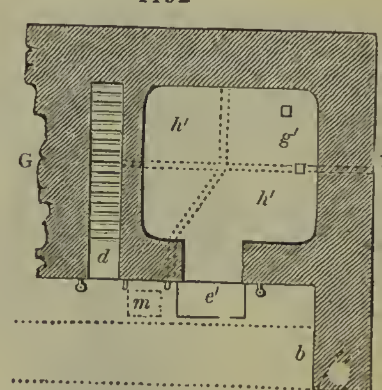
The most simple appears to be an alarum that shall be rung, for example, at every revolution of the hearth, so as to call the attention of the men to the fires; and then not more than a given quantity of wood should be thrown on the grate, which, repeated at every turn made by the bed, or once in a quarter of an hour, would sustain a nearly constant temperature in the furnace. See SILVER.

Figs. 1191, 1192, 1193 represent a reverberatory furnace employed in the smelting

1191



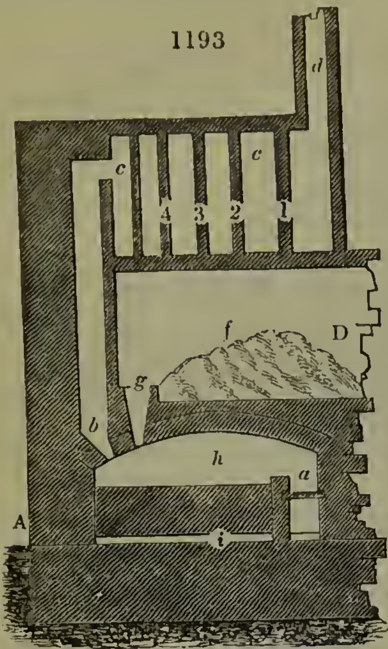
1192



works of Lautenthal, in the Harz, for roasting the *schlichs* of lead ores, which contain much blende or sulphide of zinc. In *fig.* 1191 we see that the two parts A B, B C, are absolutely like, the two furnaces being built in one body of brickwork. *Fig.* 1192 is the plan of the furnace B C, taken at the level E F of *fig.* 1191. *Fig.* 1193 is a vertical section of the similar furnace A B, taken in the prolongation of the line G H in *fig.* 1192.

a is the fire-place of the furnace, its grate and ash-pit. *b* is the conduit of vaporisation, which communicates with the chambers *c*; into which the vaporised substances are deposited; *d*, chimney for the escape of the smoke of the fire-place *a*,

1193



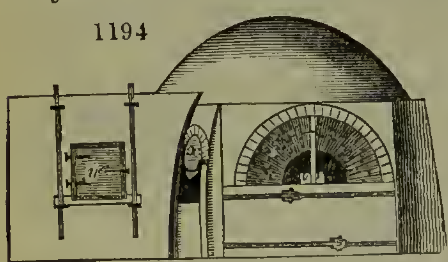
after it has gone through the space *b c c*; *e'*, is the charging door, with a hook hanging in front to rest the long iron rake upon, with which the materials are turned over; *f*, chamber containing a quantity of *schlich* destined for roasting; this chamber communicates with the vaulted corridor (gallery) D, seen in *fig.* 1191; *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 *h*. 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 Ehrenfriedensdorf 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.

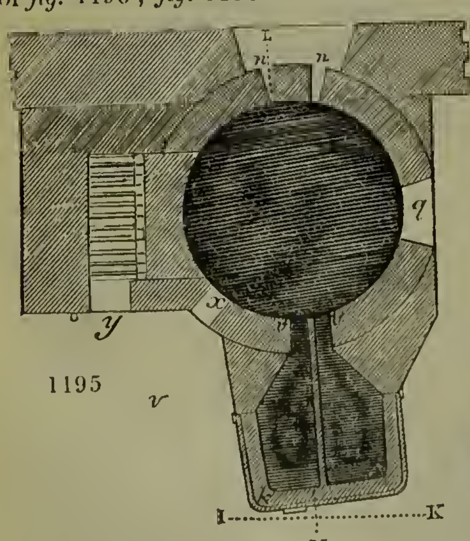
Figs. 1194, 1195, 1196 represent the reverberatory furnace generally employed in

1194



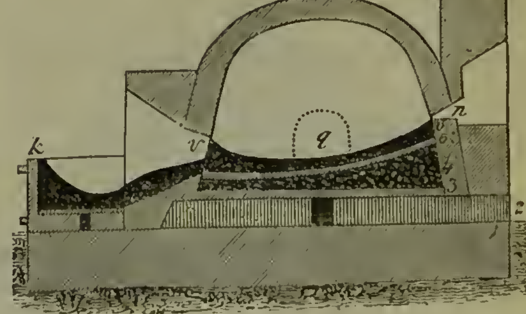
the Harz, in the district of Mansfeldt, Saxony, Hungary, &c., for the treatment of black copper, and for refining rose copper upon the great scale. An analogous furnace is used at Andreasberg for the liquefaction or purification of the matts, and for workable lead when it is much loaded with arsenic.

Fig. 1194 presents the elevation of the furnace parallel to the line I K, of the plan *fig.* 1195, which plan is taken at the level of the tuyère *n*, of *fig.* 1196; *fig.* 1196 is a vertical section in the line L M, *fig.* 1195. *k* represents



1195

1196



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; *q*, 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 *k*; *x*, door through which the slags of cinders floating upon the surface 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.* 1196, 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. 1197, 1198, 1199 show the furnace employed for liquation in one of the principal smelting works of the Harz. *Fig.* 1199, 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.* 1198 is the plan, in the line F, G, of *fig.* 1197.

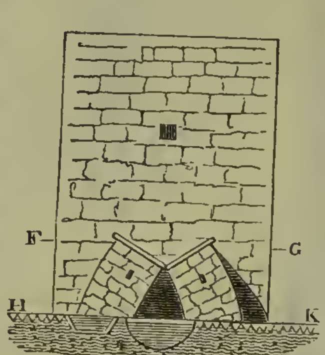
A liquation cake is composed of—

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.

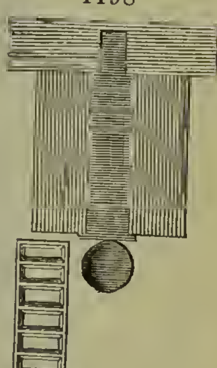
Lead obtained from litharge, 2 cwts. Litharge, $\frac{1}{2}$ cwt.

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 possible way.

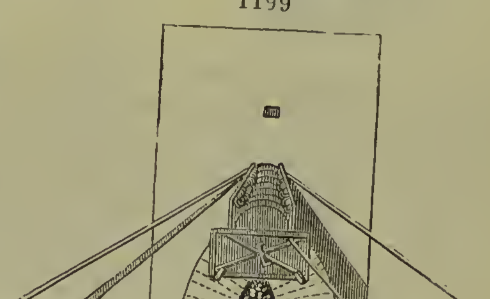
1197



1198



1199

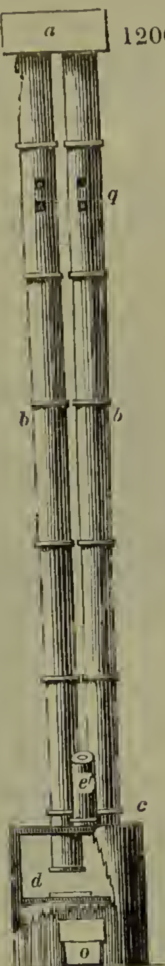


From 8 to 16 of these cakes (*pains*) are usually placed in the liquation furnace, *figs.* 1197, 1198, 1199. The operation lasts 3 or 4 hours, in which time about $1\frac{1}{2}$ quintals of charcoal are consumed. The cakes are covered with burning charcoal supported, as before stated, by the iron plates. 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.* 1198. 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.

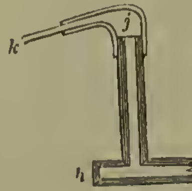
The *trompe*, or water-blowing engine, *figs.* 1200, 1201, 1202, is employed in some of the great metallurgical works of the continent. *Fig.* 1200 is the elevation; *fig.* 1201 is a vertical section, made at right angles to the elevation. The machine is formed of two cylindrical pipes, the bodies of the *trompe b b*, set upright, called the funnel, which terminate above in a water-cistern *a*, and below in a close basin under *c*, called the *tub* or *drum*. The conical part *p* of the funnel has been called *etranguillon*, 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*, holes, *q q*, 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 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.* 1201 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 leathern 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

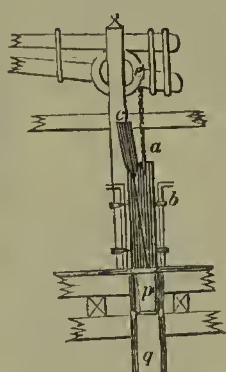
1200



1201




1202



cistern, *a*, to regulate the admission of water into the trompe; but in Carniola the tunnel is closed with a wooden plug, suspended to a cord, which goes round a pulley mounted upon a horizontal axis, as shown in *fig.* 1202. 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 q*.

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 mètres (36 feet 6 inches), and its width 2 feet, to give room for the drums. It is situated 10 mètres (33⅓ 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 control over the metallurgic processes, and afford a clear indication of the quantities of precious metal which they ought to produce.

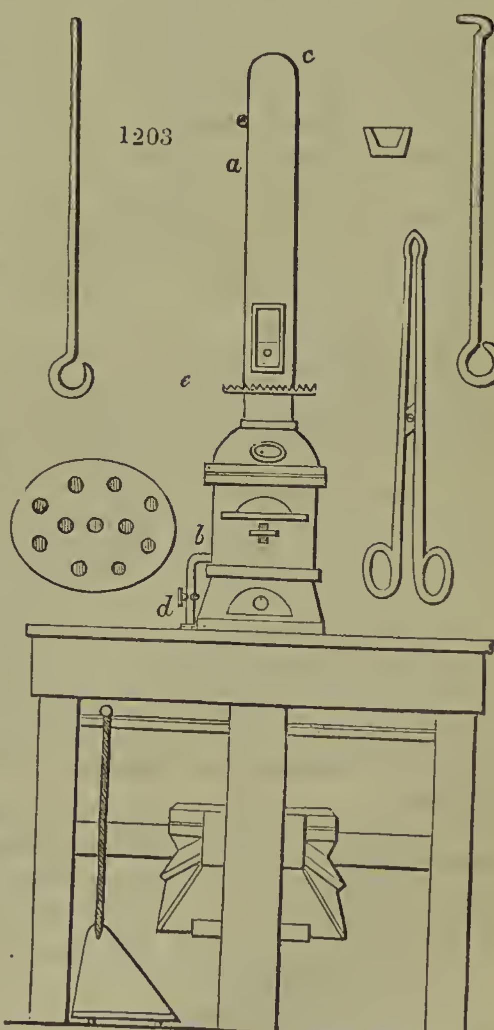
By the title *Assays*, in a metallurgic point of view, is meant the method of ascertaining for any substance whatever, not only the presence and nature of a metal, but its proportional quantity. Hence the operations which do not lead to a precise determination of the metal in question, are not to be 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. See ASSAY.

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 on a shovel, in a small trough of an oblong shape, called a *sebilla.* After pulverising with more or less pains the matters to be assayed by this process, a determinate weight of them is put on a shovel 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, by which the whole of the metal may be insulated. See ORES, DRESSING OF.

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 sulphide of lead (galena) being often susceptible of becoming almost pure sulphide (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 sulphide 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.

1203



The assay by washing is also had recourse to for ascertaining if the *scoriæ* or other product of the furnace contain metallic grains which might be extracted from them by stamping and washing on the large scale; a process employed with the *scoriæ* of tin and copper works.

2. *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 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.

In smelting houses which purchase ores, it is necessary to bestow much attention on the assays, because they serve to regulate the quality and 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.

3. *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.

Furnace of assay. — Under Assay a furnace constructed by Messrs. Anfrye and D'Arcet is mentioned which gives some peculiar facilities and economy to the process by fire.

It had originally a small pair of bellows attached to it, for raising the heat rapidly to the proper vitrifying pitch. This is not shown in the previous figure.

The furnace is 17½ inches high and 7½ inches wide, made of pottery or fine clay as represented in *fig.* 1203, supported on a table having a pair of bellows beneath it. The laboratory is at *b*, the blow pipe of the bellows at *d*, with a stop cock, and the dome is surmounted by a chimney *a c*, in whose lower part there is an opening with a sliding door for the introduction of charcoal fuel. The furnace is formed in three pieces; a dome, a body, and an ash pit. A pair of tongs, a stoking hook, and cupel, are seen on the right hand; and the plan of the stoneware grate pierced with conical holes and a poker are seen to the left. An exceedingly ingenious, and in all respects most useful *Blast Gas Furnace* has been recently introduced by Mr. J. J. Griffin. It consists of two parts: 1st, of a particular form of gas-burner, which is supplied with gas under the usual pressure, and with a blast of common air supplied by bellows or a blowing machine, at about ten times the pressure of the gas. 2nd, of a furnace, which is built up in a particular manner round the flame that is produced by the gas-burner, and the crucible that is exposed to ignition. The object of the particular construction of this furnace, is to accumulate and concentrate in a focus, the heat produced by the gas flame, and to make it expend its entire power upon any object placed in that focus. Mr. Griffin has published a detailed account of this valuable little furnace.

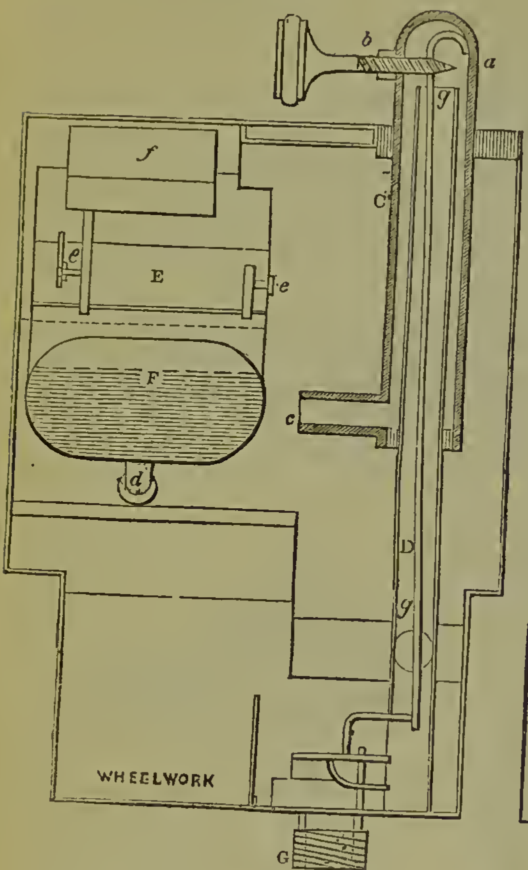
METEORITES (*Aerolithes*, Fr.) are stones of a peculiar aspect and composition, which have fallen from the air. See Iron.

METER, GAS. Under the head of Coal Gas a description is given of the hydraulic, or wet gas meter in ordinary use. This instrument, when properly constructed, measures with great accuracy, and requires only a very slight pressure of gas to work it; but it readily admits of fraudulent means being employed by the consumer, so as to cause the instrument to under-estimate the amount of gas consumed; whilst, on the other hand, the condensation of moisture within the meter may so far elevate the water level as to cause an over-estimation of the consumption. The water in the hydraulic meter is also liable to freeze in winter, thus completely stopping the supply of gas; at other times, especially when the meter is fixed in a comparatively warm place, the gas, becoming saturated with aqueous vapour, subsequently deposits water during its passage through the cooler portions of the pipes of distribution. The water thus deposited collects in the lower portions of the pipes, breaking the flow of gas into a succession of bubbles, and causing that flickering or dancing of the gas flames which is so frequently a source of annoyance in winter.

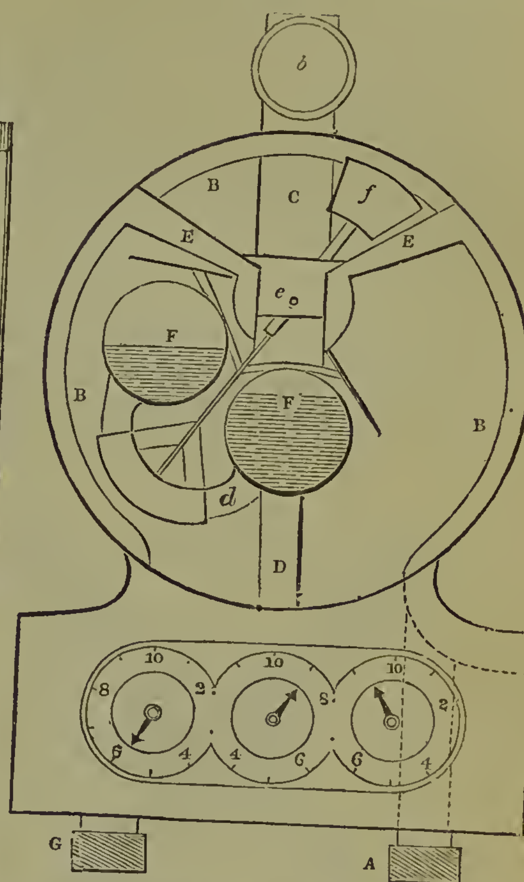
These defects and inconveniencies are all obviated by the *dry gas meter*, several forms of which have of late years been invented. The first in point of date is Clegg's patent dry gas meter, an instrument displaying great ingenuity, although it has never come into extensive use. *Figs.* 1204 and 1205 show the construction of this meter, and are half the full size: the letters of reference are the same in both.

B B, *fig.* 1204, represents a cylindrical vessel, about 3¾ inches in diameter and 4 inches deep, being the dimensions of a meter capable of measuring gas for three burners, called a three-light meter. In this vessel are two glass cylinders F F, connected together by the bent tube *d*. The cylinders being perfectly exhausted of air, and half filled with alcohol, are made to vibrate on centres *e*, *e*, and are balanced by the weight *f*. This instrument accurately indicates the excess of heat to which either cylinder may be exposed upon the principle of Leslie's differential thermometer.

1204



1205



C is a hollow brass box, called the heater, about 4 inches long and ½ an inch broad, projecting out of the meter about 1 inch. At *a* issues a small jet of gas, which, when inflamed, gives motion to the cylinders.

The gas enters the meter by the pipe A, and circulates throughout the double case B. Having passed round the case B, a portion of it enters the top of the box C, by the pipe D, and passes out again at the bottom by the tube *c*, into the meter; the rest of the gas enters the body of the meter through holes in the curved faces of the hoods E E, and, after blowing on the glass cylinders, passes to the burners through the outlet pipe.

To put the meter in action, let the jet *a* be lighted about an hour before the burners are wanted. In most cases this jet will be lighted all day as a useful flame. The hole *a* is so situated on the box C, that whatever be the size of the jet, a fixed temperature is given to the box, that temperature depending on the quantity of flame in contact with the box, and not at all on the length of the jet. The jet being lighted, and the box C thereby heated, the gas which passes through it is raised to the same temperature, and, flowing out at the tube *c*, impinges on the glass cylinder which happens for the time to be the lowest; the heated gas soon raises a vapour in the lower cylinder, the expansion of which drives the liquid into the upper one, until it becomes heavier than the counterpoise *f*, when the cylinders swing on their centre, the higher one descends, and comes in the line of the current of hot gas, and the lower one ascends; the same motion continues as long as the jet *a* burns. The same effect on the cylinder is maintained, however the outward temperature may change, by the cold gas, which, issuing from the curved side of the hood E E, impinges on the upper cylinder, and hastens the condensation of the vapour which it contains.

The cold gas and the heater vary in temperature with the room, and thus counteract each other.

The lighting of the jet *a* is essential to the action of the meters; in order to insure this, the supply of gas to the burners is made to depend on it in the following manner. The pipe G, by which the gas leaves the meter, is covered by a slide valve, which is opened and shut by the action of the pyrometer *g*; the pyrometer is in communication with and receives heat from the jet, and opens the valve when hot, closing it again when cold.

The speed at which the cylinders vibrate is an index of the quantity of heat communicated to them, and is in exact proportion to the quantity of gas blowing on them through the pipe *c* and curved side of the hoods E E.

The gas passed through the heater is a fixed proportion of the whole gas passing the meter; therefore the number of vibrations of the cylinders is in proportion to the gas consumed.

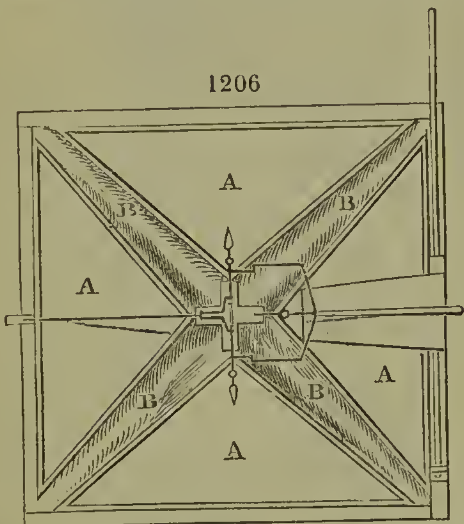
A train of wheel-work with dials, similar to that used in the common meter, registers the vibrations.

Simplicity, accuracy, and compactness are the most remarkable features of this instrument, and the absence of all corrosive agents will insure its durability.

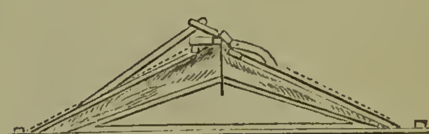
The most recently constructed meters on the dry principle are those of Defries, and of Messrs. Croll and Richards. Both of these contrivances consist in causing the gas to fill expansible chambers of definite volume, and the alternate expansion and contraction of these is registered by wheel-work.

Defries' meter has three of these measuring chambers, separated from each other by flexible leather partitions which are partly covered by metallic plates, to protect them from the action of the gas. A A A A, *fig.* 1206, represent these metallic plates fixed upon the leather diaphragm B B B B. As the gas enters, it causes the flexible

1206



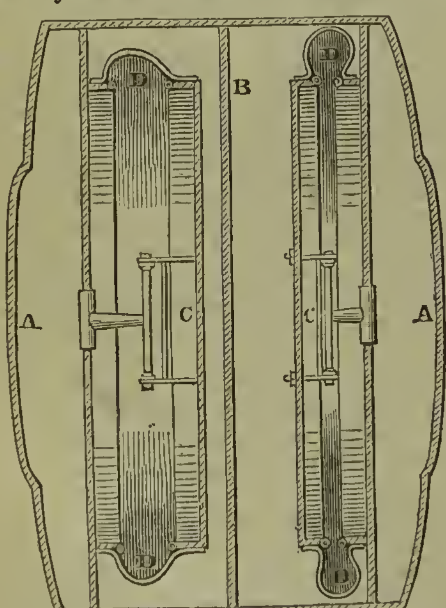
1207



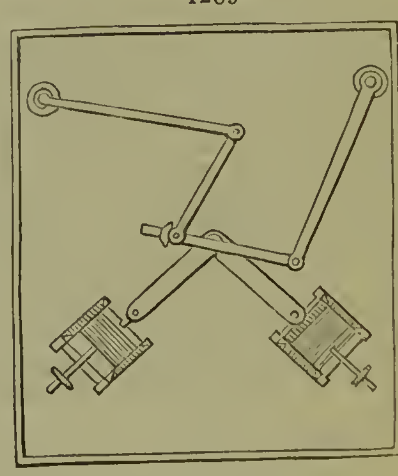
partition to expand, which it does by assuming the form of a cone, as seen in *fig.* 1207. Three such chambers are attached to each meter, so as to insure a uniform and steady supply of gas, and the motion of the chambers being communicated to clockwork the consumption of gas is registered upon dials in the usual manner.

The dry meter invented by Messrs. Croll and Richards is superior in construction

1208

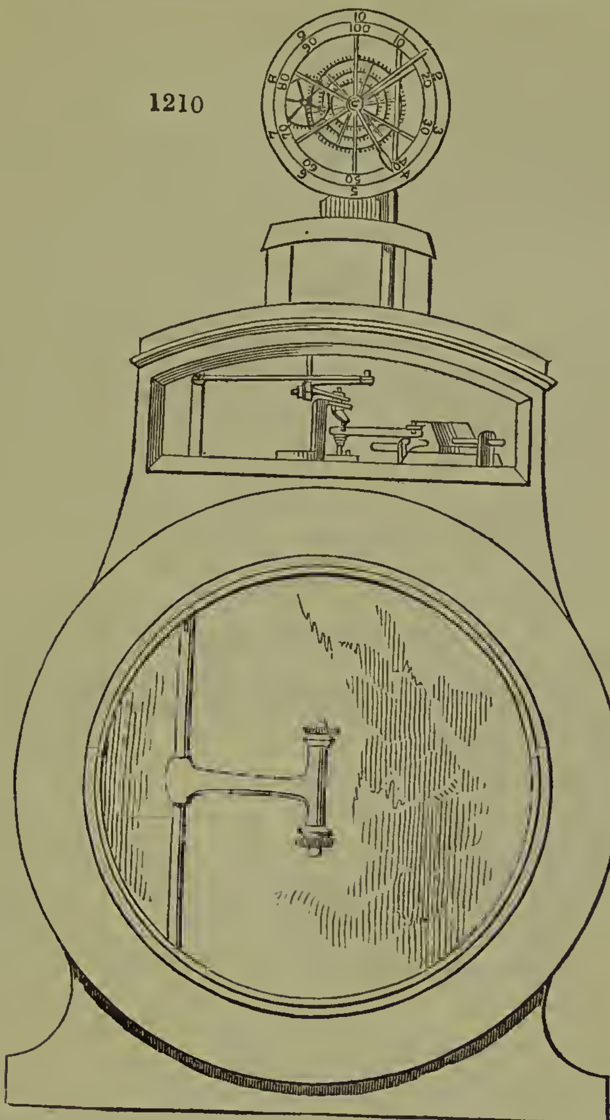


1209



and accuracy of measurement to that of Defries. It is shown in *figs.* 1208, 1209, and 1210. A A *fig.* 1208 is a cylindrical case divided into two cylindrical compartments by the inflexible metallic diaphragm B. These compartments are closed at opposite ends by the metal discs C C. The latter perform the functions of pistons, and are retained in their proper position by universal joints attached to each. The

1210



dises are restrained from moving through more than a fixed space by metallic arms and rods, shown in *fig.* 1209, and when this space has been once adjusted it cannot afterwards vary. It will be seen that the principle of this meter is that of a piston moving in a cylinder; but, in order to avoid the friction which such an arrangement would cause if literally carried out, bands of leather D, D, are attached, which act as hinges, and allow of the motion of the discs without friction.

The gas enters the cylinder from the upper space containing the levers, valves, &c., *fig.* 1210; its pressure forces the discs forward through the space limited, as above described. The flow of gas is then reversed; that is, a passage to the burners is opened from the internal space, whilst the supply is now directed into the outer chamber, thus forcing the disc back to its original position and expelling the first portion of gas through the pipes of distribution. Each motion of the disc thus evidently corresponds to a given volume of gas, and, being registered by clockwork, indicates the consumption upon the usual dial plates.

Dry gas meters have of late years come into very extensive use, especially in the metropolis.—E. F.

METHYLAMINE. C^2H^5N. The most volatile of the organic bases. It is formed by similar reactions to ethylamine; it is regarded as ammonia in which an equivalent of hydrogen is replaced by methyle; it is gaseous at ordinary temperatures; it is the most soluble in water of all known gases, one volume of water at 54° dissolving 1150 volumes.—C. G. W.

METHYLATED SPIRIT. When ordinary alcohol is mixed with 10 per cent.

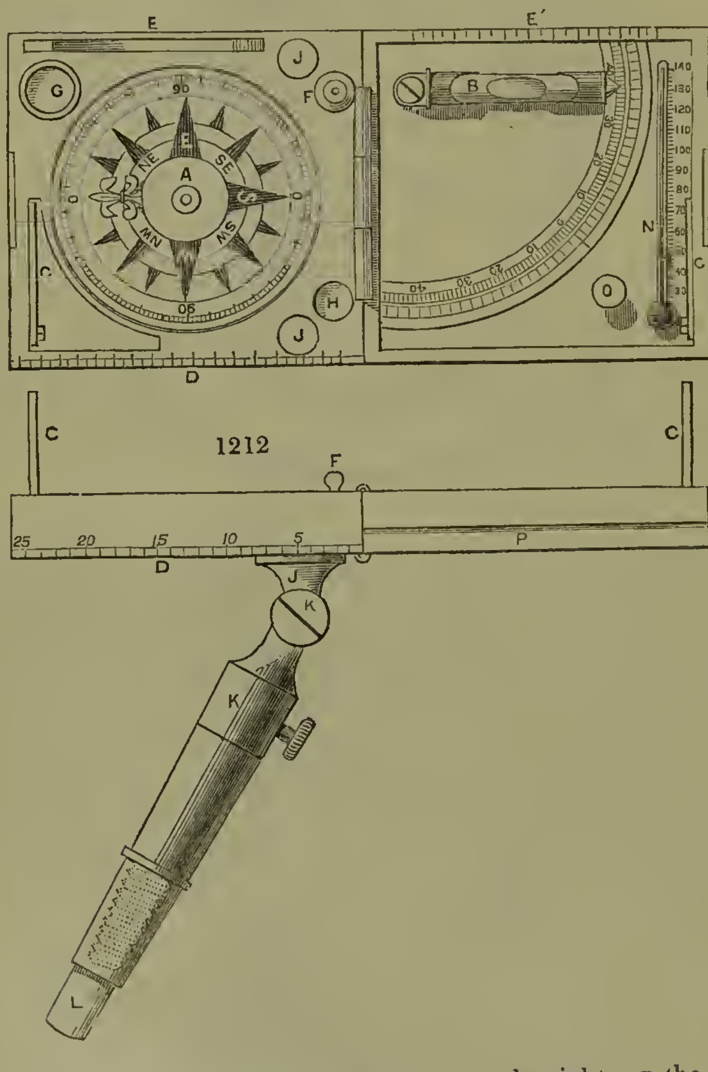
of "wood alcohol," "*Methyle*," it is, according to an excise regulation, sold duty free under this name. Methylated spirit is extensively used in the manufacture of varnishes, lacquers, &c.

METHYLENE, a peculiar liquid compound of carbon and hydrogen, extracted from pyroxilic spirit, which is reckoned to be a bi-hydrate of *methylène*.

METRA. This pocket instrument, constructed by the late Mr. Herbert Mackworth — one of H. M. Inspectors of Collieries, — enables the traveller or engineer to take, with considerable accuracy, most of those measurements which it is useful to record, and to make use of opportunities which would otherwise be lost. In a brass case, less than three inches square and an inch thick, are contained a clinometer, thermometer, goniometer, level, magnifying lens, measure for wire gauze, plummet, platina scales of various kinds, and an anemometer. The traveller can ascertain by its means the temperature, the force of the wind, the latitude, the position of the rocks, or survey and map his route. The geologist can determine and draw the direction and amount of dip of the rocks, the angles of cleavage and crystallisation, the temperature of springs, or examine by a plate of tourmaline the bottoms of pools or shallow depths along coast lines otherwise invisible to the eye. The miner can survey and level the roof or floor of his workings, and requires only a pencil to map them upon paper. He can ascertain the temperature of the air under ground, discover whether the ventilation is deficient, or see whether the wires of his Davy lamp are in safe condition.

Figs. 1211, 1212 represent the plan and side view of the "metra" when open and ready for use. A is the double compass, and B the level. The arc of the level is

1211



graduated in degrees, and in inches fall per yard. C the sights; D the scales; E the goniometer; E′ the goniometer scale; F the plummet; G the lens, with a telescopic slide underneath to measure wire gauze; H the tourmaline; J the pivots on which the instrument stands; K are the two joints of the brass leg, by which the horizontality of the instrument can be obtained; L is a flat chisel point for entering joints of rock or masonry. This end unscrews exposing a wood-screw (shown by the dotted lines M), by which the leg can be secured to a tree or stand; N is the thermometer, which, like the compass and level, will read correctly to half a degree; O is the screw which holds the top and bottom of the instrument together when they are opened out for use, as in the drawing. Beneath the bottom cover P are placed the anemometer, which consists of a thin sheet of transparent mica suspended by pieces of silk, and underneath the mica is a table of "constants," giving the weights of gases, liquids, and solids, besides some thirty measures and formulæ for steam, boilers, engines, ropes, air, &c. The brass leg is seldom of use, and may be dispensed with. By resting the under edge of the side E E′ on a bed of rock, and turning the instrument till the bubble comes in the middle of the level, the direction of the "strike" or "level course" of the rock will be ascertained instrumentally. E E′ offers a long line to measure the amount of inclination with. To lay down surveys on paper, a line should be ruled, and the edge E E′, laid to it. The paper should then be moved until the ruled line comes exactly north and south, when it can be weighted down. The survey is then made by the compass and the scales on the paper, just as it had been made on the ground without the usual calculation and ruling of parallel lines. A simpler form is made in wood as a clinometer, containing only the compass, level, magnifying glass, and thermometer for the use of geologists.

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 Fahlun, analysed by Rose, afforded silica, 46·22; alumina, 34·52; peroxide (?) of iron, 6·04; potash, 8·22; magnesia, with oxide of manganese, 2·11; fluoric acid, 1·09; water, 0·98.

MICACEOUS IRON; one of the varieties of hæmatite; so called from its micaceous structure. — See IRON.

MICROCOSMIC SALT. A term given to a salt extracted from human urine. 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 crystallising the mixture. A small excess of ammonia aids the crystallisation.

MILK. A well known nutritious fluid, which, as it has no especial use in the arts, need not be described. See BUTTER.

MILL, THE. A name given to the cylinder used by the calico printers, in which the impression is obtained by a process like that of a milling tool, from a cylinder engraved by hand, called *the Die*. See CALICO PRINTING.

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, greyish, 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 super-position 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, in the locality in which it is found, 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 filled 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-Ferté 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 parallelopipeds, 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 apiece, 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.

MILLSTONE GRIT. A geological term applied to a series of coarse sandstone rocks, belonging to the Coal Measure formations. "The term gritstone is perhaps most applicable to the harder sandstones, which consist most entirely of grains of quartz most firmly compacted together, by a purely siliceous cement. The angularity of the particles cannot be taken as a character, since the rock commonly called *millstone grit* is generally composed of perfectly round grains, sometimes as large as peas, and even larger; the stone then commencing to pass into a conglomerate." — *Jukes.*

MINERAL CANDLES. These candles and other products (liquid hydro-carbons) are manufactured by Price's Candle Company, at Belmont and Sherwood, according to processes patented by Mr. Warren De la Rue. The novelty of these substances consists — 1. In the material from which they are obtained. 2. In the method by which they are elaborated. 3. In their chemical constitution.

The *raw material* is a semifluid naphtha, drawn up from wells sunk in the neighbourhood of the river Irrawaddy, in the Burmese empire. The geological characteristics of the locality are sandstone and blue clay. In its raw condition the substance is used by the natives as a lamp-fuel, as a preservative of timber against insects, and as a medicine. Being in part volatile at common temperatures, this naphtha is imported in hermetically-closed metallic tanks, to prevent the loss of any constituent. Reichenbach, Christison, Gregory, Reece, Young, Wiesman (of Bonn), and others have obtained from peat, coal, and other organic minerals, solids and liquids bearing some physical resemblance to those procured from the Burmese naphtha; but the first-named products have, in every instance, been formed by the decomposition of the raw material. The process of De la Rue, is, from first to last, a simple separation, without chemical change.

In the commercial processes, as carried out at the Sherwood and Belmont Works, the crude naphtha is first distilled with steam at a temperature of 212° Fahr.; about one-fourth is separated by this operation. The distillate consists of a mixture of many volatile hydro-carbons; and it is extremely difficult to separate them from each other on account of their vapours being mutually very diffusible, however different may be their boiling points. In practice, recourse is had to a second or third distillation, the products of which are classified according to their boiling points or their specific gravities, which range from ·627 to ·860, the lightest coming over first. It is worthy of notice, that though all these volatile liquids were distilled from the original material with steam of the temperature of boiling water, their boiling points range from 80° Fahr. to upwards of 400° Fahr.

These liquids are all colourless, and do not solidify at any temperature, however low, to which they have been exposed. They are useful for many purposes. All are solvents of caoutchouc. The vapour of the more volatile Dr. Snow has found to be highly anæsthetic. Those which are of lower specific gravity are called in commerce *Sherwoodole* and *Belmontine;* these have great detergent power, readily removing oily stains from silk, without impairing even delicate colours. The distillate of the higher specific gravity is proposed to be used as lamp-fuel; it burns with a brilliant white flame; and, as it cannot be ignited without a wick, even when heated to the temperature of boiling water, it is safe for domestic use.

A small percentage of hydro-carbons, of the benzole series, comes over with the distillates in this first operation. Messrs. De la Rue and Müller have shown that it may be advantageously eliminated by nitric acid. The resulting substances, nitrobenzole, &c., are commercially valuable in perfumery, &c.

After steam of 212° has been used in the distillation just described, there is left a residue, amounting to about three-fourths of the original material. It is fused and purified from extraneous ingredients (which Warren De la Rue and H. Müller have found to consist partly of the colophene series) by sulphuric acid. The foreign substances are thus thrown down as a black precipitate, from which the supernatant liquor is decanted. The black precipitate, when freed from acid by copious washing, has all the characteristic properties of native asphaltum. The fluid is then transferred to a still, and, by means of a current of steam made to pass through heated iron tubes, is distilled at any required temperature. The distillates obtained by this process are classed according to their distilling points, ranging from 300° to 600° Fahr. The distillations obtained, at 430° Fahr. and upwards, contain a solid substance, resembling in colour and in many physical and chemical properties, the paraffine of Reichenbach; like it, it is electric, and its chemical affinity is very feeble: but there are reasons for believing that a difference exists in the atomic constitution of the two substances. The commercial name of *Belmontine* is given to one of the fluids from the Burmese pitch. Candles manufactured from the solid material (*Paraffine*) possess great illuminating power. It is stated that such a candle, weighing $\frac{1}{8}$th lb., will give as much light as a candle weighing $\frac{1}{6}$th lb. made of spermaceti or of stearic acid. Its property of fusing at a very low temperature into a transparent liquid, and not decomposing below 600° Fahr., recommends this substance as the material of a bath for chemical purposes. As to the fluids obtained in the second distillation, already described, they all possess great lubricating properties; and, unlike the common fixed oils, not being decomposable into an acid, they do not corrode the metals, especially the alloys of copper, which are used as bearings of machinery. This aversion to chemical combination, which characterises all these substances, affords, not only a security against the brass-work of lamps being injured by the hydro-carbon burnt in them, but also renders these hydro-carbons the best detergents of common oil lamps. It is an interesting physical fact, that some of the non-volatile liquid hydro-carbons possess the fluorescent property which Stokes has found to reside in certain vegetable infusions.

An important characteristic of the Burmese naphtha is its being almost entirely destitute of the hydro-carbons belonging to the olefiant gas series. See NAPHTHA.

MINERAL STATISTICS of the United Kingdom.

Within our limited space, the following tables will give a satisfactory view of the progress of the mining industries of these islands.

Mr. Carne has given a table of the production of tin in Cornwall from 1750 to 1837. (See TIN.) In the following table, however, we repeat a portion of this, our object being to show the progress of tin mining during the present century, and at the end we continue the returns with much exactness to the present time:—

Produce of British Tin Mines since 1800.

Years.	Tons.	Years.	Tons.	Years.	Tons.	Years.	Tons.
1800	2,522	1815	2,941	1830	4,444	1845	
1801	2,365	1816	3,348	1831	4,300	1846	
1802	2,669	1817	4,121	1832	4,323	1847	
1803	2,960	1818	4,066	1833	4,065	1848	6,613
1804	3,041	1819	3,315	1834	2,989	1849	6,952
1805	2,785	1820	2,990	1835	4,228	1850	6,729
1806	2,905	1821	3,373	1836	4,054	1851	6,143
1807	2,465	1822	3,278	1837	4,790	1852	6,287
1808	2,371	1823	4,213	1838	5,130	1853	5,763
1809	2,548	1824	5,005	1839		1854	5,947
1810	2,036	1825	4,358	1840		1855	6,000
1811	2,385	1826	4,603	1841		1856	6,177
1812	2,373	1827	5,565	1842		1857	6,582
1813	2,324	1828	4,931	1843		1858	6,920
1814	2,611	1829	4,434	1844			

Mr. Carne again informs us that the prices paid to the tinner in Cornwall, between the years 1746 and 1788, varied from 60*s.* the cwt. to 72*s.* the cwt. In a Report of a Select Committee of the House of Lords, on the state of the British Wool Trade, is a table compiled by Edward Charles Hohler, giving the average prices of several articles, amongst others of tin, from 1783 to 1828 inclusive. From this table the following extract is made:—

	£	s.	d.			£	s.	d.	
1783 - -	4	1	7	per cwt.	1810 - -	7	9	8	per cwt.
1789 - -	3	10	3	"	1815 - -	7	3	0	"
1794 - -	5	0	3	"	1820 - -	3	15	9	"
1800 - -	5	4	2	"	1825 - -	4	16	6	"
1805 - -	5	15	8	"					

This does not differ materially from the prices given by Mr. Carne as the prices paid to the tinner in Cornwall: the apparent discrepancies arise from the fact, that the above table is the price of tin in the metal market, therefore we have to add, to the price for tin ore, the cost of bringing it into the metallic state.

The value of the metallic tin produced in 1853, when the price varied from 112*l.* to 118*l.* per ton, may be estimated at 700,000*l.* In 1854, the range of prices, not very different from those of the previous year, gives a total value of 690,000*l.* The average prices of 1855 were — English blocks, 125*l.*; bars, 126*l.*; refined, 129*l.* In 1858 the mean average price was 119*l.* per ton.

The produce of the Copper Mines of Cornwall from the year 1725, *in periods of ten years.*

	Tons of Ore.	Average Price per ton.			Amount realised.
		£	s.	d.	£
From 1725 to 1735 -	64,800	7	15	10	473,500
„ 1735 to 1745 -	75,520	7	8	6	560,106
„ 1745 to 1755 -	98,790	7	8	0	731,457
„ 1755 to 1765 -	169,699	7	6	6	1,243,045
„ 1765 to 1775 -	264,273	6	14	6	1,778,337
„ 1775 to 1785 -	304,133	6	3	0	1,827,106
„ 1785 to 1795* -					
„ 1795 to 1800 -	249,834	8	9	6	2,177,724†

The produce of copper ore has been given by Sir Charles Lemon to the end of 1837. Commencing from that date, the following may be received as an exact statement of the progress of this especial mineral industry. The accounts are made up to the 30th of June in each year specified.

Date	Number of Mines Selling Ore at Ticketings.‡	Total of Ore Sold.				Fine Copper in Ore.				Money Value.			Standard.		
		Tons. 21 cwt.	cwt.	qrs.	lbs.	Tons. 21 cwt.	cwt.	qrs.	lbs.	£	s.	d.	£	s.	d
1838	76	145,688	20	0	0	11,527	4	1	17	857,779	11	0	109	3	0
1839	79	159,551	0	0	0	12,450	18	1	24	932,297	12	6	110	2	0
1840	79	147,266	0	0	0	11,037	16	3	1	792,758	3	6	108	10	0
1841	79	135,090	0	0	0	9,987	2	1	23	819,949	2	0	119	6	0
1842	70	135,581	0	0	0	9,896	3	0	15	822,870	12	0	120	16	0
1843	64	144,806	0	0	0	10,926	1	0	6	804,455	19	0	110	1	0
1844	68	152,667	0	0	0	11,246	14	1	20	815,246	9	6	109	17	0
1845	77	157,000	0	0	0	12,239	2	3	11	835,358	19	6	103	10	0
1846	88	158,913	0	0	0	12,447	16	1	16	886,785	1	6	106	8	0
1847	92	148,674	0	0	0	11,966	8	0	18	830,739	9	0	103	12	0
1848	90	155,616	0	0	0	12,869	19	1	16	825,080	2	6	97	7	0
1849	89	144,938	0	0	0	12,052	17	3	23	716,917	7	0	92	11	0
1850	72	150,890	0	0	0	11,824	0	1	21	814,037	3	0	103	19	0
1851	76	154,299	0	0	0	12,199	16	1	15	808,244	1	6	101	0	0
1852	82	152,802	0	0	0	11,706	16	3	20	828,057	19	6	106	12	0
1853	94	180,095	0	0	0	11,839	14	0	0	1,124,561	2	0	136	16	0
1854	96	180,687	0	0	0	11,779	14	0	0	1,153,756	3	6	140	2	0

For some years the annual produce of the copper mines for each particular year is made up to the end of December. Without this statement it might appear that some discrepancy existed between the returns now given and those published in the *Memoirs of the Geological Survey of Great Britain.* There may be some advantage in giving the sales from our Cornish copper mines for each particular year to

* The produce of the mines for the years 1789 to 1794 cannot be obtained, but the quantities of copper ore sold in the other years of the period were as follows: —

	1786	1787	1788	1794	1795
Years - -	1786	1787	1788	1794	1795
Tons - -	39,895	38,047	31.541	42,815	43,589
Amount - -	£237,237	190,738	150,303	320,875	326,189

† This includes the last five years of the last century only.

‡ Sundry small mines selling under 10 tons are not included in this number

December, 1854; these may be regarded as very close to the truth, the private contract sales having been unimportant.

	Ore.	Copper.				Value.		
	Tons.	Tons.	cwt.	qrs.	lbs.	£	s.	d.
1848	147,701	12,241	19	2	5	720,090	17	0
1849	146,326	11,683	13	0	22	763,614	19	0
1850	155,025	12,253	10	2	21	840,410	16	0
1851	150,380	11,807	8	2	18	782,947	8	6
1852	165,593	11,776	17	2	24	975,975	14	0
1853	181,944	11,913	12	0	12	1,155,167	3	6
1854	184,858	11,979	4	2	21	1,192,696	12	6

The earliest accounts of the Swansea sales which we have been enabled to obtain are from 1804, when first the copper sales were published in the *Cambrian* newspaper. The publication of the printed ticketing papers commenced in 1839. As these returns show a very remarkable extension of the copper trade of Swansea, the amount sold for each year is given.

Copper Ores sold at Swansea from the year 1804 *to* 1847.

Date.	English.	Welsh.	Irish.	Foreign.	Date.	English.	Welsh.	Irish.	Foreign.
	Tons.	Tons.	Tons.	Tons.		Tons.	Tons.	Tons.	Tons.
1804	- -	52			1826	505	1,115	4,271	
1805					1827	508	1,140	7,383	
1806	- -	41	62		1828	320	3,555	8,510	199
1807	- -	68	810		1829	720	6,076	7,044	668
1808	- -	312	1,391		1830	415	1,788	9,115	934
1809	- -	240	530		1831	540	1,442	9,707	975
1810	- -	400	603		1832	646	3,184	11,399	641
1811	- -	88	68		1833	361	1,786	11,293	1,059
1812	- -	622	120		1834	377	3,336	17,280	2,077
1813	- -	442	213		1835	268	3,770	22,123	6,758
1814	- -	321	429		1836	535	1,698	21,013	9,046
1815	77	1,079	700		1837	179	2,216	22,306	14,521
1816	35	600	673		1838	964	3,410	22,161	19,868
1817	- -	422	9		1839	1,812	2,637	23,613	24,092
1818	317	247	349		1840	752	1,525	20,166	35,354
1819	1,796	90	1,531		1841	705	1,180	14,321	41,364
1820	1,408	124	2,200		1842	1,910	857	15,253	44,392
1821	957	191	2,040		1843	756	1,133	17,600	40,739
1822	521	412	1,923		1844	430	700	20,063	45,491
1823	633	564	3,673		1845	622	1,914	19,647	46,643
1824	436	358	4,471		1846	549	1,035	17,553	39,348
1825	2,061	1,191	5,350		1847	406	340	14,373	35,700

The great advance in the quantities of copper ores from Ireland, shows the advantage of a better system of mining in that country than such as had been previously practised. Improvements are still required: there is no doubt but that the mineral resources of Ireland are of the highest order; they only wait further development.

The quantity of Foreign copper ores imported has been steadily increasing. The largest quantities have been produced in the following localities.

Previously to 1848, the total quantities sold at Swansea, of which any returns can be obtained, were as follows: —

Cobre	172,634	tons of 21 cwt	St. Jose in Cobre	8,246	tons of 21 cwt.
Chili -	82,580	"	Burra Burra -	5,389	
Cuba -	36,033	"	Kapunda -	2,354	"
Santiago -	57,230	"	Bacuranco -	1,112	"
Copiapo -	14,887	"	Cobija - -	1,798	"
Valparaiso	9,306	"	Pennsylvania -	1,454	"
Norway -	8,357	"			"

From that year to the end of 1854 the quantities of ore sold at Swansea have been as follows: —

From the Foreign Mines.

Name.	1848.	1849.	1850.	1851.	1852.	1853.	1854.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Cobre - -	17,564	19,409	5,905	14,724	11,106	9,141	12,804
Chili - -	3,398	213	662	421	- -	407	311
Burra Burra -	4,047	7,238	3,405	829	- -	550	
Cuba - -	7,486	2,697	4,548	2,955	3,799	3,829	3,110
Copiapo - -	765	710	875	406	892	796	1,070
Kapunda - -	661	213	949	868	889	893	732
Santiago - -	716	1,518	1,119	2,036	1,272	789	785
Recompensa -	460						
Giburra - -	- -	151					
Kanmantoo -	321	- -	- -	- -	169		
Cabral - -	- -	96	87				
Montacute -	93						
New Zealand -	- -	- -	- -	96			
Parniga - -	82						
Havannah -	- -	209	- -	161	- -	302	
Adelaide - -	33	- -	135	48			
Australian -	40	- -	- -	65	113	- -	102
Cantabra - -	43						
Carridad - -	20						
Kaw-aw - -	- -	307	853	961	209	104	
West Kaw-aw -	- -	- -	- -	423	64		

The recent importations are given under Copper.

From 1847 to 1854, the following Irish mines sold copper ore at Swansea. In the *Mineral Statistics of the United Kingdom*, published annually from the Mining Record Office, these accounts are continued.

Name.	1848.	1849.	1850.	1851.	1852.	1853.	1854.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons
Bearhaven - -	5,872	5,812	6,137	6,969	5,692	5,868	5,030
Knockmahon - -	4,674	2,787	-	3,624	3,471	3,373	4,421
Holyford - - -	302	-	-	-	89	499	555
Ballymurtagh - -	1,449	1,059	370	104	556	455	1,237
Lackamore - -	152	114	101	204	140	-	159
Cronebane - -	137	-	13	-	25	121	50
Gurtnadyne - -	-	-	154	-	-	-	-
Ballinoe - - -	-	-	59	97	-	-	-
Tigrony - - -	-	-	13	-	-	-	-
Connorree - -	-	-	-	-	22	40	-
Galway - - -	-	-	-	-	-	54	-
Cosheen - - -	-	-	-	-	-	-	45
Total quantities of ores sold in each year from the Irish mines by public tickétings at Swansea.	12,586	9,772	6,847	10,998	9,995	10,410	11,505

Number of Copper Mines, and Quantities and Total Value of Ore raised, in each County in England and Wales, and in Ireland, and of Fine Copper produced therefrom, in each of the Years 1854, 1855, 1856, 1857, *and* 1858.

Counties.	Number of Mines. 1854.	1855.	1856.	1857.	1858.	Copper Ore. 1854.	1855.	1856.	1857.	1858.	Fine Copper from Ore raised in each County. 1854.	1855.	1856.	1857.	1858.
ENGLAND AND WALES:						Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Cornwall	110	115	135	134	126	153,033	161,169	164,153	154,334 }	183,416	{ 9,858	10,317	10,731	9,800 }	12,127
Devon	16	19	23	23	21	31,825	34,024	42,024	37,800 }		{ 2,121	2,261	2,802	2,400 }	
Cumberland and Lancashire	2	4	5	4	4	3,185	3,504	3,917	3,516	3,820	213	234	261	380	216
Anglesey	2	2	2	3	3	-	2,552	2,400	9,476	9,807	-	197	160	460	391
Caernarvon	2	3	2	1	2	201	1,673	1,565	1,804	2,198	46	112	104	44	82
Cardigan	4	8	6	9	4	76	104	162	154	62	7	10	11	9	6
Montgomery	-	-	-	-	1	-	-	-	-	110	-	-	-	-	7
Radnor	2	3	2	-	-	9	162	104	-	-	2	11	7	-	
Isle of Man	1	-	1	2	1	64	-	31	429	389	3	-	2	31	23
Cheshire	-	-	-	1	1	-	-	-	820	8,007	-	-	-	24	122
Total for England and Wales	139	154	176	177	143	188,393	203,188	214,356	208,333	207,809	12,250	13,142	14,078	13,148	12,974
						Estimated Value.									
	-	-	-	-	-	£ 1,222,504	£ 1,324,309	£ 1,293,827	£ 1,300,271	£ 1,209,467	£ 1,531,250	£ 1,880,620	£ 1,731,594	£ 1,630,352	£ 1,401,192
IRELAND:						Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Cork	5	6	3	3	1	5,247	5,530	6,149	5,122	5,303	509	546	613	922	516
Tipperary	2	1	1	1	2	714	475	443	268	363	112	81	80	47	49
Waterford	1	1	1	1	2	4,421	4,343	3,987	3,289	4,754	435	449	399	350	460
Wicklow*	4	3	6	6	3	1,357	2,033	979	1,350	3,851	70	80	61	100	137
Galway	-	-	-	-	-	-	-	32	-	128	-	-	1	-	
Clare	-	-	-	-	2	-	-	-	-	-	-	-	-	-	8
Total for Ireland	12	11	11	11	10	11,739	12,381	11,590	10,029	14,399	1,126	1,156	1,154	1,419	1,170
						Estimated Value.									
	-	-	-	-	-	£ 128,052	£ 125,980	£ 115,393	£ 61,981	£ 100,244	£ 140,750	£ 165,423	£ 141,942	£ 175,956	£ 126,360
Copper ores purchased by private contract from sundry districts, not included above	-	-	-	-	12	Tons. 97,845	Tons. 104,940	Tons. 135,375	Tons. 31,509	Tons. 4,644	Tons. 6,523	Tons. 6,996	Tons. 9,025	Tons. 2,808	Tons. 312
						Estimated Value.									
	-	-	-	-	-	£ 133,250	£ 190,100	£ 335,296	£ 198,670	£ 26,824	£ 815,375	£ 996,834	£ 1,110,075	£ 348,192	£ 35,141
Total for England and Wales and Ireland	151	165	187	188	164	Tons. 297,977	Tons. 320,509	Tons. 361,321	Tons. 250,871	Tons. 226,852	Tons. 19,899	Tons. 21,294	Tons. 24,257	Tons. 17,375	Tons. 14,456
						Estimated Value.									
	-	-	-	-	-	£ 1,483,806	£ 1,640,389	£ 1,744,516	£ 1,560,922	£ 1,336,53[illegible]	£ 2,487,375	£ 3,042,877†	£ 2,983,611	£ 2,154,500	£ 1,562,69[illegible]

* In addition to these copper ores, 32 tons of copper were separated from about 3,000 tons of iron pyrites (sulphur ores) of Wicklow. † The price of copper in 1855 was exceedingly high.

Number of Lead Mines (selling Ore), Quantities amd total Value of Ore raised and of Metallic Lead produced therefrom in each County in England, Wales, Scotland, and Ireland, in each of the Years 1854, 1855, 1856, 1857, *and* 1858.

Counties.	Number of Mines (selling Ore).					Lead Ore.							Metallic Lead from Ore raised in each County.						
	1854.	1855.	1856.	1857.	1858.	1854.	1855.	1856.	1857.		1858.		1854.	1855.	1856.	1857.		1858.	
						Tons.	Tons.	Tons.	Tons.	Cwts.	Tons.	Cwts.	Tons.	Tons.	Tons.	Tons.	Cwts.	Tons.	Cwts.
ENGLAND:																			
Cornwall - - -	41	29	42	30	23	7,460	8,962	9,973	9,559	16	9,710	0	5,005	5,882	6,597	6,036	7	5,436	15
Devon - - -	15	14	14	9	9	4,139	4,035	3,138	2,590	11	2,779	6	2,612	2,292	2,000	1,535	14	1,695	4
Cumberland - -	84	71	73	62	61	9,890	9,627	7,311	6,450	0	7,235	13	6,622	6,929	5,321	4,791	8	5,207	14
Durham and Northumberland - -	39	32	34	31	30	22,329	22,107	24,125	21,580	1	19.999	2	16,669	16,309	17,674	17,073	14	16,776	7
Westmoreland - -	6	4	11	10	6	383	319	2,923	2,798	10	2,190	9	289	241	2,179	2,102	20	1,673	15
Derby* - - -	-	-	-	-	-	7,554	8,527	9,524	9,233	0	10,466	0	4,508	5,798	6,261	6,061	0	6,277	0
Shropshire - -	10	9	9	7	11	3,797	3,310	4,407	3,349	15	3,994	12	2,765	2,420	3,228	2,560	15	2,993	7
York - - -	10	14	14	14	14	9,244	9,378	12,174	12,405	19	11,480	20	6,476	6,369	8,986	7,875	12	7,605	18
Somerset - - -	-	-	1	3	4	-	-	750	485	10	1,000	0	-	-	500	350	20	435	0
Total - -	205	173	198	166	158	64,796	66,265	74,325	68,452	19	68,855	20	44,986	46,240	52,746	48,388	5	48,100	17
WALES:																			
Cardigan - - -	42	36	47	35	25	7,034	7,043	8,560	7,572	20	7,086	12	4,948	5,014	6,191	5,509	12	5,440	3
Carmarthen - -	4	3	3	3	3	901	1,137	1.280	1,081	0	1,328	12	666	763	932	776	10	934	7
Denbigh - - -	2	2	2	7	8	1,824	2,401	3,103	4,181	0	4,749	20	1,363	1,929	2,367	3,240	20	3,7[illegible]8	5
Flint - - -	40	32	48	26	27	7,027	6,273	4.607	3,006	10	3,696	11	5,408	4,926	3,513	2,280	14	2.839	2
Montgomery - -	11	11	12	11	9	1,184	1,087	1,723	2,389	12	1,975	7	894	847	1,349	1,839	5	1,495	20
Merioneth - -	2	1	7	4	2	98	48	349	332	10	326	12	63	38	266	250	4	244	4
Glamorgan - -	2	1	-	-	-	62	12	-	-	-	-	-	45	9					
Brecknock - -	-	1	-	-	-	-	24	-	-	-	-	-	-	20					
Radnor - - -	-	1	2	2	2	-	24	12	108	10	102	3	-	16	8	81	5	76	9
Caernarvon - -	-	4	3	8	5	-	155	237	441	17	289	12	-	111	163	320	13	202	20
Total - -	103	92	124	96	81	18,130	18,204	19,871	19,113	16	19,555	5	13,387	13,673	14,789	14,298	20	14,961	7
ISLE OF MAN - -	4	3	4	4	4	2,800	3,573	3,217	2,656	0	2,457	0	2,137	2,725	2,450	2,027	15	1,880	20

* The number of mines in Derbyshire is not known, but the ore is generally obtained from small workings, producing only from a few cwts. to two or three tons per annum.

Number of Lead Mines, &c.—continued.

Counties.	Number of Mines (selling Ore					Lead Ore.							Metallic Lead from Ore raised in each County.						
	1854.	1855.	1856.	1857.	1858.	1854.	1855.	1856.	1857.		1858.		1854.	1855.	1856.	1857.		1858.	
						Tons.	Tons.	Tons.	Tons.	Cwts.	Tons.	Cwts.	Tons.	Tons.	Tons.	Tons.	Cwts.	Tons.	Cwts.
SCOTLAND:																			
Argyle - - -	1	1	2	1	1	174	100	148	51	0	44	5	131	74	109	39	5	34	0
Kirkcudbright - -	4	4	4	4	3	522	355	320	238	20	235	5	383	259	252	173	4	166	16
Lanark - - -	1	1	1	2	1	262	324	525	689	10	1,087	0	169	210	355	456	6	717	16
Dumfries - - -	1	1	1	1	1	759	808	808	850	0	870	0	596	616	606	640	0	630	0
Perth - - -	-	-	1	1	1	- -	- -	130	61	0	54	0	- -	- -	94	42	10	37	0
Total - -	7	7	9	9	7	1,753	1,587	1,931	1,890	9	2,290	10	1,279	1,159	1,416	1,351	4	1,585	11
IRELAND:																			
Clare - - -	2	2	-	-	2	165	55	- -	-	-	40	11	121	31	- -	-	-	27	16
Down - - -	1	1	1	1	1	1,379	734	602	453	4	323	14	1,084	590	430	363	10	242	10
Louth - - -	2	-	-	-	-	55	- -	- -	-	-	-	-	41						
Limerick - - -	1	-	-	-	-	142	- -	- -	-	-	-	-	95						
Wicklow - - -	3	2	2	2	2	1,328	1,324	1,520	1,653	0	2,054	17	869	930	933	915	10	1,317	0
Antrim - - -	-	1	-	-	-	- -	31	- -	-	-	-	-	- -	23					
Donegal - - -	-	2	-	-	-	- -	23	- -	-	-	-	-	- -	15					
Kerry - - -	-	1	-	-	-	- -	110	- -	-	-	-	-	- -	55					
Moneghan - -	-	-	-	-	2	- -	- -	- -	-	-	31	0	- -	- -	- -	-	-	21	15
Tipperary - -	-	2	-	-	-	- -	128	- -	-	-	-	-	- -	88					
Cork - - -	-	-	1	-	-	- -	- -	50	-	-	-	-	- -	- -	32				
Waterford - -	-	-	3	2	2	- -	- -	311	162	15	84	10	- -	- -	206	107	4	54	0
Armagh - - -	-	-	-	1	1	- -	- -	- -	30	0	69	0	- -	- -	- -	21	0	42	0
Total - -	9	11	7	6	10	3,069	2,405	2,483	2,298	19	2,603	10	2,210	1,732	1,601	1,407	3	1,704	20
Sundries - - -	-	-	-	-	-	- -	- -	170	-	-	-	-	- -	- -	127				
Total - -	328	286	342	281	250	90,553	92,330	101,997	94,412	12	95,855	18	64,005	65,529	73,129	67,393	5	68,303	12
						Estimated Value.													
						£ 1,110,721	£ 1,311,971	£ 1,431,509	£ 1,428,095		£ 1,370,726		£ 1,497,717	£ 1,516,996	£ 1,755,096	£ 1,523,852		£ 1,489,005	

Quantities and total Value of Silver extracted from Lead Ore raised in each County in England and Wales, the Isle of Man, Scotland, and Ireland, in each of the Years 1854, 1855, 1856, 1857, *and* 1858.

Counties, &c.	1854.	1855.	1856.	1857.	1858.
ENGLAND:	Oz.	Oz.	Oz.	Oz.	Oz.
Cornwall	176,675	211,348	248,436	224,277	223,189
Devon	119,288	89,908	77,456	50,262	53,366
Cumberland	42,020	62,879	51,931	43,460	43,721
Durham and Northumberland	78,577	75,435	79,924	74,091	78,238
Westmoreland	80	140	23,860	24,808	22,508
Derbyshire	-	-	-	-	3,000
Shropshire	184				
York	-	273	302	445	1,657
Somersetshire	-	-	-	-	1,295
Total for England	416,824	439,983	481,909	417,343	426,974
WALES:					
Cardigan	32,418	28,079	38,751	37,097	41,100
Carmarthen	-	868	-	2,032	3,263
Denbigh	1,455	1,180	1,034	2,206	3,176
Radnor	-	-	-	-	304
Flint	28,588	25,823	19,340	13,297	18,797
Montgomery	3,238	1,269	2,660	4,825	3,173
Merioneth	-	266	572	640	1,341
Glamorgan	352	36	-		
Caernarvon	-	-	-	-	439
Total for Wales	66,051	57,521	62,357	60,097	71,593
ISLE OF MAN	52,262	51,597	60,382	48,016	46,985
SCOTLAND	5,426	4,947	5,282	4,206	4,882
IRELAND	18,096	7,252	3,700	3,071	14,361
Sundries	-	606	550	133	300
Silver from silver ore	-	-	-	-	4,250
Total for United Kingdom	558,659	561,906	614,180	532,866	569,345
	Estimated Value.				
	£ 140,664	£ 140,476	£ 153,170	£ 133,216	£ 156,569

Number of Mines, Quantity of Ore raised, and of White Tin produced therefrom, in England, in each of the Years 1854, 1855, 1856, 1857, *and* 1858.

Counties.	Number of Mines.*					Tin Ore.					White Tin from Ore raised in each County.				
	1854.	1855.	1856.	1857.	1858.	1854.	1855.	1856.	1857.	1858.	1854.	1855.	1856.	1857.	1858.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Cornwall - - -	121	129	144	131	133	8,447	8,627	9,114	9,613	9,905	5,743	5,785	5,987	6,310	6,456
Devon - - - -	18	27	16	4	4	300	325	236	95	54	204	215	190	70	36
Total -	139	156	160	135	137	8,747	8,952	9,350	9,708	9,959	5,974	6,000	6,177	6,380	6,491
	Estimated Value.														
	- -	- -	- -	- -	- -	£ 559,808	£ 608,736	£ 663,850	£ 748,158	£ 633,501	£ 690,000	£ 720,000	£ 821,541	£ 867,680	£ 772,429

* The number of mines only includes those which have paid dues to the Stannary Court within the year; a few other mines, selling small parcels of tin ore, may not have made their returns until the following year.

Quantities and Total Value of Iron Ore raised, in each County in England and Wales, and in Scotland and Ireland, in each of the Years 1855, 1856, 1857, *and* 1858.

Counties.	1855.	1856.	1857.	1858.
ENGLAND AND WALES:	Tons.	Tons.	Tons.	Tons.
Northumberland, Durham - - - -	185,000	495,500	500,000	20,924
Cumberland and Lancashire - - - -	537,616	732,109	926,315	787,184
York, West Riding - - - - - - -	255,000	242,100	207,500	189,750
,, North ,, - - - - - - -	970,300	1,197,417	1,414,155	1,367,395
Derby - - - - - - - - -	409,500	392,400	550,500	328,950
Stafford - - - - - - - - -	2,500,000	2,725,000	1,664,862	1,658,947
Buckingham - - - - - - - -	- -	- -	2,500 }	
Northampton - - - - - - - -	74,084	91,592	58,079 }	140,485
Warwick - - - - - - - - -	- -	48,000	40,000	29,500
Shropshire - - - - - - - - -	365,000	335,700	320,500	150,500
Flint, &c. - - - - - - - - -	65,820	68,464	150,374	88,575
South Wales - - - - - - - -	1,665,500	1,784,700	1,038,241	752,231
Gloucester - - - - - - - - -	92,608	109,268	127,554	107,652
Somerset - - - - - - - - -	4,940	14,620	25,842	26,041
Wilts - - - - - - - - -	- -	15,000	15,500	9,822
Hants - - - - - - - - -	- -	13,000	7,000	6,933
Devon - - - - - - - - -	1,500	4,100	2,000	4,754
Cornwall - - - - - - - - -	24,057	22,650	19,359	5,150
Total for England and Wales - - -	7,150,925	8,291,620	7,070,281	5,724,793
ISLE OF MAN - - - - - - - - -	2,240	- -	- -	566
SCOTLAND - - - - - - - - -	2,400,000	2,201,250	2,500,000	2,312,000
IRELAND - - - - - - - - -	576	441	3,000	3,600
Total for United Kingdom - -	9,553,741	10,493,311	9,573,281	8,040,959
	Estimated Value.			
	£ 5,254,557	£ 5,695,815	£ 3,829,312	£ 2,570,701

Note.—The returns of iron ore raised in 1854 are not sufficiently complete for comparison with those of subsequent years. In 1855 and 1856, the estimated values were made from the cost at the furnace 1857 and 1858 are from prices at the place of production.

Quantities and Total Value of Pig Iron made, in each County in England and Wales, and in Scotland, in each of the Years 1854, 1855, 1856, 1857, *and* 1858.

Counties.	1854.	1855.	1856.	1857.	1858.
ENGLAND AND WALES:	Tons.	Tons.	Tons.	Tons.	Tons.
Northumberland, Durham, and North Yorkshire - - -	275,000	214,020	331,370	527,588	499,816
Cumberland and Lancashire -	20,000	16,574	25,530	31,748	29,104
York, West Riding - - -	73,444	175,340	275,600	117,000	85,936
Derby - - - - - -	127,500	116,550	106,960	112,160	131,577
Stafford and Worcester - -	847,600	855,500	907,731	791,352	733,117
Shropshire - - - - -	124,800	121,680	109,722	117,141	101,016
Flint, &c. - - - - -	32,900	31,420	47,682	37,049	28,150
South Wales - - - -	750,000	840,070	877,150	970,727	886,478
Gloucester - - - - -	21,990	19,500	24,132	23,882	23,580
Somerset and Wiltshire - -	- -	- -	- -	300	2,040
Northampton - - - -	- -	- -	- -	11,500	9,750
Total for England and Wales	2,273,234	2,390,654	2,705,877	2,740,447	2,530,564
SCOTLAND - - - - - -	796,604	827,500	880,500	918,000	925,500
IRELAND - - - - - -	- -	- -	- -	1,000	
Total for Great Britain -	3,069,838	3,218,154	3,586,377	3,659,447	3,456,064
	Estimated Value.				
	£ 12,279,325	£ 12,872,616	£ 14,345,508	£ 12,838,560	£ 10,713,798

Number of Collieries and Quantities and total Value of Coals raised in each County in England, and in Wales, Scotland, and Ireland, in each of the Years 1854, 1855, 1856, 1857, *and* 1858.

Counties.	Number of Collieries.					Quantities of Coals raised.				
	1854	1855	1856	1857	1858	1854	1855	1856	1857	1858
						Tons.	Tons.	Tons.	Tons.	Tons.
England.										
Northumberland and Durham - - -	225	273	270	268	275	15,420,615	15,431,400	15,492,969	15,826,525	15,853,484
Cumberland -	23	23	28	28	28	887,000	809,549	913,891	942,018	920,137
York - - -	276	333	399	374	383	7,260,500	7,747,470	9,083,625	8,875,440	8,302,150
Derby - -	123	171	176	194	184	2,406,696	2,256,000	3,293,325	3,687,442	3,960,750
Nottingham -	17	20	24			813,474	809,400			
Warwick -	15	17	16	16	17	255,000	262,000	335,000	398,000	356,500
Leicester - -	11	11	14	14	14	439,000	425,000	632,478	698,750	750,000
Stafford and Worcester -	516	500	548	563	548	7,500,000	7,323,000	7,305,500	7,164,625	6,680,780
Lancashire -	333	357	359	359	380	9,080,500	8,950,000	8,950,000	8,565,500	8,050,000
Cheshire - -	30	32	31	31	35	786,500	755,500	754,327	750,500	695,450
Shropshire -	48	56	55	55	57	1,080,000	1,105,250	752,100	750,000	749,360
Gloucester -		55	56	62	59					
Somerset - -	87	31	29	35	35	1,492,366	1,430,620	1,530,000	1,225,000	1,125,250
Devon - -		2	2	2	2					
Total for England - -	1704	1881	2007	2001	2017	47,421,651	47,365,189	49,043,215	48,883,800	47,443,861
Wales { North	60	65	91	84	81	1,143,000	1,125,000	1,046,500	1,046,500	1,022,500
Wales { South	246	245	304	325	352	8,500,000	8,552,270	8,919,100	7,132,304	7,495,289
Total for Wales	306	310	395	409	433	9,643,000	9,677,270	9,965,600	8,178,804	8,517,789
Scotland -	368	403	405	425	417	7,448,000	7,325,000	7,500,000	8,211,473	8,926,249
Ireland - -	19	19	22	70	74	148,750	145,620	136,635	120,630	120,750
Total for U. Kingdom -	2397	2613	2829	2905	2941	64,661,401	64,453,079	66,645,450	65,394,707	65,808,649
						Estimated Value at the Pits.				
	-	-	-	-	-	£ 16,165,350	£ 16,113,267	£ 16,663,862	£ 16,348,676	£ 16,252,162

Quantities and estimated Value at the Place of Production of the principal Minerals and Metals produced in the United Kingdom in each of the Years 1854, 1855, 1856, 1857, *and* 1858.

		Coal.	Copper, fine.*	Iron, pig.*	Lead, metallic.*	Tin, white.*	Silver from Lead.*
		Tons.	Tons.	Tons.	Tons.	Tons.	Ozs.
Quantities produced -	1854	64,661,401	19,899	3,069,838	64,005	5,974	558,659
	1855	61,453,079	21,294	3,218,154	65,529	6,000	561,966
	1856	66,445,450	24,257	3,586,377	73,129	6,177	614,180
	1857	65,394,707	17,375	3,659,447	67,393	6,380	532,866
	1858	65,008,649	14,456	3,456,064	68,303	6,491	569,345
		£	£	£	£	£	£
Estimated value - -	1854	16,165,350	2,487,375	12,279,325	1,497,717	690,000	140,664
	1855	16,113,267	3,042,877	12,872,616	1,516,996	720,000	140,476
	1856	16,663,862	2,983,611	14,345,508	1,755,096	821,541	153,470
	1857	16,348.676	2,154,500	12,838,560	1,523,852	867,680	133,216
	1858	16,252,162	1,562,693	10,713,798	1,489,005	772,429	156,569

* Produced from British ores.

It appears desirable to give a permanent record of the accidents in coal mines:—

Number and Nature of Accidents in Coal Mines, and Deaths therefrom, in the several Coal Districts of Great Britain, in each of the Years 1854, 1855, 1856, *and* 1857.

Nature of Accidents.	England and Wales.										
	Northumberland, Durham, and Cumberland.			South Durham.*		Yorkshire.			Derby, Nottingham, Leicester, and Warwick.		
	1851	1855	1856	1856	1857	1855	1856	1857	1855	1856	1857
	Accidents.										
In the mines:											
Explosions of fire-damp	8	12	-	3	2	11	6	6	3	3	4
,, gunpowder	-	2	-	-	2	-	2	2			
Suffocation by gases	2	1	-	-	-	1	-	-	-	-	2
Fall of material in mines:											
Of coal	11	11	8	2	4	12	6	7	7	8	6
,, stone	32	41	28	22	20	15	13	19	13	13	7
Total fall of material	43	52	36	24	24	27	19	26	20	21	13
In shafts:											
Overwinding	-	-	1	-	-	1					
Ropes and chains breaking	-	-	-	1	1	5	3	2			
Whilst ascending or descending	7	14	3	-	1	}7	8	5	-	2	2
Falling into shaft from surface	9	14	5	3	2				11	6	3
Things falling from surface	3	2	1	-	-	}3	3	-	—		
Falling from part way down	3	-	1	2	2				1	1	1
Miscellaneous	-	-	-	2	9	1	2	-	5	4	
Total in shafts	22	30	11	8	15	17	16	7	17	13	6
Irruptions of water	-	-	-	-	-	}-	1	-	1		
Falling into water	-	-	-	-	-				-	-	1
On inclines underground	3	5	3	5	9	}2	2	5	-	1	
By trams ,,	19	20	6	6	14				4	1	4
,, machinery ,,	1	2	1								
Miscellaneous ,,	1	3	-	-	2	-	-	-	1	3	
Total in mines	99	127	57	46	68	58	46	46	46	42	30
On the surface:											
By machinery	13	12	9	5	1	2	1	-	1	-	1
Boilers bursting	3	2	5	4	1	-	-	2	-	1	
Miscellaneous	2	-	-	5	5	-	-	2	1	-	1
Total on the surface	18	14	14	14	7	2	1	4	2	1	2
Total accidents	117	141	71	60	75	60	47	50	48	43	32
	Deaths from Accidents.										
In the mines:											
Explosions of fire-damp	11	15	-	3	2	13	7	198	3	3	15
,, gunpowder	-	2	-	-	2	-	2	2			
Suffocation by gases	2	1	-	-	-	1	-	-	-	-	13
Fall of material in mines:											
Of coal	12	11	8	2	4	13	6	7	7	8	6
,, stone	34	42	28	23	20	15	13	19	13	13	8
Total fall of material	46	53	36	25	24	28	19	26	20	21	14
In shafts:											
Overwinding	-	-	1	-	-	1					
Ropes and chains breaking	-	-	-	1	1	6	3	4			
Whilst ascending or descending	13	17	5	-	1	8	9	5	-	2	2
Falling into shaft from surface	10	11	5	3	2				11	6	3
Things falling from surface	2	2	1	-	-	4	5	-	—		
Falling from part way down	1	-	1	2	2				1	1	1
Miscellaneous	-	-	-	2	10	1	2	-	5	7	
Total in shafts	26	33	13	8	16	20	19	9	17	16	6
Irruptions of water	}-	-	-	-	-	-	2	-	1		
Falling into water									-	-	1
On inclines underground	3	5	3	6	9	}2	2	5	-	1	
By trams ,,	19	20	6	6	11				4	1	4
,, machinery ,,	1	2	1	-	-						
Miscellaneous ,,	1	3	-	-	5	-	-	-	2	3	
Total in mines	109	134	59	48	72	64	51	240	47	45	53
On the surface:											
By machinery	13	12	9	5	1	2	1	-	1	-	1
Boilers bursting	3	2	5	4	2	-	-	3	-	1	
Miscellaneous	2	-	-	5	5	-	-	2	1	-	1
Total on the surface	18	14	14	14	8	2	1	5	2	1	2
Total deaths	127	148	73	62	80	66	52	245	49	46	55

* Previous to 1856 the South Durham district was included with Northumberland, Durham, and Cumberland.

Number and Nature of Accidents in Coal Mines, and Deaths therefrom, in the several Coal Districts of Great Britain, in each of the Years 1854, 1855, *and* 1856—continued.

Nature of Accidents.	England and Wales.											
	North and East Lancashire (Manchester).			West Lancashire (North Wales).			North Staffordshire, Shropshire, and Cheshire.			South Staffordshire and Worcestershire.		
	1854	1855	1856	1855	1856	1857	1854	1855	1856	1854	1855	1856
	Accidents.											
In the mines:												
Explosions of fire damp	13	16	18	8	9	12	7	12	7	10	12	11
,, gunpowder	1	3	1	6	3	4	-	2	2	2	2	1
Suffocation by gases	-	1	2	1	1	-	1	-	1	3	1	2
Fall of materials in mines:												
Of coal	22	28	20	7	2	-	6	8	8	83	67	56
,, stone				20	34	33	9	11	8	15	19	31
Total fall of material	22	28	20	27	36	33	15	19	16	98	86	87
In shafts:												
Overwinding	1	-	1	-	1	2	-	1	1	2	3	1
Ropes and chains breaking	2	2	1	1	2	2	-	1	-	3	-	4
Whilst ascending or descending	8	11	7	10	4	4						
Falling into shaft from surface	3	1	1	5	5	8	10	1	8	20	19	6
Things falling from surface	1	-	1	-	1	1	4	5	5	6	3	6
Falling from part way down	5	2	4	5	7	3	7	3	6	7	8	8
Miscellaneous	6	4	4	1	1	-	-	-	-	-	1	1
Total in shafts	26	20	19	22	21	20	21	11	20	38	34	26
Irruptions of water	-	-	1	1	1	-	-	-	1	-	1	
Falling into water	-	-	-	2	-	-	2	1	-	-	4	3
On inclines underground	1	2	4	1	3	4	1	1	4	-	1	
By trams ,,	-	1	3	4	2	-	1	2	2	-	-	
,, machinery ,,	2	-	1	-	-	-	1	-	1	-	1	2
Miscellaneous ,,	-	-	-	3	-	-	1	-	-	2	2	4
Total in mines	65	71	69	75	76	73	50	48	54	153	144	136
On the surface:												
By machinery	6	4	4	2	3	1	3	1	7	6	2	
Boilers bursting	-	-	-	1	1	-	-	-	-	-	2	
Miscellaneous	2	3	-	4	1	7	-	-	-	-	-	2
Total on the surface	8	7	4	7	5	8	3	1	7	6	4	2
Total accidents	73	78	73	82	81	81	53	49	61	159	148	138
	Deaths from Accidents.											
In the mines:												
Explosions of fire damp	18	20	24	13	12	30	11	27	8	11	21	21
,, gunpowder	1	3	1	7	3	4	-	3	2	2	2	1
Suffocation by gases	-	1	2	2	1	-	1	-	1	4	2	2
Fall of material in mines:												
Of coal	22	30	22	8	4	-	8	8	8	93	80	57
,, stone				20	38	33	10	11	11	15	19	31
Total fall of material	22	30	22	28	42	33	18	19	19	108	99	88
In shafts:												
Overwinding	1	-	1	-	2	2	-	2	1	2	4	1
Ropes and chains breaking	9	3	4	1	2	3	-	2	-	5	-	11
Whilst ascending or descending	9	14	7	12	4	9						
Falling into shaft from surface	3	1	1	5	5	8	10	1	8	20	19	6
Things falling from surface	1	-	1	-	1	1	4	5	5	6	3	6
Falling from part way down	5	2	4	5	8	3	7	3	6	9	8	8
Miscellaneous	7	4	4	1	1	-	-	-	-	-	1	1
Total in shafts	35	24	22	24	23	26	21	13	20	42	35	33
Irruptions of water	-	-	1	7	13	-	-	-	3	..	2	
Falling into water	-	-	-	2	-	-	2	1	-	-	4	3
On inclines underground	1	2	4	1	3	4	1	1	4	-	1	
By trams ,,	-	1	3	4	2	-	1	2	2	-	-	
,, machinery ,,	2	-	1	-	-	-	1	-	1	-	1	2
Miscellaneous ,,	-	-	-	3	-	-	1	-	-	2	2	4
Total in mines	79	81	80	91	99	97	57	66	60	169	169	154
On the surface:												
By machinery	6	5	4	2	3	1	3	1	10	7	2	
Boilers bursting	-	-	-	1	2	-	-	-	-	-	5	
Miscellaneous	2	3	-	4	1	7	-	-	-	-	-	2
Total on the surface	8	8	4	7	6	8	3	1	10	7	7	2
Total deaths	87	89	84	98	105	105	60	67	70	176	176	156

Number and Nature of Accidents in Coal Mines, and Deaths therefrom, in the several Coal Districts of Great Britain in each of the Years 1854, 1855, *and* 1856—continued.

Nature of Accidents.	England and Wales.							
	South West of England.			South Wales.			Total England and Wales.*	
	1854.	1855.	1856.	1854.	1855.	1856.	1855.	1856.
	Accidents.							
In the mines:								
Explosions of fire damp	7	4	3	6	12	8	90	68
,, gunpowder	-	-	-	1	-	2	15	11
Suffocation by gases	-	-	2	1	-	1	5	9
Fall of materials in mines:								
Of coal	9	15	11	14	25	35		
,, stone	20	35	19	25	26	20		
Total fall of material	29	50	30	39	51	55	360	344
In shafts:								
Overwinding	-	-	-	-	1	-	6	5
Ropes and chains breaking	2	3	1	-	-	1	12	13
Whilst ascending or descending	7	1	6	2	6	4	} 104	78
Falling into shaft from surface	3	-	3	4	4	7		
Things falling from surface	1	-	-	4	4	2	} 37	49
Falling from part way down	5	1	1	-	-	-		
Miscellaneous	2	2	1	2	3	-	17	15
Total in shafts	20	7	12	12	18	14	176	160
Irruptions of water	-	1	-	1	2	-	} 15	7
Falling into water	1	1	-	-	1	-		
On inclines underground	-	-	-	4	1	3	} 54	51
By trams	1	3	2	6	7	2		
,, machinery ,,	-	3	-	-	-	-	6	3
Miscellaneous ,,	-	1	1	-	4	2	14	10
Total in mines	58	70	50	70	96	87	735	663
On the surface:								
By machinery	-	1	-	3	3	-	28	29
Boilers bursting	-	-	-	-	-	1	5	12
Miscellaneous	-	-	1	4	5	6	13	15
Total on the surface	-	1	1	7	8	7	46	56
Total accidents	58	71	51	77	104	94	781	719
	Deaths from Accidents.							
In the mines:								
Explosions of fire damp	8	4	13	10	17	136	133	227
,, gunpowder	-	-	-	1	-	2	17	11
Suffocation by gases	-	-	6	1	-	1	7	13
Fall of material in mines:								
Of coal	9	15	11	14	25	35		
,, stone	21	36	19	25	26	21		
Total fall of material	30	51	30	39	51	56	379	358
In shafts:								
Overwinding	-	-	-	-	8	-	15	6
Ropes and chains breaking	2	5	1	-	-	2	17	24
Whilst ascending or descending	14	2	6	2	7	4	} 115	81
Falling into shaft from surface	3	-	3	4	4	7		
Things falling from surface	1	-	-	4	4	2	} 38	52
Falling from part way down	5	1	1	-	-	-		
Miscellaneous	2	2	1	2	3	-	17	18
Total in shafts	27	10	12	12	26	15	202	181
Irruptions of water	-	1	-	2	2	-	} 22	22
Falling into water	1	1	-	-	1	-		
On inclines underground	-	-	-	4	1	3	} 54	52
By trams ,,	1	3	2	6	7	2		
,, machinery ,,	-	3	-	-	-	-	6	3
Miscellaneous ,,	-	1	1	-	4	2	15	10
Total in mines	67	74	64	75	109	217	835	877
On the surface:								
By machinery	-	1	-	3	3	-	29	32
Boilers bursting	-	-	-	-	-	1	8	13
Miscellaneous	-	-	1	4	5	6	13	15
Total on the surface	-	1	1	7	8	7	50	60
Total deaths	67	75	65	82	117	224	885	937

* The total for England can only be given for 1855 and 1856, the returns for the several districts not having been made for the same years.

Number and Nature of Accidents in Coal Mines, and Deaths therefrom, in the several Coal Districts of Great Britain, in each of the Years 1854, 1855, *and* 1856 — continued.

Nature of Accidents.	Scotland.								Total Great Britain.†	
	Eastern District.*			Western District.		Total Scotland.				
	1855	1856	1857	1856	1857	1855	1856	1857	1855	1856
	Accidents.									
In the mines:										
Explosions of fire damp	6	2	1	3	7	6	5	8	96	73
,, gunpowder	2	-	1	1	1	2	1	2	17	12
Suffocation by gases	1	-	-	-	-	1	-	-	6	9
Fall of material in mines:										
Of coal	8	6	7	6	7	8	12	14		
,, stone	18	12	13	20	8	18	32	21		
Total fall of material	26	18	20	26	15	26	44	35	386	388
In shafts:										
Overwinding	-	2	1	3	-	-	5	1	6	10
Ropes and chains breaking	1	-	1	1	2	1	1	3	13	14
Whilst ascending or descending	8	7	6	2	3	8	9	9 }	116 }	92 }
Falling into shaft from surface	4	5	-	-	3	4	5	3 }		
Things falling from surface	7	1	1	-	1	7	1	2 }	47 }	54 }
Falling from part way down	3	2	1	2	2	3	4	3 }		
Miscellaneous	1	-	1	4	1	1	4	2	18	19
Total in shafts	24	17	11	12	12	24	29	23	200	189
Irruptions of water	1	-	1	1	-	1	1	1 }	16 }	8 }
Falling into water	-	-	-	-	-	-	-	- }		
On inclines underground	1	-	-	-	1	1	-	1 }	55 }	51 }
By trams ,,	-	-	-	-	1	-	-	1 }		
,, machinery ,,	-	1	-	-	-	-	1	-	6	4
Miscellaneous ,,	-	-	-	-	-	-	-	-	14	10
Total in mines	61	38	34	43	37	61	81	71	796	744
On the surface:										
By machinery	-	4	-	2	-	-	6	-	28	35
Boilers bursting	-	-	-	-	-	-	-	-	5	12
Miscellaneous	-	-	-	-	-	-	-	-	13	15
Total on the surface	-	4	-	-	-	-	6	-	46	62
Total accideuts	61	42	34	45	37	61	87	71	842	806
	Deaths from Accidents.									
In the mines:										
Explosions of fire damp	7	6	1	3	8	7	9	9	140	236
,, gunpowder	3	-	1	1	2	3	1	3	20	12
Suffocation by gases	1	-	-	-	-	1	-	-	8	13
Fall of material in mines:										
Of coal	9	6	7	6	7	9	12	14		
,, stone	19	13	13	20	9	19	33	22		
Total fall of material	28	19	20	26	16	28	45	36	407	403
In shafts:										
Overwinding	-	2	1	3	-	-	5	1	15	11
Ropes and chains breaking	2	-	1	1	2	2	1	3	19	25
Whilst ascending or descending	8	7	7	2	4	8	9	11 }	127 }	95 }
Falling into shaft from surface	4	5	-	-	3	4	5	3 }		
Things falling from surface	7	1	1	-	1	7	1	2 }	48 }	57 }
Falling from part way down	3	2	1	2	2	3	4	3 }		
Miscellaneous	1	-	1	4	1	1	4	2	18	22
Total in shafts	25	17	12	12	13	25	29	25	227	210
Irruptions of water	3	-	4	1	-	3	1	4 }	25 }	23 }
Falling into water	-	-	-	-	-	-	-	- }		
On inclines underground	1	-	-	-	1	1	-	1 }	54 }	52 }
By trams	-	-	-	-	1	-	-	1 }		
,, machinery ,,	-	1	-	-	-	-	1	-	7	4
Miscellaneous ,,	-	-	-	-	-	-	-	-	15	10
Total in mines	68	43	38	43	41	68	86	79	903	963
On the surface:										
By machinery	-	4	-	2	-	-	6	-	29	38
Boilers bursting	-	-	-	-	-	-	-	-	8	13
Miscellaneous	-	-	-	-	-	-	-	-	13	15
Total on the surface	-	4	-	2	-	-	6	-	50	66
Total deaths	68	47	38	45	41	68	92	79	953	1029

* The whole of Scotland is included in the return for 1855; in 1856 Scotland was divided into the Eastern and Western Districts.

† The total for Great Britain can only be given for 1855 and 1856, the returns for the several districts not having been made for the same years.

MINERAL WATERS. See SODA WATER, and WATERS, MINERAL.

MINES. (*Bergwerke.* Germ.) 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 an *adit level*, or *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, where it is feasible, in mines which promise a long continuance. There are many adit levels several leagues in length; and sometimes they are so contrived as to discharge the waters of several mines, as may be seen in the Gwennap district of Cornwall, and in the environs of Freyberg. Such an amount of slope should be given them as is barely sufficient to make the water run, at the utmost from $\frac{1}{200}$ to $\frac{1}{400}$, so as to drain the mine to the lowest possible level.

Whenever the workings are extended 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 *tubbing* 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 *sumps* or 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 lifting pumps are employed, but in those districts where the necessity of raising large volumes of water from great depths has led to improvement, forcing pumps or *plunger* lifts are introduced, placed over each other at intervals of from 180 to 240 feet, although, for convenience, a lifting pump or *drawing lift* occupies the deepest extremity of the shaft, whence it raises the water to the first plunger, and that again forces the stream upward through the column or *trees* to the one next above it, and so on, up to the adit level, or to the surface.

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 an adit level, 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 adit-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 greater 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 some few 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 sledges, barrows, or, still better, by little waggons. In many continental countries 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 inclines forwards. But when the miner, in pushing it before him, leans 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 trammer 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 often crooked, that these peculiar waggons are employed. In coal mines larger waggons, or frames carrying large baskets, are preferred. The above wain, called on the continent a *dog* (*chien*, *Hund*), is now often replaced by a larger tram or waggon with flanged wheels, running on edge rails of wrought iron.

In the great mines, such as many of the coal and salt mines of Great Britain, the salt mines of Gallicia, the copper mines of Fahlun, the lead mines of Alston Moor, horses have long been introduced into the workings to drag heavier waggons, or a train of waggons attached to one another. These animals often live many years underground without ever revisiting the light of day, whilst in other cases they are brought to the surface at stated intervals, sometimes daily. In a few of the largest collieries it has been found preferable to establish stationary engines underground, which bring the trains of waggons, by means of an endless rope, along the galleries to the bottom of the shaft. In other mines, such as those of Worsley in Lancashire, subterranean canals are cut, upon which the mineral is transported in boats.

When the operations of a mine are commencing, and the works are of little depth and employ few men, it is sufficient to place over the shaft a simple windlass, by means of which a few hands may raise the water barrels and tubs or kibbles filled with stone or ore; but this method soon becomes inadequate, and must be replaced by *horse-whims* or more powerful machines.

Accessory Details.

Few mines can be travelled entirely by means of galleries: more usually there are shafts for mounting and descending. In the pits of many mines, especially of collieries, the men go down and come up by means of the machines which raise the mineral. In some mines of Mexico, Northern England and the North of Europe, pieces of wood, fixed into 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 mineral, as in the quicksilver mines of Idria and the Palatinate, in the salt mines of Wieliczka, and some of the silver mines of Mexico. In the last, as in the East, they serve for the transport of the ore, which is carried up on men's backs. Lastly, some mines, as in the Austrian Alps, are descended by means of sloping timbers, some of which have an inclination of more than 30°. The workmen in sliding down, in a sitting position, regulate the velocity of the descent by holding a cord, which is fixed along the upper side or roof of the inclined shaft.

Miners derive light from candles or lamps. They carry the former in a lump of moist clay, or in a kind of socket, terminated by an iron point, which serves to fix it to the side of the excavation, or to the timbering. The lamps are made of iron, tinplate, or brass, hermetically closed, and so suspended that they may not readily droop or invert, and spill the oil. They are generally hung on the thumb by a hook, so as to leave the rest of the hand at liberty for climbing. Miners also employ small lanterns suspended from a button-hole or from the girdle. 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 or *fire damp*, that measures of precaution are indispensable against explosions. The appearance of any halo round the flame must be carefully watched, as indicating danger, and the lights should be carried near the bottom of the gallery. The great protectors against these deplorable accidents are ventilation and the safety-lamp. See Safety-Lamp.

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 in early times they could only be carried on by the employment of slaves. This dislike has diminished in proportion to the improvements made in mining; and finally, a profitable and respected source of gain, requiring a more than average exercise of skill and intellect, has given mining its proper rank among the other branches of industry; and that *esprit de corps*, so conspicuous among seamen, has also arisen among miners, and adds 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, which, as they advance in intelligence, they regard with pride, and eventually in their old age they look upon other occupations with something like contempt. They form in certain countries, such as Germany and Sweden, a body formally constituted, which enjoys considerable privileges; and the disgrace of being ejected from that body appears to exert in those countries a good moral influence. Miners work usually for 8 hours at a time, this being called a *core*, or *shift* (*poste* in French, *Schicht* in German).

Miners wear in general a hat or cap capable of withstanding a blow, and a dress suited to protect them as much as possible from the annoyances caused by water, mud, or strong draughts of air. One of the most essential parts of the costume of the German miner is an apron of leather, fitted on behind, so as to protect him when seated on a moist surface or on angular rubbish. In England the miners mostly wear flannel next to the skin, though they frequently in deep mines strip off all their clothes except their trowsers. In most countries the hammer and small pick or wedge, the instruments with which before the employment of gunpowder all mining was performed (called in German *Schlägel* and *Eisen*), disposed in a St. Andrew's cross, are the badge of miners, and are engraved on their buttons and on everything belonging to mines.

Many of the enterprises executed in mines, or in subserviency to them, occupy a distinguished rank in the history of human labours. Several mines in the Harz, in Bohemia, and in Cornwall, have been worked to a depth of above and near 2000 feet; those indeed of Kuttenberg in Bohemia are said to have penetrated to 3000 feet below the surface of the soil.

A great many descend beneath the level of the ocean; and a few even extend far 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 7½ yards wide, destined to have a depth of 560 yards, to occupy 23 years in sinking, and to cost 240,000*l.*

The great drainage gallery of the mines of Clausthal, in the Harz, is 11,377 yards, or 6½ miles long, and passes upwards of 300 yards below the church of Clausthal. Its excavation was commenced at 30 different points, lasted from the year 1777 till 1800, and cost about 66,000*l.* The *great Adit*, which drains so many of the important mines in the parish of Gwennap in Cornwall to the depth of from 30 to 60 fathoms, amounts, with its branches, to 30 miles in length. 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. Crawshay, 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 some thousands of 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 (with the exception of some few engines for the large ocean steamers) 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, generally, into three great classes:—1. Mines in unstratified rocks and the geological formations anterior to the coal strata; 2. Mines in the carboniferous and 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, geologically superior to the chalk and tertiaries; and 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.

The progress of geological science, however, shows that these divisions cannot be so definitely made as was formerly supposed, and that some of the rocks which were considered to be very ancient, are, in fact, among the more modern of the secondary strata. Thus, most of the metalliferous formations of the Andes and of Hungary ought, in strictness, to be classed with the upper secondary, or even the tertiary strata, although they have often been so metamorphosed as to present an appearance very similar to the older rocks.

The following grouping, it will be understood, refers the mines to physical and not to political boundaries: —

Mines of the Harz.

The name Harz 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 Harz is about 43 miles in length from SS.E. to NN.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 towns, *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 Harz is greywacke. It incloses the principal veins, is associated with clay-slate, Lydian stone, or siliceous slate, and greenstones; and is succeeded in geological order by a limestone referable, with a large proportion of the slaty beds, to the Devonian system. The granite of which the Brocken is formed supports all this system of rocks, forming, as it were, their nucleus.

The veins of lead, silver, and copper, which constitute the principal wealth of the Harz, do not pervade its whole extent. They occur chiefly near the towns of Andreasberg, Clausthal, Zellerfeld, and Lautenthal; are generally directed from E. to W., and dip to the N.E. in the Andreasberg, and to the S. in the Clausthal district, at an angle of about 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 2570 English feet or 428 fathoms. In the first of them there is the greatest *step* exploitation to be met with in any mine. It is composed of 80 *underhand stopes*, 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 ores 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 above 300 fathoms. Such of the mines as are at the present day most productive, have been explored since the first years of the 18th century. Two of the most remarkable ones are the mines of Dorothea, and the mine of Carolina, which alone furnish a large proportion of the whole neat product. The grant of the Dorothea mine extends over a length of 257 yards, in the direction of the vein, and through a moderate breadth 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 Harz, there were extracted from 1709 to 1807 inclusively, 883,722 marcs of silver, 768,845 quintals of lead, and 2385 quintals of copper. This mine and that of
their shareholders in the same period of time, more than
e besides powerfully contributed by loans without interest to
the less productive mines. It was in order to effect the
district of Clausthal, and those of the district of Zeller-
t Adit Level was excavated.

than the George Adit Level, is the gallery employed as
posed to open out as an adit to the daylight, an operation
ars' labour.

ts of Clausthal and Zellerfeld, and Andreasberg, comes that
rtant working in which is the copper mine of the Rammels-
ear 968, on a mass of copper pyrites, disseminated through
h galena and blende. It is worked by shafts and galleries,
fire to break down the ore. This mine produces annually
tric quintals (about 275,000 lbs. avoird.) of copper. The
it yields a small quantity of silver, and a very little gold. The
o only the five-millionth part of the mass explored; and yet
eparate it with advantage. The mine of *Lauterberg* is worked
and it furnishes annually near 66,000 lbs. avoird. of that metal.
ions just noticed, there are a great many mines of iron in dif-
Harz, which give activity to important forges, including 21
he principal ores are sparry iron, and red and brown hematites,
beds, and masses. Earthy and alluvial ores are also collected.
Anhalt-Bernburg presents, towards the S.E. extremity of the
mines, which resemble closely those of the general district.
33,000 libs. avoird. of lead.
of the Harz, at Ihlefeld, there is a mine of manganese.
e Harz mines may be traced back for about 900 years. The
prosperity was the middle of the 18th century. Their gross
1808, upwards of one million sterling. Lead is their principal
ey furnish annually 100,000 quintals, with 44,000 marcs, or
silver, about 360,000 lbs. avoird. of copper, and a very great
me of these mines are worked by the Government, others by
urers. They are celebrated for the excellence of their mining
ystematic application of the processes for dressing the ores, and
ience, and skill of their workmen.
erred to especially for the manner in which the waters are collected,
r 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 watercourses 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 watercourses present a development in all, of above 125 miles. The banks of some of the reservoirs are of an extraordinary height. In the single district of Clausthal there are 63 ponds, which supply water to a great number of overshot wheels; of those attached to the mines, 46 wheels are at the surface, 21 and 3 water pressure engines underground, whilst 50 wheels are applied to the drossing machinery, and 39 to the smelting furnaces.

In the mines of the Upper Harz alone, 5000 persons are employed.

Mines of the East of Germany.

We shall embrace under this head the mines opened in the primary 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, has been considered the most complete 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 Harz, which are their rivals in good exploration. They are peculiarly remarkable for the perfection with which the engines are constructed 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 *Clausthal*, *Guanaxuato*, *Schemnitz*, and *Zmeof*, present but a moderate thickness, rarely exceeding a few feet. They form several groups, whose relative importance has varied very much at different periods.

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. Many of the mines now exceed 220 fathoms in depth, and with a view of relieving them of a part of the height through which the water has to be raised, it is proposed to bring up an Adit Level from the valley of the Elbe at Meissen, a distance of above 18 miles. The most productive and the most celebrated in the present century have been the mines of Himmelsfürst, Himmelfahrt, and that of Beschertglück.

Among the explorations of the Erzgebirge, there are none which were formerly so flourishing as those of Marienberg, a small town situated seven leagues SS.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*, *Johann-Georgenstadt*, *Annaberg*, *Oberwiesenthal*, and *Schneeberg*. Those of the last three localities produce also cobalt.

The mines of Saint-George 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's dinner was served at the bottom of the mine. Their richness in silver has diminished since then; but they have attained more importance during the last 200 years, as mines of cobalt, than they ever had 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. 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; but the ores of lead and copper may be regarded almost as only accessory products of the silver lodes, from which 78,000 centner or cwts. of the first of these metals are annually extracted, and 341 cwts. of copper. The actual minerals of silver are the more important ores. They are treated partly by amalgamation, at the excellent establishment of Halsbrücke (lately closed, 1859), and partly by smelting processes the principal works for which are on the Mulde, near Freyberg. 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 produced, in 1856, 55,500 lbs. of silver. Of these, the district of Freyberg alone furnishes 54,000; and among the numerous mines of that district, that of Himmelsfürst of itself used to produce 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 principally extracted from the latter, from lodes in the crystalline slates.

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. More active operations have recently been commenced ; and the minerals raised are various ores of silver, and ores of cobalt, nickel, uranium and bismuth. The ancient mines of Kuttenberg, situated farther east, near Gitschin, have been excavated, according to old authors, to the depth of 500 fathoms, but have long been abandoned.

Mines of silver and lead are also worked in gneiss at Ratiborzitz ; Adamstadt, near Budweis, which yielded in 1852, 1200 marcs of silver ; Michelsberg, near Plan; Klostergrab, near Teplitz ; and Mies, 25 leagues W.S.W. of Prague, at the base of the Böhmerwaldgebirge, a chain of mountains which separates Bohemia from Bavaria.

The most important in the country, and some of the most flourishing in Europe, are at *Przibram*, 12 leagues S.W. of Prague, at the extremity of the mountains which separate the Beraun from the Moldau. In this district, the argentiferous galena is accompanied by blende, in which the presence of cadmium has been observed. These mines, which are worked with all the newest appliances, and have reached in places above 300 fathoms in depth, yield annually 45,000 marcs of silver, and 20,000 cwts. of lead. The lodes, about 50 in number, are most productive in the greywacke, and course N.E. and S.W

Gold, which in early times was obtained in large quantity from the rivers of Bohemia, has been extracted from veins in gneiss at Bergreichenstein and at Eule, and in granite at Tok and Mileschow.

The copper ore at present worked in several localities is very unimportant.

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 working since the 15th century. Some tin is mined also near Geyer, 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 ; important mines also occur in the latter territory at Schlackenwald, Graupen, and Abertham, and slightly productive ones at Platten and Joachimsthal. In several of these mines, particularly at Altenberg and Geyer, fire has been employed for attacking the ore, because its matrix is extremely hard. In almost the whole of them, chambers of too great dimensions have been excavated, whence have arisen, at different epochs, serious 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 mines tin of the Erzgebirge produce annually 2500 cwts of this metal.

The tin ores are accompanied by arsenical pyrites, which, in the roasting or calcination that it undergoes, produces a certain quantity of arsenious acid.

The Erzgebirge presents also a great many iron mines, particularly in Saxony, at *Rothenberg*, near Schneeberg, where the lode is of fine hæmatite, and from 12 to 24 feet in thickness. In Bohemia, at Platten, where may be remarked especially the great explorations opened in the vein called the *Irrgang*; at Horzowicz, where an excellent hæmatite is worked; at Ransko, and many other places.

There is also in the Erzgebirge a mine of anthracite (stone coal) at *Schœnfeld*, 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 Hof and Bayreuth, contains some mines, among which may be noticed, principally, mines of magnetic black oxide of iron and of antimony.

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 marcs of silver; the mine of arsenical pyrites at Reichenstein, in the circle of Glatz, yields also a very small proportion of gold. Chrysoprase has been found in the mountain of Kosenitz.

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 western 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* iu 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 beeu abandoned. The workings were resumed in 1837. See description in *Journal des Mines*, t. xx.

The department of the Isère presented a more important mine, worked with regularity from 1768 to 1815 ; 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 iu 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, as 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. In the High Alps the mine of argentiferous galena called l'Argentière has recently been resumed.

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 occurrence 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 *Forneaux* and *Laprat*, in the latter country, are also meutioued. The irregularity of the miniug 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 frequently in mines 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 iu this place to from 8 to 13 yards ; thus a void space is exhibited of nearly 300,000 cubic 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 iu 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 *Pesey* 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 Pesey was taken up in 1792 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 lbs. avoird. of lead, and 2500 marcs of silver. It is now explored on account of the kiug of Sardinia ; but has for some years been poor. That of *Macot*, opened a few years ago, begius 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 iu small veins, and disseminated in a clay slate ; but the exploration is now suspeuded. Lastly, slightly productive workings of anthracite are mentioned in several poiuts of these mountains and in the conterminous portions of the Alps.

There exist in Piedmont some small mines of argentiferous lead. The copper miues 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 been but feebly developed. Mines of plumbago, little worked, occur in the neighbourhood of *Vinay* 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. Several similar mines are working in the valleys of Anzasca, Toppa, and Antrona, in the province of Pallanza; the value of the produce being about 20,000*l.* annually.

The most important mines in this country are those of iron. These generally consist of masses of magnetic oxide of iron, of a nature analogous to those of Sweden; the principal ones being those of Cogne and Traversella, 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 *Bovernier*, 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 was proposed to make a new mineral species, under the name of Chamoissite.

The district of the Grisons possesses iron mines with very irregular workings, situated a few leagues from *Coire.*

In Tyrol, the mines of Kitzbühel and Röhrerbüchel were formerly worked with great activity, and in the middle of the eighteenth century had attained the depth of 440 fathoms; they were then considered the deepest in Europe, but were soon afterwards abandoned. The ores, copper pyrites, and argentiferous *fahlerz* occurred in clay slate. The products of some small mines in this locality, certain of which are worked in a secondary limestone (as at Rattenberg), are carried to the foundry of Brixlegg, four 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, eight leagues from Schwatz. The auriferous veins traverse clay-slates and quartzose-slate. The richer portions contain 16 to 20 loth (at $\frac{1}{2}$ an oz.) of gold in 100 cwts. of vein-stone; the remainder only $\frac{1}{2}$ to $\frac{3}{4}$ of a loth in the same quantity.

At Borgo, near Trient, and Pfundererberg, near Clausen, lodes occur in clay-slate and greenstone-porphyry, from which are extracted ores of silver, lead, copper, and zinc. An unimportant occurrence of mercury has also been mentioned in that country, near the *Brenner.*

In the territory of Salzburg there are some copper mines; at Zell am See, Brennthal, Muhr, and Mitterberg, near Werfen. In the lofty mountain region near Gastein, auriferous lodes have been worked for centuries at the Rathhausberg, Sieglitz, and Rauris. From 118 marcs of gold in the earlier part of the century, the annual yield has diminished to 80.

At Leogang and Nöckelberg an inconsiderable amount of cobalt and nickel ore is raised.

There are mines of argentiferous copper, some of them also yielding nickel and cobalt, analogous to those of the Tyrol, at Schladming, Feistritz, Walchern, and Kallwang; in Styria; at Gross-Fragant and Arza in Carinthia. In the last-mentioned province, the mines of St. Marein and Saversnig yield considerable quantities of lead; whilst at Agordo, in the Venetian Alps, copper ores are raised on a large scale.

At Radlberg and Lassnigberg, in Carinthia, about 328 cwts. of antimony were annually produced a few years since.

Other lead mines of this portion of the Alps, as those of Bleiberg and Raibl, are worked in limestones belonging to the secondary period.

In the Tyrol and in Salzburg, at Schwartz, Pillersee, Bischofshofen, &c., various ores of iron are worked. 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 Vordernberg, 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 Wolfsberg, Hüttenberg, and Waldenstein, in Carinthia, are among the more notable.

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 Allevard.

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 has increased within the last few years from 20,000 to nearly 100,000 tons of pig iron. These two provinces are famous for the steel which they produce, and for the good iron and steel tools which they manufacture, such as scythes, &c. Carniola contains also a great many forges, and affords annually about 5000 tons of iron.

The limestones surmounting the southern slope of the Alps, contain also some lead mines; but the quicksilver mine of Idria, situated in Carniola, 10 leagues N.W. of Trieste, is worthy of particular notice; it lies beneath a limestone which everything leads us to refer to the *trias* and Halstatt beds, the most ancient of the secondary limestone; but it is uncertain whether the shales in which the cinnabar occurs, and their underlying limestone, belong to the carboniferous or to an older series. About 2500 cwts. of quicksilver are produced annually.

The Apennines, which may be considered as a dependence of the Alps, present a small number of mines, most of them worked on repositories of ore which have a marked relation to the occurrence of serpentine. Thus a most successful copper mine has been in active operation for some years at Monte Catini, in Tuscany; and in the same district of the Maremme several other localities have been worked for copper, mercury, and antimony.

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 25,000 tons of ore, which are smelted in the furnaces of Tuscany, Liguria, the Roman states, the kingdom of Naples, and the island of Corsica. The island of Sardinia contains many indications of silver, lead, and copper ores; but no important mines have been opened in modern times.

There has been worked for a few years a mine of chromite of iron, at Gassin, department of the Var.

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 *Lacroix-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, ruby silver ore, native 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-aux-mines* also traverse the gneiss; but their direction is nearly perpendicular to that of the vein of *Lacroix*, 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 ancient in France; and yet they have been worked very little below the level of the adjoining valleys.

There has been opened up in the environs of *Giromagny*, 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. The workings have been pushed as 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 *Lacroix*, of *Sainte Marie-aux-mines*, and of *Giromagny*, 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, mines which have at times been actively worked. In the Furstenberg district, near *Wolfach*, particularly at *Wittichen* and *Schapbach*, 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 manufacture 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*, whose ores are red oxide of iron, with crystalline specular ore, which appear to form veins of great thickness, much ramified, and very irregular, in a district composed of greenstone, limestone and clay slates. 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, Erelenbach, and Schenau, several mines have been opened on very powerful veins of brown hæmatite 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 include the mine of brown hæmatite of *Creutzwald*, 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 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 Croix-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 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, an extensive range of hilly country and culminate in the Hündsruck, the Taunus, the Eifel, and the Westerwald mountains, 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, Rheinbreitbach, and near Dillenburg. That of Rheinbreitbach yielded formerly 110,000 lbs. avoird. of copper per annum, and those of the environs of Dillenburg have more recently furnished 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 Holzappel, Pfingstwiese, Lœwenburg, and Augstbach on the Wied, and Ehrenthal on the banks of the Rhine, which altogether produce 600 tons of lead, and 3500 marcs of silver. To the above, we must add those of the environs of Siegen and Dillenburg, situated in the slaty rock and greywacke of the *Devonian* system, to which the greater part of the area in question belongs. 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 hydrous oxide, or brown hæmatite, are explored in a great many points of Hessia, and of 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 Müsen; and the numerous lodes of hæmatite, brown oxide and sparry iron, in the same district; 2. The abundant and beautiful mines of hydrous oxide and sparry iron on the banks of the Lahn and the Sayn, and among them the mine of Bendorf; 3. The mine of Hohenkirchen in Hessia, where a powerful bank of manganesiferous 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. manufactured there. Nassau alone appears to raise about 250,000 tons of first-rate ore annually, the majority of which is exported.

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 hydrous oxide 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. Great activity has within the last few years been imparted to these operations, by the rapid development of the Westphalian coal-field, and the increased manufacture of coke-made iron.

The Eifel 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, 3 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. The mine Wohlfahrt, near Rehscheid, produces annually 500 tons of a fine galena, suitable for "potter's ore."

More to the north a great many deposits of calamine occur. The most considerable, and the one which for many years past has given the Company working it the command of the zinc trade of the world, is called the *Vieille Montagne* (Altenberg), at Moresnet, between Aix-la-Chapelle and Herbesthal. The mass upon which the works are opened, and in which the calamine is very irregularly intermixed with clay and ochre, is about 450 yards in length, and 150 in width: it is situated at the junction of the carboniferous limestones and the slate termed the *schiste anthraxifère*, upon which geological horizon a number of other deposits of a similar character have been found at intervals, with a thickness and richness equally variable. The minerals, brown iron ore, galena, zinc-blende, and iron pyrites occur with the calamine, and the former especially sometimes overpowers it. Among such deposits, many of them largely worked, are Herrenberg near Holberg, Engis, Huy, Verviers, Corphalie, Membach, and some which reappear, after dipping beneath the alluvial valley of the Rhine, in the same geological position, in Westphalia.

The *Vieille Montagne* Company possess other sources of zinc ore in the Prussian and in the Baden territory, and, employing about 7000 men in all, produce no less than 16,000 tons of zinc from their own mines, besides manufacturing a large quantity purchased from other producers. The *Nouvelle Montagne* Company, Verviers, also work their deposits on a large scale, and increasing success appears to attend the works established more recently on the right bank of the Rhine.

Of the mines in this border district which produce lead, the most important are those of the Stolberg Westphalia Company, yielding annually 5000 tons of lead, and those of the *Eschweiler* and the *Alliance* Company, also of Stolberg.

A lead mine is opened at Vedrin, N. of Namur, on a vein of galena, nearly vertical, which courses from N. to S. in a limestone in nearly vertical strata. The vein is from 4 to 15 ft. thick, and is recognised through a length of half a league. The mine, worked for two centuries, presents very extensive excavations; particularly a fine Adit Level. From its former annual production of 900 tons of lead it has now sunk to a very small amount.

Mines of the Centre of France.

The ancient formations, principally granitic, which constitute the basis 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. Many metalliferous veins have been observed in the mountains of the Auvergne, Forez, Cévennes and Lozère, but very few of the workings have attained to any importance. Most of the mining trials have been made near the eastern border of the mass of primary formations, in a zone characterised by a great abundance of schistose rocks.

At Villefort and Vialas, 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 persons, and produce annually about 1000 quintals of lead, and about 2000 marcs of silver.

Pontgibaud has been for some years the centre of mines of argentiferous lead, opened upon a group of north and south lodes intersecting a rock of gneissose granitic character. Explorations have been commenced mostly where these lodes were discovered in the valleys, as at Roure, Rosier, Mioche, Pranal and Barbecot: and since 1853, by the joint exertions of an English and French proprietary, the mines have been raised to an important position, employing about 1200 work people. An unusual source of difficulty has been presented, in the form of strong emanations of carbonic acid gas from the lode and the fissures of the country, and which renders it necessary to employ powerful ventilating machines, driven by water wheels. The presence of this gas is evidently connected with the volcanic phenomena of the adjacent district, where streams of recent lava overlie the metalliferous granite, and are not penetrated by the lodes.

In the department of the Loire, the lead mines of *St. Martin-la-sauveté* south of Roanne have been extensively opened on veins running N.W. and S.E.; they are now in English hands.

The mountains of Ambert, on the west of the valley of the Dore, Saint-Amand-Roche-Savine and Giroux, as well as the mountains above Jumeaux, exhibit veins of somewhat analogous character.

At Malbosc and Bordezac (Ardèche), small lodes of antimony are seen in the slaty rocks.

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 *Joux*, department of the Rhone.

At Chessy, seven leagues N. W. of Lyons, mines, now worked out, were opened upon an irregular repository of copper ore, occurring at the contact of granite with the lower sandy beds of the lias. The carbonates of copper were especially abundant, and the azurite, or blue carbonate, from this mine is noted for the beauty of its crystallisation. At Sainte-Bel, two leagues S. of Chessy, a very similar deposit of copper pyrites, has also, after many years of activity, been abandoned.

An abundant deposit of manganese ore, very irregularly worked, at Romanèche (Saone et Loire) occurs in an analogous geological position; as do also smaller bodies of galena, calamine, and zinc-blende at Figeac, Villefranche, and Lardin.

At Ecouchets, near Couches, the oxide of chromium disseminated in the sandstones termed *arkoses*, has been occasionally worked. Some important veins of zinc-blende have been traced at Clairac, in the department du Gard, for above 1000 yards from N. to S. in the beds of metamorphic lias.

Lastly, tin ore, accompanied by wolfram, has been found to occur in small lodes in the district of Limoges, so well known for its china clay, especially at Vaulry, a few leagues NN.E. of that town.

Mines of Brittany.

In its geological conformation Brittany has a great analogy to its opposite neighbour, Cornwall; but notwithstanding the resemblance of its granites, ancient schists, (killas) and porphyries, it bears no comparison in the importance of its mineral repositories. Tin ore has been found at two places, Piriac, a few miles to the N. E. of the mouth of the Loire, where small quartzose veins, containing that mineral, occur at the junction of the granite and schists, and appear to have given rise to the alluvial deposits of tin found near the mouth of the Vilaine; and at Villeder, department of Morbihan, where a quartzose tin-bearing vein intersects the granite, in the direction E.N. E. and W. S. W., and contains also mispickel, topaz, and beryl. These localities have afforded very fine specimens of tin ore, excellent examples of which appeared at the Paris Exposition in 1855; but although frequent trials have been made upon them, they have not yet led to an extensive and systematic working.

The most important exploitations in this district are the lead mines of *Poullaouen* and *Huelgoat*, situated near Carhaix. The mine of Huelgoat, celebrated for the plomb-gomme (hydro-aluminate) discovered in it, is opened on a vein of galena, which traverses clay slate rocks. The workings have subsisted for about three centuries, and have attained to a depth of 270 meters.

The lode has been followed over a horizontal distance of about 1000 meters, and contains, besides argentiferous galena, ochreous substances yielding about $\frac{1}{1000}$th of silver in the native state, or as chloride.

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 250 meters 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 some years since constructed there.

The vein courses through greywacke in a direction N. 22° E., and including five branches, has in some places reached the width of 60 feet.

The annual produce of these mines is 300 tons of lead and 1400 kilograms of silver. Several veins of galena exist at *Chatelâudren*, near Saint-Brieuc, but they are not worked at present. There is also one at Pontpéan, near Rennes, which has been worked to a depth of 140 yards, but has in like manner been till lately abandoned. It affords, besides the galena, a very large quantity of blende (sulphuret of zinc), considerable amounts of which, of a very crystalline character, have, during the last few years, been exported. This is also a N. S. lode.

There occurs, moreover, a lead mine at Pierreville, department of the Channel, opened on a vein which traverses limestone. The same department presents a deposit of sulphuret of mercury at Ménildot. A mine of antimony was worked at La Ramée, department of La Vendée.

At Melles (Deux Sèvres), ancient works on argentiferous galena are traceable, of which the date is unknown.

The production of metals other than iron in France, in the year 1852, was, according to official statements : —

Copper, in bars -	19,192	metriquintals,	in value	5,167,388 francs.
Lead - - -	23,403	,,	,, ,,	1,036,179 ,,
Litharge - -	5,868	,,	,, ,,	224,326 ,,
Gold - -	18,312	grammes	,, ,,	62,261 ,,
Silver - - -	6,286	kilograms	,, ,,	1,354,012 ,,
			Total	7,844,166 francs.

It is, however, evident that these metals are only in part the production of the mines of France proper.

Mines of the West 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 and west of Scotland.

It will be observed that the metalliferous rocks, analogous to those of the N. W. of France last described, present themselves in the West of England, Wales and Scotland, striking in a direction of E. N. E. or N. E; whilst in Ireland, although the same general direction is generally apparent, similar rocks form the surface in many portions of the island.

Cornwall and Devonshire present four principal mining districts, viz. that of Penzance, including St. Just, St. Ives, Marazion and St. Erth. Secondly, that of the centre, including Gwennap, Redruth, Camborne, St. Agnes and Wendron. Thirdly, the environs of St. Austell and Lostwithiel. Fourthly, the eastern district, from Liskeard to Tavistock.

The first two of these districts are the most important of the four in the number and richness of their mines of copper and tin. The ores of copper, which consist almost entirely of copper pyrites and vitreous sulphuret of copper, constitute very regular veins, running nearly from east to west, and incased most frequently in a clay-slate locally termed *killas*, and belonging to the Devonian system of modern geologists, but frequently also in the granite, which forms a series of protuberances rising from beneath the schists, in an E. N. E. direction from the Land's End to Dartmoor. The tin, besides being found in alluvial deposits or " stream-works," also occurs in veins or lodes which have a general east and west direction, the same which is held by numerous dykes of granitic porphyry (" elvan,") which appear to have a close relation to the metalliferous veins. The copper lodes are sometimes found to cut across and interrupt those of tin, and are consequently held to be of more recent formation. The tin ore in a few mines forms also irregular masses (termed *tin-floors* and *carbonas*), which appear most usually attached to the veins by one of their points. Certain veins present the copper and tin ores together; a mixture which occurs often 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.

Among the more important mines of the above metals in the western districts, may be noticed Huel Basset, North and West Basset, South Francis, United Mines, Huel Buller, Alfred Consols, Carn Brea, Levant and Botallack; for tin more especially, Huel Vor, Dolcoath, and Polberro.

In the environs of St. Austell the more remarkable mines are those of Fowey Consols (now, 1858, the deepest actively worked in Britain), Par Consols, Crinnis, the tin mine of Polgooth, recently abandoned, and the singular open-cast of Carclaze, worked on numerous small strings of tin, coursing through a granite so decomposed, as to be in great part available for china-clay.

North of Liskeard, the Phœnix and Caradon mines have attained, since 1838, a great degree of prosperity; whilst still further east, the neighbourhood of Callington is marked by several productive copper mines on a smaller scale, and the large ancient tin mine of Drake Walls. The Tavistock district has been rendered famous by the long-continued successful working of Huel Friendship, and the enormous wealth extracted since 1845 from the series of mines on one great lode, entitled the Devon Great Consols.

There exists also throughout Cornwall, a series of veins running more or less north and south, the "cross courses," which intersect and often dislocate the above lodes sometimes containing only clay (*flucan*) or quartz (*spar*), at other times particular metallic minerals. Thus near Helston several such veins have been worked for silver-lead ore; at Restormel near Lostwithiel, and in the St. Austell granite, for red and brown oxides of iron; east of Liskeard, at Herodsfoot, Huel Mary Anne, Redmoor, and the Tamar mines (now working successfully at 225 fathoms deep), for lead ores containing from 30 to 80 ounces of silver to the ton.

In some few instances, and chiefly in connexion with these cross veins, ores of silver, cobalt, and nickel, have been raised; whilst very rich silver ores were obtained some years ago from E. and W. veins, near Callington; at Huel Vincent, Huel Brothers, &c.

Antimony has been raised from mines near Endellion, and at Huel Boys, and manganese from shallow irregular deposits in the slates at many points in the east of Cornwall and in Devonshire.

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).

The total production of Cornwall and Devonshire was in 1858 —

Tin ore, or "black tin"	10,618 tons.
Metallic tin	6,920 ,,
Metallic copper	11,831 ,,
Metallic lead	7,131 ,,
Silver	276,555 oz.

The tin ores are treated at several works situate in Cornwall. The copper ores are sent to Swansea in South Wales to be smelted; and a part of the lead ores, only, is reduced at smelting works near Truro, at Par, and on the Tamar.

In consequence of the dearness of wood, and the great influx of subterranean waters, the mines of Cornwall and Devonshire are worked upon principles somewhat differing from those of many other mining districts, expedition being regarded as one great source of economy. Especially in the application of steam power to pumping purposes, have the inventive powers of the engineers, in modifying the engines and boilers, and the skill of the miners in placing the pit-work or pumps, attained a high degree of perfection. For this purpose engines having a cylinder of 80, 90, and even 100 inches diameter, have been erected, employing high pressure steam expansively.

Many of the mines are explored to a depth of between 1200 and 2000 feet; and several are celebrated for the boldness of their workings. Thus several mines, especially Botallack and Levant, in the parish of St. Just, near Cape Cornwall, have their shafts placed close to the range of the cliffs, and extend several hundred fathoms under the sea, and to depths of from 120 to 240 fathoms beneath its level. At Huel Cock, 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 a reef of rock, 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 water. 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.

An important group of veins of lead, often argentiferous, is opened in the slaty rocks of Cardiganshire and Montgomeryshire, all of which have an E. W. direction, although so far from parallel, that they often meet, and frequently form at such points of intersection "courses" of ore. The galena is accompanied generally by quartz and blende, more rarely by iron pyrites and calcspar. Some of these mines were very profitably worked in the 17th century, and during the last thirty years several of them, as Goginan, Cwm Ystwyth, Logylas, and Frongoch have been highly productive.

In 1856 these counties yielded 7540 tons of metallic lead.

The more complicated geological formations of Carnarvonshire and Merionethshire, present chiefly among the slaty rocks a number of veins bearing copper, lead, and zinc ores, in which a special point of interest is, the occurrence of gold. This metal has been found within the last few years in very rich specimens, mostly associated with quartz and blende; but there has hitherto been a want of systematic workings to prove whether it may be remuneratively raised. The veins occur chiefly in two groups, the one to the north and north-west of the town of Dolgelly, the other in the hills about Beddgelert.

The adjacent isle of Anglesey is celebrated for the copper mines of Mona, and the Parys mountain. The ore is copper pyrites, intercalated among slaty rocks and felstone, and near the surface occurred in enormous volume. The workings have thence been carried on as open casts; but beneath these, again, regular subterranean operations have been conducted, although the veins there show themselves small, and comparatively poor. Large quantities of copper are here obtained by cementation from the mine water, and the various ores are treated at furnaces situate in the neighbourhood.

The ancient slates of Cumberland and Westmoreland yield also copper and lead ores, among which the Coniston copper mine is specially notable. At Borrowdale, near Keswick, a mine of graphite (plumbago) has been worked for a long period. It furnishes the blacklead of the English pencils, so celebrated over the world. The mineral occurs in irregular lumps and nests, in a variety of greenstone rock.

There are famous lead mines in the south of Scotland, at Wanlock-head and Leadhills in Lanarkshire, the veins of which are encased in greywacke. Some manganese has also been found. At Cally, in Kirkcudbrightshire, copper ore has been 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 granite and gneiss. A lead mine in schist is also worked by the Marquis of Breadalbane at Tyndrum.

The produce of the Scotch lead mines is about 1400 tons of lead per annum. The Isle of Man has two important lead mines, the Foxdale and Laxey, the former remarkable for the great size of its main, E. and W. coursing, lode and the occasional high percentage of silver, the latter for the fine crystalline blende, and for the copper pyrites which are met with in the N. and S. lead lode.

In Ireland the Allihies or Berehaven, and the Knockmahon mines, have, with great profits to the adventurers, for many years past produced large quantities of copper ore, which is sent to Swansea to be smelted.

Among the other most considerable mines of Ireland, are those of Cronebane and Tigrony, and of Ballymurtagh, 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 iron pyrites, which last since 1840 has formed a large article of export, amounting in some years to from 60 to 100,000 tons. The veins, some of which are very large, are almost perfectly conformable to the clay slates.

The granite of Wicklow also contains some important lead mines, at Luganure and Glenmalure.

In the south-west of Ireland, indications of copper and lead ores have been met with at many other points, but no important mines have yet been opened upon them.

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 most 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 *Sommorostro*, opened on a bed of red oxide of iron; and in the province of Guipuscoa, the mines of Mondragon, Oyarzun, and Berha, situated on deposits of sparry iron. There are several analogous mines in Aragon 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 Vicdessos, department of the Arriège, and averaging sixty feet in thickness, occurs in a limestone, now regarded as of the age of the lias. 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 Catalonian 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 Aragon, on the southern slope of the Pyrenees. The mines of plumbago opened at Sahun in Aragon, should not be forgotten. Analogous deposits are known to exist in the department of the Arriège, but they are not mined.

In the limestones, near Santander, very important mines of calamine have been worked for the last three or four years (1858).

Previous to the discovery of America, considerable workings were carried on in auriferous sands, at various points in this department. A gold mine has also been recently wrought, but without success, near Cabo de Creus, on the Spanish side.

Spain and Portugal.

The granite, gneiss, and slaty formations of the Iberian Peninsula, noted in early times for their mineral wealth, have during the last 25 years again become the scene of important mining operations The region of the Sierra-Morena, comprising parts of the provinces of Andalusia, Estremadura, and La Mancha, forms one of those primary districts which offer close analogies with some of the mining localities already described, and exhibits numerous mines now in activity, and the traces of former extensive operations.

The noted quicksilver mines of Almaden, producing about 2000 tons per annum, are worked on three parallel veins of from 6 to 12 mètres in width, lying conformably with highly inclined Silurian strata.

The silver mines of Guadalcanal and Cazalla, north of Seville, in mica slate, were very rich in the time of the Counts Fugger, but are now inconsiderable; this territory presented formerly important mines at Villa-Guttier, 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-Crux-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, whence 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.

Systematic workings have been for some years carried on by English companies at some of these mines, with excellent results; and with the aid of steam-engines, a depth of 80 or 90 fathoms has now been attained.

The lodes, which have a medium width of 3 or 4 feet, course generally NN.E., dipping towards the N.W., and traverse a granite, which on the outskirts of the district is overlaid by clay slates and sandstone, also penetrated by the veins. The galena is accompanied by barytes in large quantity, and in greater depth by calc spar. A single mine, that of Pozo Ancho, raises 500 tons of lead ore per month.

At Rio Tinto, near Seville, a massive deposit of iron pyrites, 50 *varas* in width, has been worked, chiefly for the copper pyrites which is mingled with it.

Abundant mines of zinc ores occur near Alcaraz, 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 in the Sierra de Gador near Almeria, a harbour situated some leagues to the west of the Cape de Gata, and also near Cartagena. A fine silver lode has been worked to a depth of 110 fathoms, at Almagrera.

The kingdoms of Murcia, Grenada, and Cordova, include several iron mines. Near Marbella aud Ronda, in the kingdom of Grenada, mines of plumbago are explored.

Among the most remarkable mines in Spain, are those of silver at Hiendelaencina in the district of Guadalaxara, discovered only a few years since, and worked on regular lodes in gneiss, and stated to yield hundreds of thousands of pounds profit per annum.

Lastly, near Ferrol in Galicia, and Zamora in Leon, tin ores occurs in granite, and at the latter place are worked in several mines, not far distant from others, which produce argentiferous lead and antimony ores. The Carthaginians appear to have worked tin mines in this part of the Peninsula.

Within the Portuguese frontier, very similar tin ores occur near the river Douro; and other localities in that kingdom are indicated as exhibiting ores of copper, antimony, and lead. Among the latter, the Palhal and Carvalhal mines are working by an English (the "Lusitanian") mining company.

Ores of iron occur at very numerous places in the Peninsula, but have hitherto been worked on a comparatively small scale. Those of Sommorostro near Bilbao, and of Marbella, are among the best known.

Two ancient iron works exist in Portuguese Estremadura, 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.

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 furnaces, 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 *Quikkne*, *Lœken*, *Selboe*, and *Rœraas*, near Drontheim. The mine of Rœraas, 16 miles from Drontheim to the S. E. of this city, is opened on a very considerable mass of copper pyrites, and has been worked as an open-cast since 1664. It has poured into the market, from that time till 1701, 77 millions of pounds avoird. of copper. In 1805, its annual production was 864,600 lbs. Not far from the North Cape, copper mines have been for some years past actively worked by an English (the Alten) mining company, on irregular veins at Kaafiord and Raipas.

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, it is generally as an open-cast, which embraces several veins, and they then prosecute by subterranean workings only those that appear to be of consequence. The workings are about 200 fathoms deep. Fire is employed for attacking the ore. In 1782, the formation of a new adit level 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 above four millions of pounds sterling. The year 1768 was the most productive, having yielded 38,000 marcs of silver. Twice during the present century they have been threatened with abandonment, but have again become profitable, yielding from 1300 to 1400 kilograms of silver per annum.

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 *Englidal;* 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.

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 somewhat lenticular, and vertical, running from N. E. to S. W., and are incased in a ground formed of primary 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 chasm 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.

Of the works which prepare bar iron from the Dannemora ores, may be mentioned in the first class Löfsta, Osterby, Simö, and Rånäs.

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 *Taberg* occurs, formed in a great measure of magnetic black oxide of iron, contained in a greenstone in the midst of gneiss.

In several parts of Lapland, the magnetic oxide 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 Lulea ; and thence by water carriage to the port of Lulea, 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 annual production of the iron mines and furnaces of Sweden and Norway has increased but little of late years, the chief attention being devoted to the quality, and not to the quantity. At present it amounts to above 150,000 tons of pig iron, of which probably two thirds are exported as bar iron, steel, &c.

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 iron pyrites, but in others, particularly near the circumference, 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 famnars (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 per 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; sulphur is also saved; 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 above a sixth part of the whole copper of Sweden.

There are several other copper mines in Sweden. Their whole number is ten; but t was formerly more considerable. They yield at the present day in all, about 2000 tons of metallic 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 *Sahla* 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 marcs of gold *per annum*, but for the last few years it has furnished only from 3 to 4.

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 also been relinquished.

The transition limestone which constitutes the body of Esthonia contains lead ore at *Arossaar* 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 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 *Kirghiz*, 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 upon 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 *Tourinsk* and *Nijni-Taguil.*

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 rock consists 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 lbs. avoird.) of copper.

The mine of Nijni-Taguil is remarkable for the fine masses of malachite which it has produced.

At Bogoslowsk copper ores have also been largely worked from a contact deposit between greenstone and limestone.

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 grey compact limestone, which contains encrinites and other petrifactions, and 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 hydrous oxide of iron, hematite, or compact iron ore, sometimes mixed or accompanied with oxide 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. They yield rarely less than 50 or 60 per cent., and keep in action numerous smelting-houses situated on 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 *Blagodat* and *Keskanar*, situated on the eastern slope from 30 to 50 leagues north of *Ekaterinbourg* In the foundries of the eastern slope, anchors, guns, shot, and shell, &c. are manufactured; 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 passes of the Urals.

The quantity of materials manufactured by the iron works of both slopes, amounted annually, as far back as 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 manufacture 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 enterprises. It has established at Tourinsk a considerable colony, and at Irbitz a fair, which has become celebrated.

There is only one gold mine in the Ural mountains, that of *Berezof*, 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 Berezof is a cavernous hydrate of iron, presenting here and there some small striated cubes of hepatic iron, and occasionally some pyrites. It contains five parts of 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. It becomes poor in proportion to its distance from the surface. The exploitation, which is in the open air, has attained a small depth, although 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. Since that period, however, great attention has been bestowed on the education of the mining engineer officers, who now form a corps pre-eminent in attainments.

The auriferous sands, or "stream" deposits of the Ural were discovered in 1814, and since 1823 have become very important. They extend over a district of some hundreds of miles in length, although with interruptions; the continuous portions of gold-bearing detritus, being generally from 50 to 600 yards in length, and 10 to 60 in breadth. In some few places platinum has been similarly found. The form in which these precious metals occur, is generally in minute scales or grains, more rarely as lumps or *pepites*, which have, in the case of gold, attained in one instance the weight of 100 lbs., in that of platinum 23 lbs.

The Russian miners have observed that these deposits rarely overlie the granite or syenite; but generally the slaty rocks of the chain, near the outbursts of serpentine or hornblendic rocks.

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*.

Twenty-five 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.
	Kil.	Kil.	Kil.	Kil.	Kil.
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
Copper - -	8,860,696	3,904,533	3,620,201	(3) 3,387,252	?
Lead - -	698,478	792,935	688,351	716,500	?
Cast iron - -	182,721,274	180,043,730	162,480,224	(3) 159,118,372	?
Salt - - -	342,240,893	(2) 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 Altai Mountains.

At the western extremity of the chain of the Altai 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 primary rocks. These schists alternate in some points with quartzose rocks, called by M. Renovantz hornstone, and with limestone. They are covered by a limestone, replete with ammonites. 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 Zméof, or Zmeinogorsk, 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, grey 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 fluate 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 upper 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 foot-wall 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 most important of the other silver mines of this department are those of Tcherepanofsk, 3 leagues S. E. of Zméof; those of Semenofsk, 10 leagues S. E.; those of Nicolaiefsk, 20 leagues to the SS.W.; and of Philipofsk, 90 leagues S. E. of the same place. The last mine lies on the extreme frontier of Chinese Tartary.

The mine of Zyrianofsk is opened amid talco-chloristic schists, and from workings about 180 yards in length yields about 800 tons of lead, 500 tons of copper, and 700 kilograms of silver per annum.

About 36,000 lbs. weight of silver, at the most, are furnished by the whole of the Altaï mines.

Since the year 1830, the gold workings of Siberia have attained a high degree of value, and although the average proportion of gold is but 1 to 250,000 parts of refuse, a total quantity of 75,000 Russian lbs. of gold is given as the produce of the Siberian works in the best years. Those on the Yenisei and the Lena are the most productive.

The precious metals are not the sole product of this mineral district. There is an important copper-mine 15 leagues 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, sulphide 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 Loktiefsk, furnished annually at the date of 1782, 330,000 lbs. avoird. of copper. At present it and the neighbouring mine of Solotoushinsk yield little more than 120,000 lbs. per annum each.

At Tchakirskoy, on the banks of the Tscharisch, 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 200 leagues east of Zméof, near the spot where the river Yenisei issues from the Saïansk mountains, which are a prolongation of the Altayan chain.

The Altaï produces but little lead. But the Crown works in this and the Nertschinsk district, together produce about 1,680,000 lbs. annually.

The first smelting-house erected in this district was 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 Barnaoul on the Ob, 50 leagues north of Zméof.

Mines of Daouria.

The name Daouria is given to a great region wholly mountainous, which extends from the Baikal Lake to the Eastern Ocean. Its chief mining district is beyond the Jablonnoï chain, which divides the waters of the Saghalien or Amour from the streams which flow to the icy sea. 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 St. Petersburg.

The country of the metalliferous portion of Daouria is formed of granite, hornschiefer, and schists, on which reposes a grey limestone, sometimes siliceous and argillaceous, rarely fossiliferous, and in which the repositories of lead occur. The plains of these regions, often salt deserts, exhibit remarkable sandstones and puddingstones ; 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 Schilca 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 ores are principally oxides and carbonates of lead, with brown oxide of iron, calamine, and a varying proportion of native silver, occurring seldom in regular bodies, but generally in cavernous openings, more or less united by narrow veins.

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 mares of silver. Since that time it has diminished. 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. Many of the mines are reputed to be exhausted: among the best of the now existing works are those of Akatouiefsk, Algatchinsk, and Ivanofsk.

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 veins containing cavities filled with a ferruginous clay, in which are found 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 been realised by its discovery on the Onone. There are some unworked deposits of sulphide of antimony in this country.

Mines of Hungary.

It must be premised of this country, as also of South America, that many of the metalliferous formations which used, some years ago, to be considered of high geological antiquity, have been proved to belong to the secondary, and even to the tertiary period; whence it is only as a matter of convenience, rendered the more needful by a number of undetermined questions, that all the mines are here classed together, as in the former editions of this work.

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, Kœnigsberg, Neusohl, and the environs of Schmœlnitz, 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 within their ambit, 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 green-stone porphyries of Schemnitz have intimate relations with the metalliferous porphyries of South America. M. Beudant, on comparing them with those brought by Von 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 of Schemnitz appear in a tract of a few miles in extent, and are traversed by a principal group of five master-lodes coursing N. E. and S. W., besides a great number of less important veins, which occur on the north side of the ridge of the Paradise mountain. The most powerful of the first of these, the *Spitaler Gang*, attains occasionally a width of from 10 to 20 fathoms; and is traceable for upwards of four miles in length. The lodes seldom exhibit distinct walls, but a portion of the green-stone porphyry (*saxum metalliferum* of the older miners) is often decomposed and impregnated with iron pyrites for some distance from the plane of contact. Intersections and dislocations are of rare occurrence.

The substances which constitute the body of these veins, are fragments of the adjoining rock, often decomposed to clay, drusy quartz, ferriferous carbonate of lime, and sulphate of baryta, with which occur sulphuret of silver mixed with native silver containing more or less gold, which is rarely in visible scales; ruby silver ore, argentiferous galena, blende, copper, and iron pyrites, &c. The sulphuret of silver and the galena are the most important ores. Sometimes these two substances are isolated, sometimes they are mixed in different ratios, 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 variable proportion, which has undoubtedly diminished in depth. The galena appears to occur in comparatively larger quantity in the greatest depths attained.

The ores of Schemnitz are all treated by fusion; the poor galenas at the smelting work near Schemnitz (Bleyhütte), and the resulting lead is sent as *work lead* to the smelting houses of Kremnitz, Neusohl, and Scharnowitz, 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 200 fathoms. The explorations are in general well conducted. Excellent galleries of efflux have been excavated; the waters for driving the machinery are collected and applied with skill. It may be remarked, however, that these mines have declined from the state of prosperity in which they stood a century ago. Maria Theresa established in 1760, at Schemnitz, a school of mines. This acquired at its origin, throughout Europe, a great celebrity, but will probably not recover from the blow which it received in the civil war of 1848—9. After numbering before those events 3 or 400 students, it has seen a great proportion of them pass to the rival schools of Gratz and Przibram.

Kremnitz lies about 5 leagues NN.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 is also found comparatively a great abundance of sulphide of antimony. The metalliferous district is of very moderate extent, and is surrounded by the trachytic formation which geologically 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 NN.E. from Schemnitz, on the banks of the Gran, lies the town 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 *Herrengrund*, 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 ore is argentiferous, and these mines produce annually about 2137 cwts. of copper, and 1345 marks of silver.

In the higher ridge which adjoins this range, and worked in a region of snows and bears, is the interesting mine of Magurka, on an E. and W. lode in granite, yielding gold, antimony, and a little galena.

The mines of Lower Hungary (Nieder-Ungarn), employ 15,500 workmen, and yield metals of the annual value of 360,000*l*.

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, Schmœlnitz, Einsiedel, Rosenau, &c. Talcose and clay slates form the principal body of the mountains here, along with hornblende rocks. The veins appear to lie generally conformably to the strata. The ores of iron are sparry ore, and especially hydrous oxide of iron, compact and in concretions, accompanied with specular iron ore. They give employment to many large smelting houses, mostly in the counties of Gömor and Zips. The copper mines lie chiefly in the neighbourhood of Schmœlnitz and Gœlnitz. The copper extracted contains about 6 or 7 ounces of silver in the hundredweight, and the *fahlerz* has been proved to contain a considerable percentage of mercury, which is now extracted. This group of mines, belonging almost entirely to private persons, and chiefly worked by a company called the *Waldbürgerschaft*, produces annually 17,000 cwts. of copper, 4650 marcs of silver, and 7967 lbs. of quicksilver. In the neighbourhood of Dobschau, large quantities of the ores of cobalt and nickel are obtained.

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 Czervenitza, situate in the trachytic conglomerate, which in several localities contains *opalised* wood.

Group of the North East, or of Nagybanya. — The mines of this group lie in a somewhat considerable chain of mountains, which, proceeding from the frontiers of Buckowina, 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 Nagybanya, Kapnik, Felsobánya, Veresviz, Miszbanya, and Laposbanya. All these mines produce gold. Those of Laposbanya furnish, likewise, argentiferous galena, and those of Kapnik copper, especially as silver-fahlerz. Realgar occurs in the mines of Felsobánya; and orpiment in those of Ohlalapos. Several of them produce manganese and sulphuret of antimony. Lastly, towards the north, in the county of Marmarosh, lies the important copper mine of *Borscha*, and near the frontiers of Buckowina the lead mine of *Rodnau*, 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 the *Lapos* and *Maros*, in the environs of *Abrudbanya.* There may be noticed in this region, limestones, sandstones, trachytes, basalts, and porphyries, very 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 veins are at Nagyag, Körösbanya, Offenbanya, Vöröspatak, Boitza, Csertesch, Fatzbay, Füzes, Vulkoj, Porkura, Butschum, and Toplitza. There are very numerous mines, the whole of which produce auriferous ores smelted at the works of Zalathna. These mines contain also silver, copper, antimony, and manganese. They are celebrated for their *tellurium* ores, which were 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 of the district occur partly in the porphyry, and partly in a sandstone which used to be termed greywacke and considered a transition rock, but is now ascribed to the upper secondary period. The gold is accompanied by galena, realgar, ores of manganese, iron, zinc, and rarely of silver.

At Rez-banya ores of copper and lead are worked in small veins, which intersect crystalline schists and marble.

Large deposits of iron ore are worked near Vayda Hunyad, and south-west of Rez-banya on the borders of porphyry and limestone.

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, Szaszka, and Dognaczka. They produce chiefly argentiferous copper, yielding a marc of silver (nearly ½ pound) in the hundredweight, 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 flats 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 Moravitza and Ruskberg; Cobalt ores occur likewise in these regions. The mines of the Bannat have been leased, together with the railroads, to a French company.

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 frem Moldavia and Wallachia. Their principal object is the exploration of some singular deposits of galena.

Besides the mines just noticed, Hungary contains some coal and lignite 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 production of gold was in 1854, in Vienna marcs, of which 5 = 6 Cologne marcs,

		Marcs.	
	Hungary and the Bannat - -	2,402	6,213
	Transylvania - - - -	3,811	
Of Silver,	Hungary, Bannat and mil^y. frontier	71,373	79,150
„	Transylvania - - - - -	7,777	
		Centners or cwts.	
Quicksilver, 1853,	Hungary and Transylvania - -	638	
Copper, 1853,	Hungary, Bannat and mil^y. frontier	31,160	36,167
„	Transylvania - - - - -	2,685	
„	Buckowina - - - - - -	2,322	

		Centners.
Lead, 1853,	Hungary, Bannat, and mil^y. frontier	16,965
,,	Do. litharge - - - - - -	5,582
,,	Transylvania - - - - - -	1,411
Cobalt and Nickel ores - - - -	10 to	12,000
Antimony, *crude* - - - - - - -		2,211
Sulphur, Hungary and Croatia - - - - -		3,554
Pig-iron, Hungary - - - - - - -		706,645
,,	Bannat - - - - - -	207,827
,,	Transylvania - - - -	65,160

Mines 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. More recently the gold of California has thrown half the world into a fever of excitement.

The most important mines of the Cordilleras have been 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 in a small number of districts, far distant from each other.

In the Andes of Chili, particularly in the district of Copiapo, silver mines are explored, which afford chiefly ores of an earthy or ferruginous nature, mingled with small particles of ores with a silver base, known there under the name of *Pacos*. Sulphide, chloride, and chloro-bromide of silver are also found, and an alloy of silver and mercury called *arquerite*. The same province presents also copper mines of considerable importance, especially in Coquimbo and Huasco, from which are extracted native copper, red oxide, carbonate of copper (malachite), and copper pyrites, associated with some chloride 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 mountains 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 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, and are now included in Bolivia. 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 present yield is estimated at about 50,000 lbs. troy. The ore lies in veins in a primary clay slate, 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. 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 Iquique, 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.

Baron Humboldt quotes 40 cantons of Peru as being at the time of his journey most famous for their subterranean explorations of silver and gold. Those of gold are found in the provinces of Huaailas and Pataz ; the silver is chiefly furnished by the districts of Huantajaya, Paseo, and Chota, which far surpass the others in the abundance of their ores.

The silver mines of the district of Paseo 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 Amazon. They were discovered in 1630. These mines, and especially those of the Cero of Yauricocha, are actually the richest in all Peru. Their annual produce is above 400,000*l.* 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* were collected ; and much grey copper and antimoniated sulphuret of silver were thrown among the rubbish. The mean produce of all the ores is $\frac{1}{1250}$; or an ounce and $\frac{28}{100}$ 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 seems 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, erected, under the direction of the celebrated Richard Trevithick, several high-pressure steam engines, imported from England, and introduced a considerable improvement in the workings.

The total yield of Peru is estimated at above 300,000 lbs. troy per annum.

The mines of the province of Chota are situated in about seven degrees of south latitude. The principal ores are those of Gualcayoc, near Mecuicampa, discovered in 1771 ; their outcrop occurs at the height of 4500 yards above the sea; the city of Mecuicampa 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 marcs of silver, according to Humboldt.

In the districts of Huaailas and Pataz, 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 primary schistose mountains. The district of Huaailas contains also lead miues. Peru possesses, moreover, some mines of copper.

The quicksilver mine of Huancavelica, long the only important mine of this species which was 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, but occurs in sandstones and shales, apparently of the carboniferous period. Indications of mercurial ores have been observed in several other points of the Andes of Northern Peru, and of the south of New Granada.

Deposits of sal-gem are known to exist in Peru, especially near the silver mines of Huantajaya; and nitrate of soda is found in large quantity in the desert of Tarapaca.

On receding from the district of Chota, the Cordilleras are less abundantly 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 coal-field 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, 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 *Oaxuaca*, 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 *Tasco*. 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 Bezicana* 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 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 *Guanaxuato*, a city of 70,000 inhabitants, placed at it southern extremity, and 60 leagues NN.W. of Mexico. It comprises among others the famous mine districts of *Guanaxuato*, *Catorce*, *Zacatecas*, and *Sombrerete*; the richest in Mexico, which alone furnish more than half of all the silver which this kingdom brings into circulation.

The district of *Guanaxuato* 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, sulphide 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 three leagues, though the principal workings are within 2000 yards; and contains 19 exploitations, which produced annually nearly 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 nett 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 2000 feet.

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.

Since the year 1824, several English companies, on a large scale, have undertaken the working of some of the Mexican silver mines, but they have been far from attaining the success which was expected.

Towards the western part of the group of which we are now speaking, copper mines are worked in the provinces of Valladolid and Guadalaxara; the ores being chiefly composed of protoxide of copper (ruby copper), sulphide 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 sulphide of mercury (cinnabar); but in 1804 it was worked only in two places, and to an inconsiderable extent.

6. The group of *New Gallicia* is situated in the province of this name, about 100 leagues N.W. from Mexico. It comprises the mines of Bolanos, 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 *Chihuahua*. It takes its name from the town of Chihuahua, 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 provinces of New Leon, and of New Santander, present abundant ores 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 *reales* is extremely unequal. Nineteen twentieths of these *reales* 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 in veins; beds and masses are rare. The veins traverse chiefly, and perhaps only, igneous and transition rocks, among which certain porphyries are remarked as very rich in deposits of gold and silver. The silver ores are mostly sulphide of silver, black antimoniated sulphide of silver (stephanite and polybasite), muriate of silver (horn silver), and grey copper. Many explorations are carried on in certain earthy ores, called *colloradus*, 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 sulphides of lead, of copper, and 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 $2\frac{1}{3}$ ounces. Almost all the argentiferous veins afford a little gold; the silver of Guanaxuato, for example, contains $\frac{1}{360}$. 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 present yield is estimated at above 5,000,000*l.* for silver and 62,000*l.* for gold.

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 *regular stopes.* 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 the water are in general ill combined; and the horse whims for setting them in motion ill constrncted. The timbering of the shafts is very imperfectly executed; the walled portions alone are well done. There are some adit levels, but they are too few, and ill directed. The efforts of the English companies have produced but little change either in the mining or subsequent treatment of the ores.

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 on the same scale as previously. 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 shows, according to Von 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	60,680
	3,259,153	795,581	7,073,280

Besides the actual mines of the Cordilleras, auriferous alluvium occurs in various localities.

The most important of these gold sands are washed on the western slope of the Cordilleras; viz. in New Granada, from the province of Barbacoas, 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 Amazons. 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.*

Brazil.

Besides the extensive washings of the sands that produce the diamonds and other precious stones, the platinum, and a great part of the gold of this country, mines of gold, lead, and iron are opened in what appear to be ancient geological formations, very different from those of the Cordilleras. There are no silver mines, and this again indicates a great difference between the deposits of this district and those of

Spanish America. The captainry of Minas-Geraes is that most remarkable for its mineral productions. The slaty strata of the country contain intercalated portions of quartzose rock, among which a micaceous one, called Itacolumite, and one largely charged with scales of specular iron, termed Jacotinga, are regarded as constant accompaniments of the gold.

Several English companies have for years worked gold mines in this region, among which that of St. John d'el Rey still yields a considerable profit, due in a great measure to the steady skill and economy with which the underground works, as well as the stamping and dressing of the auriferous "stone" is conducted. Among the most noted of the mines are the Bahu, Gongo Soco, and Morro Velho, which although yielding only from two to three oitavas (or eighths of an ounce) per ton, are still worked on a large scale. Among other interesting minerals, the rare metal palladium is found mingled with this gold, and it is owing to the liberality of the well-known assayer, Percival Johnson, F. R. S., that the Geological Society of London has been enabled to bestow an annual "Wollaston" medal struck in palladium, of which that chemist was the discoverer.

North America.

Within the last few years a stupendous activity in the production of certain metals has succeeded to the unimportant trials which at intervals used to be made in the earlier part of this century. It is especially the discovery of gold in California in 1848, which has invited the attention of the world to the metallic riches of the Pacific side of this continent, or to the western flank of the continuation of the great chain of mountains which we have traced upwards from South America.

Almost the entire quantity of the gold produced in California is obtained from stream-works, washings, or "diggings," but the precious metal itself has evidently been derived from the granitic and the ancient slaty rocks which constitute the range of the Sierra Nevada. Numerous veins, consisting principally of quartz, have been proved to be auriferous, but although large companies, mostly English, have been organised for working them, little success has yet attended their efforts. Platinum and osmiridium have also been found here, thus establishing an analogy with the Brazilian localities.

The auriferous tract extends northward far into the British territory.

In one of the side valleys of San José, a mine of quicksilver, "New Almaden," has for some years been opened upon irregular and contorted deposits of cinnabar, associated with clay slates highly inclined and similarly contorted. It is said that above 10,000 cwts. of mercury are produced here annually.

On the eastern or Atlantic side of the North American continent, the existence of gold has long been known, as well in alluvium in Virginia, Carolina, Georgia, and Canada, as in veins which occur at intervals in the schist rocks of the Appalachian chain, and which have given rise to numerous explorations.

The veins appear generally to course NN.E. and SS.W. and to consist mainly of quartz, often extending to a great thickness. Few, however, of these mines have been followed down to a depth of more than 100 feet, or have been developed on a continuously large scale.

Lead mines have been worked in distinct veins at Rossie, St. Lawrence County, N.Y., at Shelburne in New Hampshire, Southampton and Northampton, in Massachusets, Middleton, Connecticut, Chester County, and Wheatley mines, Pennsylvania; but the most important are those opened in irregular deposits sometimes vertical, at others horizontal, which distinguish the Silurian limestones of the Upper Mississippi. The lead bearing region is 87 miles long from east to west, and 54 miles broad from north to south, the chief centres being Galena, Mineral Point, and Dubuque. The ore, generally pure galena, occurs with great irregularity, and thus leads to the expenditure of large sums in "prospecting" of a very speculative character. It occupies only one zone, about 100 feet in thickness, of the "galena" limestone, and hence the mines have been but shallow, and the production is on the decline, having dwindled from 24,300 tons of lead in 1845, to 13,300 in 1853. In Missouri an analogous state of things occurs, but on a smaller scale. Copper has been worked at several mines in the Atlantic States, at Bristol, Connecticut; Sykesville, &c., in Maryland; Schuyler, and other mines, New Jersey; several newly opened localities in Tennessee; and Perkiomen in Pennsylvania, where the veins occur in new red sandstone and shale.

In 1841 the publication of Mr. Doughton, state geologist for Michigan, first drew public attention to the native copper of Lake Superior, which since 1844 has been the object of very numerous workings, and has been produced in steadily increasing quantity up to 5000 tons per annum.

The veins here occur in a district of bedded augitic greenstone, amygdaloid, and sandstone, with conglomerate of the lower Silurian period, and are especially remarkable for bearing native copper without any of the ordinary ores of that metal.

Ores of zinc are associated with lead ores at several of the above-mentioned localities, especially in the Wisconsin district, where the calamine is known among the miners by the name of "dry-bone." But one of the most peculiar mineral deposits in the United States is that of the red oxide of zinc, and of Franklinite, which occur in Sussex County, New Jersey, at Sparta and Stirling. They are intercalated among the beds of a crystalline limestone, with a total thickness of above 30 feet, and are the scene of very successful undertakings.

Lastly, iron ores of various species, particularly the magnetic oxide and hæmatite, occur in numerous localities. Missouri is remarkable for large masses which are said to have an eruptive character, and Lake Superior offers even a greater abundance.

A bed of black oxide of iron occurs in gneiss near Franconia in New Hampshire. It has a width 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 Massachusets 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 appears 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 primary mountains which rise in the north of this state near the Delaware, include beds almost vertical of black oxide of iron, which have been worked to 100 feet in depth. In the county of Sussex the same ore occurs, accompanied with Franklinite. At Roxbury, in Connecticut, a good sized lode of sparry iron occurs; the only one of the kind known in the Alleghanies. The United States contain a great many iron works, some of which prior to the year 1773 sent over iron to London. Those in Connecticut, Massachusets, and New York, have been largely supplied with iron ores of the tertiary formation, whilst those of Virginia and Maryland employ on an extensive scale coal measure ironstone.

Before quitting America, it should be mentioned that the West India islands offer numerous indications of mineral. Many cupriferous veins have been explored on a small scale in Jamaica. Copper ore and molybdenite occur at Virgin Gorda, and Cuba has for many years past been remarkable for the richness and abundance of its copper ores. The principal mine is the Cobre, an adventure worked on an extensive scale, and very remunerative to its proprietary. The lodes, which have been very large at shallow depths, course E. and W. through greenstone and conglomeritic rock. The Santiago mines have also yielded a large amount of ore.

On some other less known Mine Countries.

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, and the adjacent provinces of European Turkey. The silver mines of Laurion, in Attica, used in early times to form a most important source of revenue to Athens. Mines of silver ore, with galena, are still worked at Keban Maden and Gumush Khaneh in Asia Minor, whilst that of copper at Arghaneh Maden, in the Taurus, yields a large supply of the ores of that metal, which are refined at Tocat. Some also occur in Arabia and in Persia; and in the territories round the Caucasus, the kingdom of Imeretia 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, or Asia Minor, furnishes orpiment, meerschaum, and chromic iron.

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 sulphide 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 Pekin, 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; and attempts have been made by English capitalists, especially near Madras, to prepare a first class iron from the magnetic ores. 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.

In Africa, large quantities of gold are washed by the natives from the alluvium. Near the Cape of Good Hope, in Namaqualand, very numerous surface indications of copper ore are met with, which, in a few instances only, have led to the opening of remunerative mines. At Bembi, near Ambriz, a powerful view of malachite has been rudely worked by the negro chiefs, and is now leased to an English company by the Portuguese government. 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. Morocco appears to contain ores of various metals; and Algeria, since it has been in the hands of the French, has given rise to active explorations, among which may especially be mentioned the copper mine of Tenes.

To these may be added the very productive copper mines of Burra Burra in South Australia, and several others in that country and in New Zealand, which, within the last few years, have attained a high degree of importance.

Mines of the Calcareous Mountains of England.

The limestone formation immediately subjacent to the coal measures, or the carboniferous 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, Alston Moor, comprehends the upper 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, in Cumberland. The veins of galena which form the object of the workings, traverse alternate beds of limestone, shale, and sandstone; and are very remarkable for their becoming suddenly thin and impoverished on passing from the limestone into the shale or sandstone; and for resuming their richness, and usual size, on returning 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 long adit levels; 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 Scotch construction. The lead is very poor in silver; but most of it is now treated by the Pattinson process. The mines of this district produce annually about 25,000 tons of lead. Copper ores have been raised, although not in large quantity, from a very strong vein, containing chiefly iron pyrites and some galena, about six miles south-west of Alston.

This region is bounded by the Cross Fell range on the west, and extends southward to the Yorkshire valleys of Swaledale, Arkendale, &c., to Grassington, where numerous lead mines are worked under very similar circumstances. The Yorkshire mines yielded in 1856, 8,986 tons of lead.

The second metalliferous district lies in the northern part of Derbyshire, and in the conterminous 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 very small in quantity. They yield annually 5000 tons of lead; with a certain quantity of calamine, and a little copper ore. At Ecton, in North Staffordshire, a remarkably rich copper mine was worked in the last century, at the intersection of several veins, in the midst of very contorted beds of grey and black limestone.

The veins of both the above districts are noted for the beauty of the fluor, calc-spar, and other crystallised minerals accompanying the galena; and those of Derbyshire, also, for the thinning or partial interruption which they suffer in crossing the "toadstone," a rock of igneous origin, which is interstratified with the limestone. Besides the lodes or "rake-veins," the less normal forms of repository termed "flats" and "pipe-veins" yield in both these districts large amounts of ore.

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 nearly 6000 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 was therefore seldom subjected to cupellation, until the introduction of Pattinson's process of desilverising. The lodes, coursing E. and W., are intersected by several great cross veins, which may be traced for many miles, and only exceptionally yield ore. None of the lead veins appear to be prolonged into the subjacent slate rocks. At the Orme's Head, cupriferous veins have also been worked in the limestone.

Mines of galena and calamine have, from a very early period, been worked in the Mendip Hills, to the south of Bristol, but are now almost entirely idle.

Besides the metallic mines just enumerated, the formation of the metalliferous limestone presents, in England, especially in the counties of Northumberland and Cumberland, seams of coal, generally very thin and anthracitic. Far more important are the red and brown oxides of iron, which this formation yields in vast quantity; the brown ore in beds and veins, Alston-Moor; hæmatite of the richest kind, in irregular deposits, near Whitehaven, Cumberland, and at Ulverstone, Lancashire; in less important repositories in Derbyshire, Flintshire, and on the flanks of the Mendip Hills; and lastly excellent brown peroxide in the upper limestone environing the Forest of Dean, where it occupies a series of devious caverns and holes lying more or less in the same plane. Appearances of the same kind, but on a smaller scale, fringe the southern side of the South Welsh coal-field.

Mines of the later Rock Formations.

The most important mines of what used to be termed, in the earlier days of geology, the secondary rocks, and perhaps of all mineral formations whatsoever, are those worked in the most ancient strata of that division, in the coal-measures. Since, however, the organic contents of the rocks have been more fully studied and compared, the coal measures have been classed with the palæozoic systems, and that supposed line of demarcation between them and the older strata already treated of, can only be retained as a matter of convenience, and as marking in most countries a great change in the character of the mineral contents as we ascend in the geological scale.

The British islands, France and Germany frequently present ranges of the older rocks, upon the flanks of which, sometimes uncomformably, repose the deposits of coal. The principal of these have become great centres of manufacture; for Newcastle, Birmingham, Glasgow, Sheffield, St. Etienne, &c., owe their prosperity and their rapid enlargement to the coal raised as it were at their gates in enormous quantities. Lancashire, Wales, Belgium, and Silesia, 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 extensive scale, have procured for their inhabitants less distinguished, but by no means inconsiderable, advantages; such, for example, in Great Britain, are Derbyshire, Cheshire, Shropshire, Warwickshire, the environs of Bristol, &c.; some parts of Ireland; in France, Litry, department of Calvados, Comanterie, Alais, le Creuzot, &c.; in Rhine Prussia, Saarbrück, and Westphalia; and several localities in Saxony, Bohemia, Spain, Portugal, the UnitedStates, &c.

We need not enter here into ampler details on coal mines; these particulars are given in the article Coal.

Nature has frequently deposited close to the 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-fields of Scotland, Yorkshire, Staffordshire, Shropshire, and South Wales. Much of it is also raised from the coal strata of Silesia and of Westphalia, and few coal fields appear to be entirely deficient of it. The iron works of England, which are supplied in great part from this iron-stone reduced with coke or coal, pour annually into commerce above three-and-a-half million tons of pig iron, of a value more than 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 the air, with or without artificial heat, produces sulphate of iron, and sulphate of alumina, whence copperas and alum are manufactured in great abundance.

The calcareous formation which surmounts the coal-measures 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 slightly 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 shores 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 Rothenburg. They produce annually 2000 tons of copper, and 20,000 mares of silver. We may also mention those of Hessia, 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. These mines have been in activity since the year 1530. Analogous mines exist near Saalfeld in Saxony.

A very remarkable deposit of the same period, whence geologists have given this formation the name of Permian, occurs in the Russian government of Perm, the sandstones containing disseminated particles of copper ore, chiefly in the form of carbonate, to the distance of 400 or 500 wersts from the chain of the Oural. Some of the thick flaggy grey grits contain as much as 2½ per cent. of copper and the imperial zavods near Perm are stated to yield 260 tons annually from this source.

To the same geological formation must probably be referred the limestone which contains the sparry iron mine of Schmalkalden 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 has been executed in the most irregular manner, and has opened up enormous excavations; whence disastrous "runs" have taken place in the mines.

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 Gallicia, about 6 leagues N. E. of Cracow, and 15 leagues E. N. E. of Tarnowitz. From their position these have been referred to the same period. The important lead mines of Villach and Bleiberg in Carinthia, have recently been shown by the Austrian geologists to belong to a rather more recent formation, whilst several minor lead-bearing localities of the same province occur in the Hallstadt limestone (Upper Trias), and Gailthal limestone (carboniferous).

There has been discovered lately near *Confolens* 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 used to be supposed that 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 *Palatinate*, *Almaden*, and *Huancavelica* are mined, but more recent observations would place some of them, at least, in rocks contemporaneous with the coal-measures.

The formation which separates the *zechstein* from the lias (*calcaire à gryphites*), called new red sandstone and red marl in England, and bunter-sandstein, muschelkalk, and keuper in Germany, presents hardly any important mines except those of rock-salt; which enrich it in Cheshire, and in many parts of continental Europe. The mines of Salzburg belong to a formation somewhat higher, and those of Wicliezka, Bochnia and of Transylvania, as well as of Cardona in Spain, are of tertiary date.

The lias often contains very pyritous lignites and shales, which are mined in many places, and particularly at Whitby and Guisborough in Yorkshire, for the manufacture of alum and copperas.

Within the last few years, most important beds of stratified iron ore have been worked in the upper parts of the lias in the north of Yorkshire.

Strata of iron ore also occur in the overlying oolitic limestones, in Yorkshire, Northamptonshire and other parts of England. The same formations have in France long been noted for the supply of large quantities of iron ore.

The iron sand beneath the chalk formation, is often so strongly imbued with iron, as to have led in former times to extensive mining operations in the south-eastern part of England. Since the general introduction of railways, some of these sources have again been utilised.

The lowest beds of the chalk contain iron pyrites, which has become the object of an important exportation 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 tertiary 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, yellow amber is extracted.

The other tertiary formations present merely a few mines of sulphur, of iron and bitumen, but it must here again be remarked, that many of the secondary, and even of the tertiary strata have in certain countries been subjected to metamorphic action, of such a nature as to have led to their being classed with the older rocks; and thus some of the metalliferous formations of the east of Europe and of South America, although still somewhat obscure, ought without doubt in strictness to be classified with these more recent deposits.

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.

The tin-stream-works of Cornwall, Bohemia, and the East Indies, and the gold washings, placers or "diggings" of Siberia, Borneo, California, and Australia, belong to beds of alluvium or drift, irregularly deposited over the older formations. —W. W. S.

MINING. As the operations of mining vary with the conditions of the rock formations, in which the minerals sought for by the miner occur, it is necessary to give a brief description of the more especially marked distinctions which are seen in our geological formations.

Geologists divide rocks into *stratified* and *unstratified.* Those mineral systems which consist of parallel, or nearly parallel planes, whose length and breadth greatly exceed their thickness, are called *stratified* rocks ; while to those which occur in thick blocks, and which do not exhibit those parallel planes, the term of *unstratified* rocks is applied. These formations have been divided into two other classes, namely the *primary* and the *secondary.* The advances of geological science, however, and more accurate information, have materially modified the views which gave rise to those divisions; and when men have learned to look on great natural phenomena without the interposition of the medium of some favourite theory, there is but little doubt the interpretation will be somewhat different from even that which is now received.

A certain set of rocks may be classed as of truly igneous origin. These are the traps, basalts, and the like. These have often been termed primary rocks. Yet we have rocks of this class, not merely forcing their way through the superincumbent and more recent rocks, but actually overflowing them ; they may, therefore, be much more recent than the secondary rocks. Granite has commonly been classed as a truly igneous rock ; but facts have lately been developed which show, at all events, the combined action of water, and the probability appears to be that granite, gneiss, and elvans have been formed under highly heated water.

Granite is usually classed with the unstratified rocks; but the section of any granite quarry will exhibit very distinct lines, conforming, more or less, to the horizontal — known to the quarrymen as the *bedway* — which would appear sufficient to place those rocks amongst the stratified ones.

It is commonly stated that the unstratified rocks possess a nearly vertical position, the stratified rocks assuming more nearly a horizontal one. There are numerous examples adverse to this view ; indeed, it must be regarded as a hasty generalisation — the bedway of the granite approaching very nearly to the horizontal, while we often find the truly stratified rocks in a vertical position.

Where the older rocks graduate down into the plains, rocks of an intermediate character appear, which, though possessing a nearly vertical position, like the unstratified and nonfossiliferous rocks, 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 the older and the 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 frequently disposed in a basin-form, and alternate with parallel beds of sandstone, slate-clay, iron-stone, and occasionally of limestone.

As a practical rule it may be here stated, that, in every mineral formation, 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 a 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 following terms have been used to express dissimilar conditions in mineral deposits, well known to the practical miner.

Masses are mineral deposits, not extensively spread in parallel planes, but irregular heaps, rounded, oval, or angular, 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 stocke, lying heaps* or *blocks.*

The orbicular masses often occur in the interior of unstratified mountains, or in the bosom of one bed. These frequently indicate preexisting cavernous spaces, which have been filled in with metalliferous or mineral matter.

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 veins, are flattened masses, with their opposite surfaces not always parallel. These sometimes 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 occurrence suggests the idea of clefts or rents having been made in the stratum posterior to its consolidation, and of the vacuities 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 portions of rounded gravel and sometimes, though rarely, organic remains. In other, but very exceptional cases, lodes are largest at their under part, and become progressively narrower as they approach the surface; from this 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 in a fluid state, has afterwards slowly crystallised. Accurate observation shows that in the large majority of cases the metalliferous deposits are of aqueous, and not of igneous origin.

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 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 stratum, by the angle of inclination, and the point of the horizon towards which it dips, whence the direction is deduced. In popular language a *lode* may be described to be a crack or fissure, such as is formed in the drying of a pasty mass, extending over a considerable extent of country, and penetrating to a great depth into the earth.

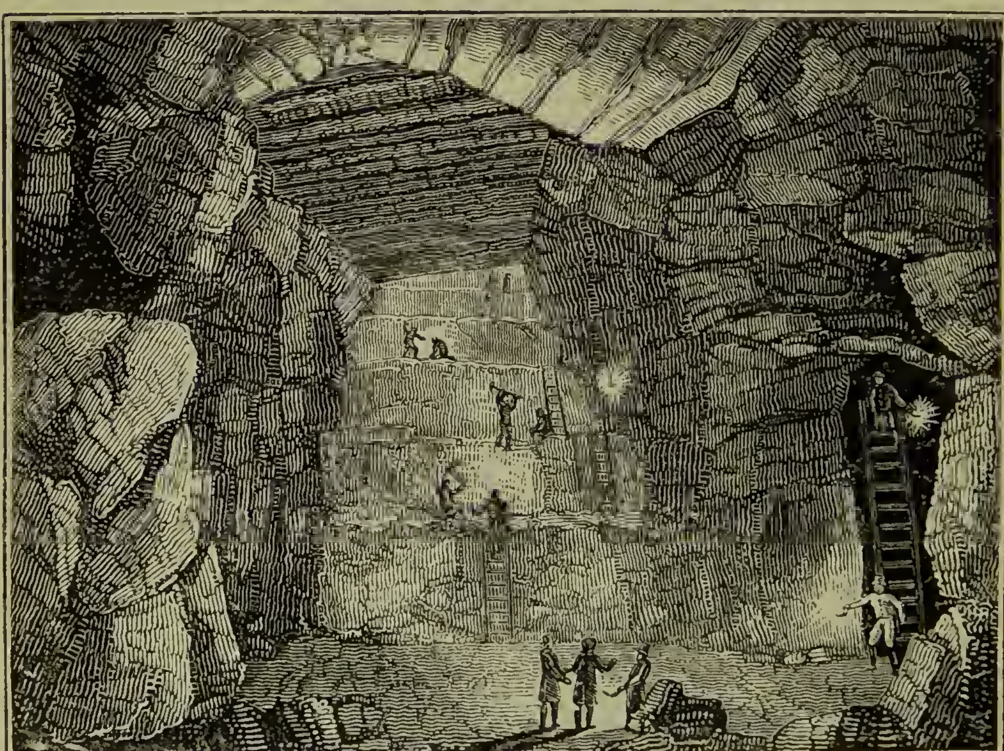
A metalliferous substance is said to be *disseminated*, when it is dispersed in crystals, spangles, scales, globules, &c., through a large mineral mass. Tin is not unfrequently thus disseminated through granite and clay-slate rocks.

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 stores occur in different stages of the geological formations; but their main portion, after having existed abundantly in the several orders of the older strata, cease to be found towards the middle of the secondary rocks. Iron ores are, with a few exceptional cases, the only ones which continue among the more modern deposits, even so high as the beds immediately beneath the chalk, when they exist almost entirely as colouring matters of the tertiary beds.

Granite, gneiss, mica, and clay-slate constitute in Europe the grand metallic domain. There is hardly any kind of ore which does not occur in these in sufficient abundance to become the object of mining operations, and many are found in no other rocks. 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 equinoctial 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 sulphides, oxides, aud 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. The ores in that case are arranged in small layers parallel to the strata, 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 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.

1213



A general view of mining operations as given in Ville-Fosse's "Sur la Richesse Minérale."

In mining, as in architecture, the best method of imparting instruction is to display the master-pieces of the respective arts. 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 subterranean explorations certainly afford some of the finest examples of the useful labours of man; but, however curious 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 which, with their sinuosities, extend at different levels over many hundred miles, 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 recognise either the symmetrical disposition of mineral bodies, or the laws which govern geological phenomena, and serve as sure guides to the skilful miner in his adventurous search. It is only by exact plans and sections of subterraneous workings, that a knowledge of the nature, extent, and distribution of mineral wealth can be acquired.

General observations on the localities of ores, and on the indications of metallic mines.

1. *Tin* exists in the primary rocks, appearing either in interlaced veins, in beds, as a constituent part of the rock itself, or in distinct veins. Tin ore is found in alluvial land, filling up low situations between lofty mountains; but this tin (stream tin) has been derived from the older rocks of the neighbourhood. See Tin.

2. *Gold* occurs either in beds, or in veins, frequently in primary 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 débris 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 secoudary 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 secoudary formations; but silver occurs in combination with the ores of copper or of lead.

4. *Copper* exists in the three mineral epochs; 1, in primary rocks, principally in the state of pyritous copper, in lodes or veins; 2, in transition districts, sometimes in masses, usually 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 primary and transition grounds, where it usually constitutes lodes, and occasionally beds of sulphide of 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, as in the sandstone of Alderley Edge.

6. *Iron* is met with in four different mineral eras, but in different ores. Among primary 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 sometimes in veins, but occasionally in very large masses, 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 to 75 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 primary rocks; small veins containing this metal are found, however, in secondary strata.

9. *Antimony* occurs in lodes among the older and transition rocks.

10, 11. *Bismuth* and *nickel* do not often constitute the predominating substance of any mineral deposits; but they commonly accompany cobalt.

12. *Zinc*, occurs in three several formations: namely as sulphide or blende, particularly in primary and transition rocks; as calamine, in secondary strata, usually along with oxide of iron, and sometimes with sulphide of lead.

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 small value in themselves, become of great consequence to the miner, either in 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, often of a complicated kind, provided we observe assiduously the accompanying *gangues*.

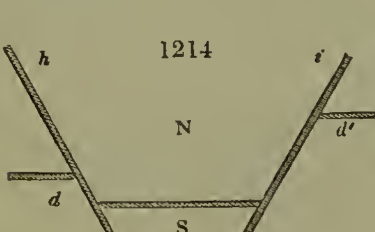
Among the indications of mineral deposits, some are proximate and others remote. The proximate are, an efflorescence, so to speak, of the subjacent metallic masses; the frequent occurrence of fragments of particular ores, &c. The remote indications consist in the geological character, and in the nature 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 veinstones 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; 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 Harz, 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. The *gossans* of Cornwall, occurring in the upper portions of lodes, may be regarded as analogous formations.

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.*

1214



The great copper lode of Carharack, *d*, *fig.* 1214, in the parish of Gwennap, is an instructive example of intersection. The thickness of this vein is 8 feet; its direction is nearly 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 *h*, called *Stevens's fluckan*, which runs from north-east to south-west, and which throws the lode several fathoms out; the second vein 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. S. denotes North and South. *d* is the copper lode running east and west. *h*, *i*, are systems of clay-slate veins called fluckans; the line over S represents the down-throw, and *d'* the up-throw.

There is a great want of exactness of expression in the terms used to describe the phenomena of dislocations. The foregoing paragraphs are strictly according to the technical language of the miner, who usually regards the cross courses, here called *fluckans*, as being the *cause* of the alteration in the mineral veins, whereas they are themselves merely the effect of the general movement of the rock masses. The singularity alluded to disappears if the wood-cut be regarded as a cross section representing the result of two distinct movements in a direction from the observer. See FAULTS.

In different districts in this country the terms used to distinguish mineral veins vary considerably. The following terms prevail in Derbyshire and the north of England.

Lodes or mineral veins are usually distinguished by the miners of these districts 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 mineral fissure; and is the form best known among practical miners. It commonly runs in a straight line, beginning at the superfices 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.

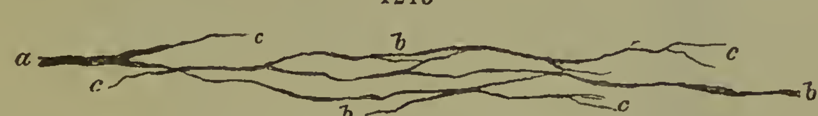
4. The interlaced mass has been already defined. The interlaced strings are more frequent in primitive formations, than in the others.

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.

In Cornwall and Devonshire, where different conditions prevail, other terms are employed.

The *lode*, or mineral vein, is, as in the former instances, a great line of dislocation, accompanied by minor lines of fracture. Of these Sir H. De la Beche says, "It could scarcely be supposed that the great lines of fracture would be unaccompanied by smaller dislocations, running from them in various directions according to modifying resistances, which would depend upon the kinds of rock traversed by the great fractures, the direction in which they were carried through them as regards the bearing of their strata, should they be stratified, and other obvious causes. The great fractures would often also tend to split in various directions and reunite into main lines, as in the annexed sketch (*fig.* 1215) in which *a b* represents the line of prin-

1215



cipal fracture, splitting at *b b* from local causes, and uniting, both towards *a* and *b*, minor cracks running into the adjoining rock at *c*, *c*, *c*, *c*. These are known as *side lodes*, *strings*, *feeders*, and *branches*.

These *strings* are sometimes very curiously developed, and illustrate the peculiar force of crystalline action, and all the phenomena of *heaves* and faults. The following figure (1216) furnishes a good illustration.

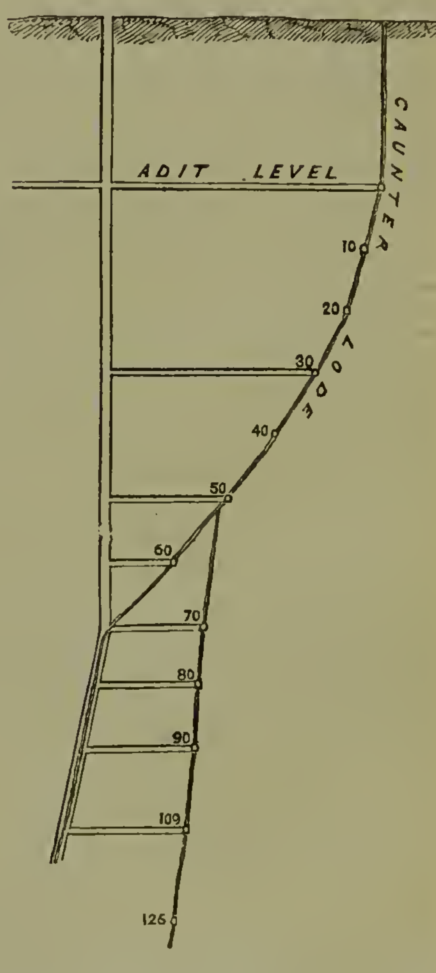
It represents a specimen of strings of oxide of tin in slate from St. Agnes, Cornwall, *h h*, illustrating the *heaves* alluded to. Sir Henry de la Beche is disposed to refer these to the fact of oxide of tin recementing fractured masses of slate.

1216

We think we have sufficient evidence for referring the action to the crystallogenic force enlarging a fissure, or small crack, and producing those lateral cracks, which again, by the operation of the same force, dislocate or heave the original fissure.

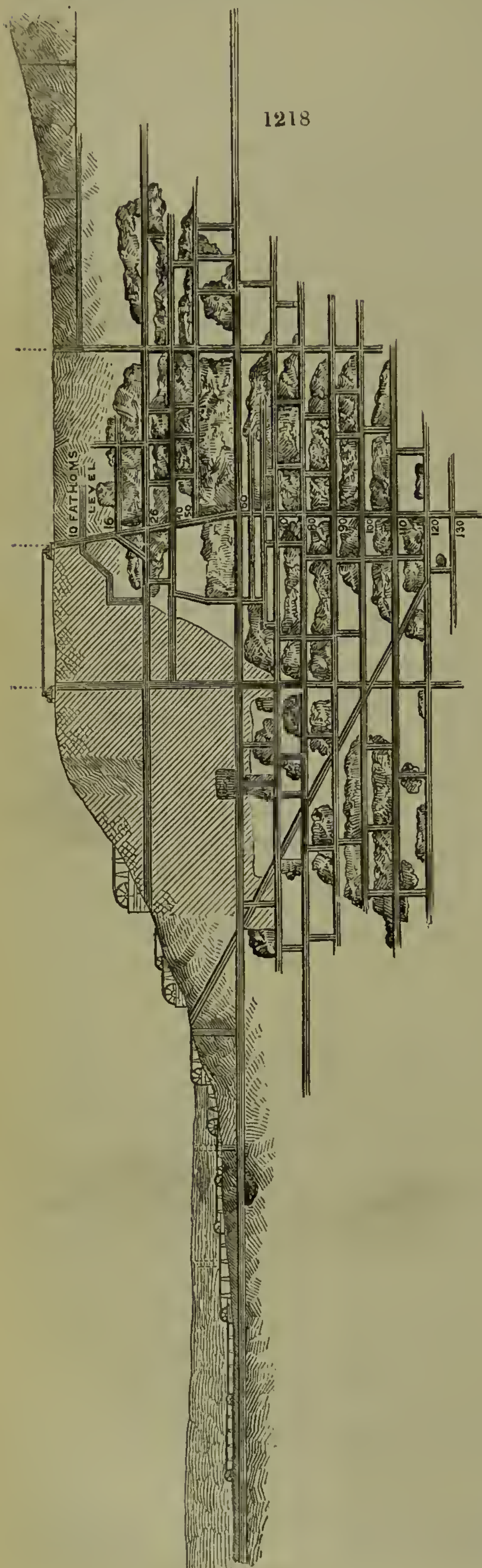
In these lodes we find peculiar mechanical arrangements, which are known by various names; a lode is

1217



said to be *comby* when we have the crystals of quartz or other mineral dovetailing, as it were, with the metalliferous masses. *Bunches* are isolated masses of ore found in the lode surrounded by earthy minerals. The

1218



upper part of a lode is known as its *back*, and the accumulations of ferruginous matter which very commonly occur in the *backs* and near the surface are known as *gossans*. These are to the experienced miner important guides as indicating the characters of the lode at a greater depth. *The country* signifies, with the Cornish miner, the rock through which the mineral vein runs, and accordingly as he is pleased with the indications he speaks of its being *kindly* or the contrary. The softer rocks, whether of clay slate or granite, are spoken of as *plumb*, and a *plumb granite*, or *elvan*, is greatly preferred to the harder varieties, and spoken of as being more kindly.

The rock forming the sides of a lode are known as its *walls* or *cheeks*. The latter term we have heard of late years in Cornwall, but we believe it to be imported by miners who have worked in the north of England. As all mineral veins incline more or less, the sides are spoken of as the upper and under walls, the upper being usually termed the *hanging wall*.

The preceding woodcuts, *figs.* 1217, 1218, will serve to assist the reader in understanding the peculiarities of mining operations in our metalliferous mines. In *fig.* 1218, which is a section of one of the lead mines of Cardiganshire, the shafts, which have been sunk on the lode are shown, at varied angles from the vertical and the several horizontal levels. In this instance these *levels* or *galleries* have heen worked at irregular distances. In Cornwall they are usually ten fathoms apart. The smaller shafts connecting the levels one with the other are called *winzes*. They serve for exploring the lode, or for purposes of ventilation, when the excavations are going forward. When these smaller connected shafts are worked upwards, as they sometimes are, they are called "*risings*," and the miner is said to he working on the "*rise*." In this woodcut the lightest shading is to indicate a portion of this particular mine which was worked out by the Romans. The darker shaded masses indicate portions of the lode which have heen very productive of metalliferous matter, and which have consequently been removed. The term *counter* or *caunter lode* is given to such lodes as dip at a considerahle angle with the direction of the other lodes in its vicinity. Such a lode is shown, *fig.* 1217, which is, however, inserted principally to explain that where the "underlie" of the lode is great, a vertical shaft is sunk at some distance from it on the surface, so as to "cut" (intersect) the lode at some depth, in this instance at 70 fathoms helow the adit level. As the inelination of the lode then alters, the shaft is continued on the lodes. Another fissure or lode, sometimes called a "*dropper*," is seen to take nearly a vertical direction from the 50 fathom level, and from the shafts levels are driven into this lode, at ahout every 10 fathoms.

1219

Fig. 1219 represents in plan the underground workings of a Cornish mine. Those who are not familiar with mining are requested to suppose that the earth is transparent so as to enahle us to see the *levels* worked at various depths, from the *adit-level*,—through which the water pumped from the mine is discharged,—to the 125 fathoms level helow it. These levels are numbered in the plan. They are not worked immediately under one another; hut, as the lode inclines, in the same way as is shown in the *Caunter lode* (*fig.* 1217), they follow in position this *underlie* of the lode. The dark lines and the dotted lines crossing the numbered lodes, are workings upon lodes, running in a contrary direction to the lode principally shown. This plan shows the junction of the granite with the killas or *clay slate* of Cornwall, and the occurrence of *elvan* courses is shown at the different levels. By studying the plan, with the horizontal and transverse section, the operations of metalliferous mining will be understood.

Of Mining in Particular.

The mode of working mines is two-fold; by *open excavations*, and *subterranean* exploitation.

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, 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 Ræraas, near Drontheim, in Norway; several mines of iron, copper, and gold in the Ural mountains. The iron mine near Whitehaven, and Carclase tin mine in Cornwall may also be quoted.

Subterranean workings may be conveniently divided into five classes, viz.: —

1. Veins, or beds, much inclined to the horizon, varying much in thickness.
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 (shafts) and levels destined to conduct the miner to the point most proper for attacking the deposit of ore, for tracing it from 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 (level) 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 but 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 moderate width, 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 parallelopipeds, by means of oblong galleries, pierced ten fathoms 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 parallelopiped blocks, in working back to that point.

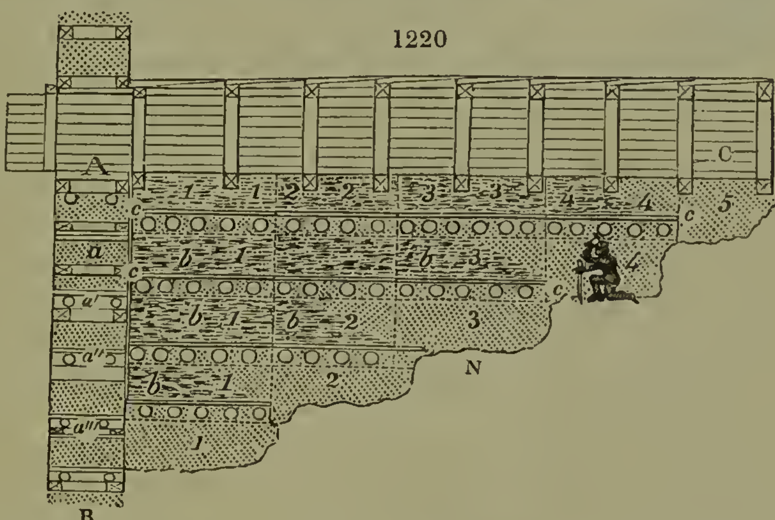
This latter operation may be carried on in two different ways; of which one consists in attacking the ore from above; and another from below. In either case, the excavations are disposed in steps similar to a stair upon their upper or under side.

The first is styled a *working* in direct or descending steps; and the second a *working* in *reverse*, or ascending steps.

The descriptions given by Dr. Ure relate chiefly to the processes carried forward in the German mines. In very many respects they resemble our own processes of mining, and, for the general information these give to the English reader, Dr. Ure's description has been retained.

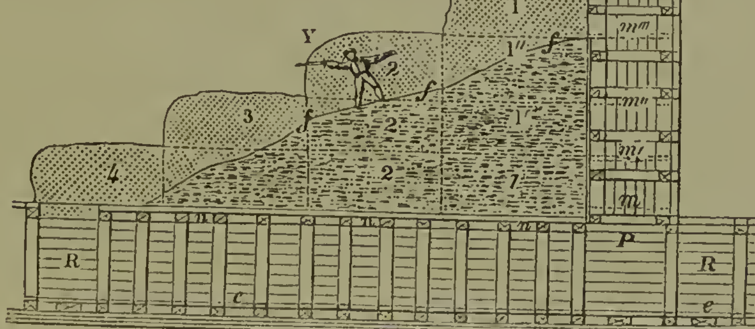
1. Suppose, for example, that the post N, *fig.* 1220, included between the horizontal gallery A C and the shaft A B, is to be excavated by direct steps, a workman stationed upon a scaffold at the point *a*, which forms the angle between the shaft and the elongated drift, attacks the rock in front of him and beneath his feet. Whenever he has cut out a parallelopiped (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

1220



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 re-

1221



paired, 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 Y, *fig.* 1221, a scaffold *m*, is erected in one of its terminal pits P P, at the level of the ceiling of the gallery R R′, where it terminates below. A miner placed on this scaffold, cuts off at the angle of this mass a parallelopiped 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 parallelopiped 1, a parallelopiped 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 forward 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, *n n n*, 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.* 1220, 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.* 1221, 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 parallelopipeds 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.

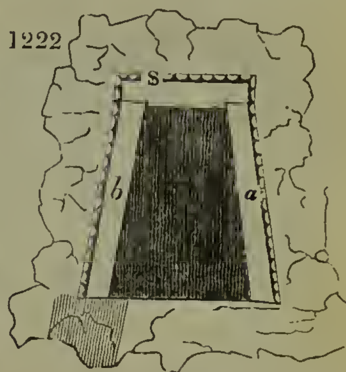
1. *Of the timbering of excavations.*— The excavations of mines, are divisible into three principal species; *shafts*, *galleries*, and *chambers*. When the width of these excavations is inconsiderable, as is commonly the case with shafts and galleries, their sides can sometimes stand upright of themselves; 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 tow walls by means of an upper joist s, *fig.* 1222, which is then called a *cap* or *cornice beam*, 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.

1222



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 framework, 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, *e e*, *fig.* 1221 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 woodwork 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 water is very great. The pieces composing the frames are commonly united by a half-cheek, 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 framework 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 abutted upon the ground.

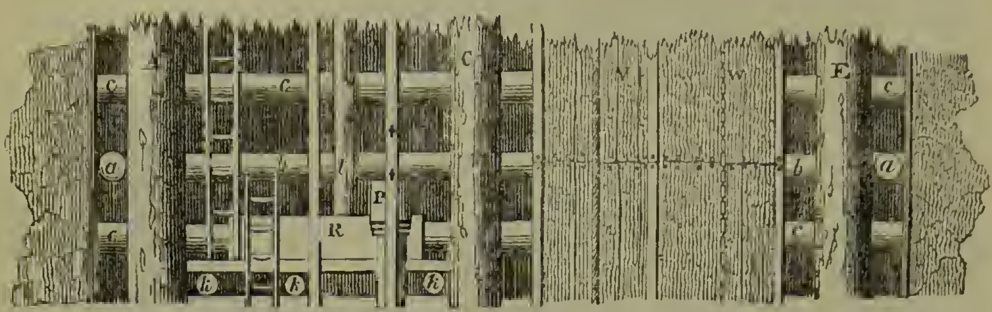
In the large rectangular shafts, which serve at once for extracting the ores, for the discharge of the waters, and the descent of the workmen, the spaces destined for these several purposes are in general separated by partitions, which also serve to increase the strength of the timberings, by acting as buttresses to the planks in the long sides of the framework. 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 alburnum 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.

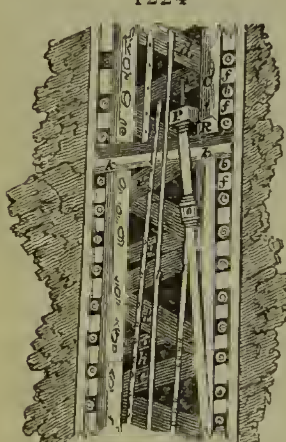
The *figs.* 1223, 1224 represent two vertical sections of a shaft, the one at

1223



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 Harz. There we may observe the spaces allotted to the descent of the miners by ladders to the drainage of the waters by pumps P, and rods *t*, 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.; R, 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.

1224



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.* 1225.

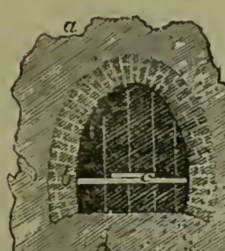
Walled shafts also are sometimes constructed in a circular or elliptic form, which is better adapted to resist the pressure of the earth and waters. Rectangular shafts of all dimensions, however, are frequently walled.

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.

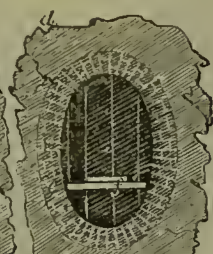
Figs. 1225, 1226, 1227, represent the principal kinds of mason-work employed in the galleries and shafts of mines. *Fig.* 1228 exhibits the walling in of the cage of an overshot water-wheel, as mounted within a mine. Before beginning to build, an excavation large enough must be made in the gallery to 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 keystone. 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

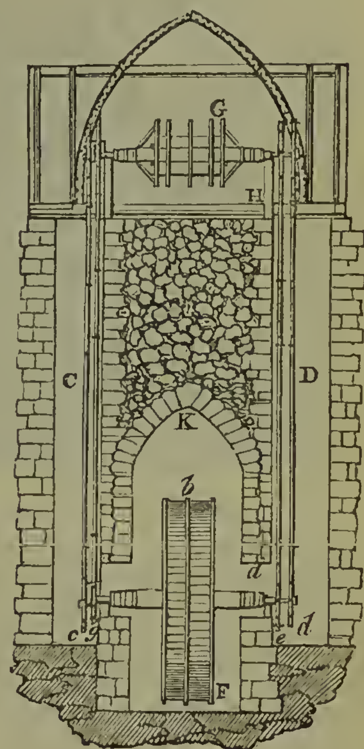
1226



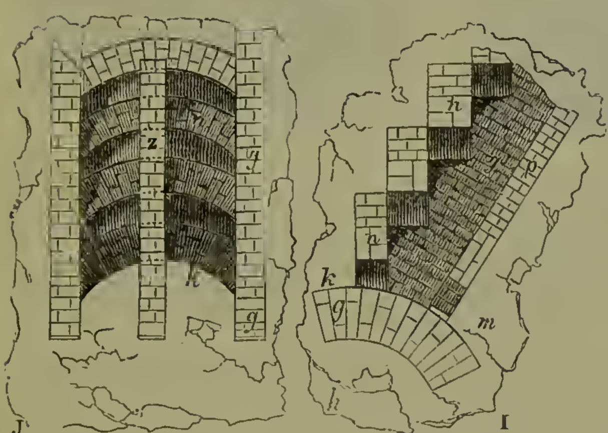
1225



1228



1227



directions, a closed vault, like *fig.* 1225, should be formed. For walls not far from the vertical, salient or buttressed arches are employed, as shown in *fig.* 1227, called in German *überspringende bogen*; for other cases, twin-arches are preferred, with an upright wall between.

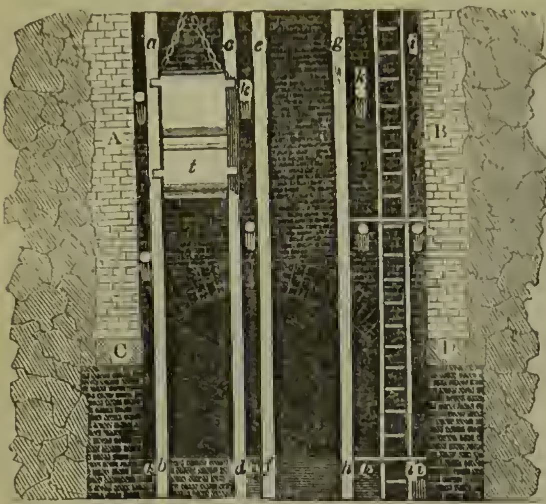
Fig. 1226 is a transverse section of a walled drain-gallery, from the grand gallery of the Harz; see also *fig.* 1228. *a* is the rock which needs to be supported only at the sides and top; *b*, the masonwork, a curve formed of the three circular arcs upon one level; *c*, the floor for the watercourse. *Fig.* 1225 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 water-course beneath it.

Fig. 1227 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; *z*, 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.

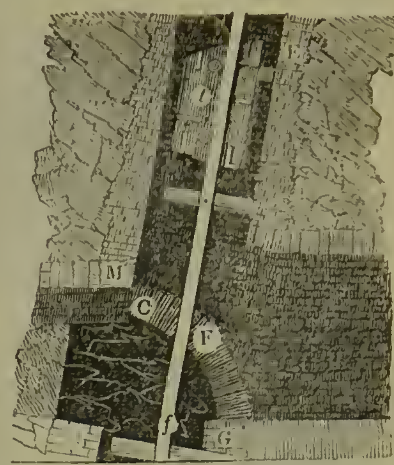
Fig. 1228, C D is the shaft in which the vertical crank-rods *c g*, *e d*, move up and down. F, is a double hydraulic wheel, which can be stopped at pleasure by a brake mounted upon the machine of extraction. G, is the drum of the gig or whim for raising the *corves* or tubs (*tonnes*); H, is the level of the ground, with the earpentry which supports the whim and its roof. *k*, 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; *c*, *g*, double crank with rods, whose motion is taken off the left side of the wheel; *e*, *d*, the same upon the right side. The distance from H to F is about 22 yards.

Figs. 1229, 1230, 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.

1229



1230



In *fig.* 1229, A B are the side walls supported upon the buttresses C and D; in *fig.* 1230, E is the masonry of the wall, borne upon the arch F at the entrance to a gallery, the continuation being at G, 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 H is the continuation of the arch or vault L, which underneath is supported in like manner at the entrance of a lower gallery.

a b, *c d*, *fig.* 1229, 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.

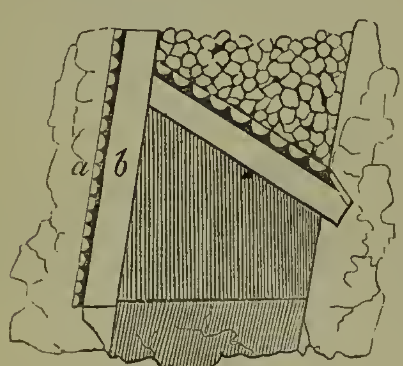
i i, are cross-bars of wood, which support the stays of the ladders of descent.

k k, are also cross-bars by which the guide-rods are secured.

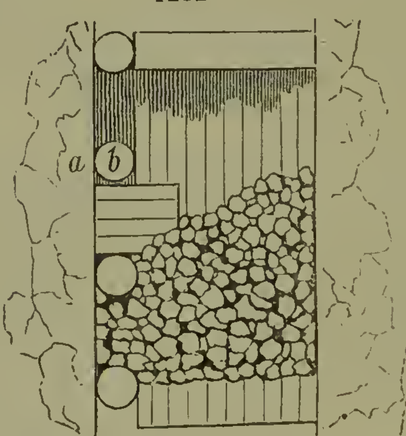
t, a *corf*, or extraction kibble, furnished with friction rollers; the other corf is supposed to be drawn up to a higher level, in the other vertical passage.

Figs. 1231, 1232 represent in a vertical section the mode of timbering the galleries of the silver and lead mines at Andreasberg in the Harz. *Fig.* 1231 shows the plan

1231



1232

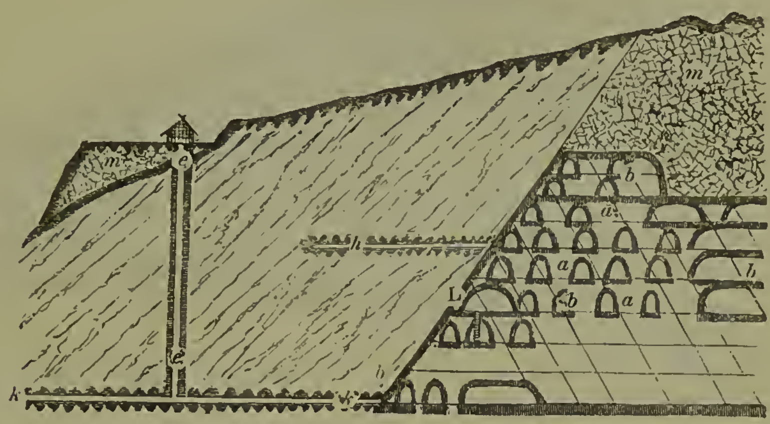


viewed from above. Upon the roof of the timbering, the workman throws the waste rubbish, and in the empty space below, which is shaded black, he transports in his waggons or wheelbarrows the ores towards the mouth of the mine. *Fig.* 1232 is the cross section of the gallery. In the two figures, *a* represents 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. 1233 is a vertical section of the bed of ore, which is a *direct* mass of spathose

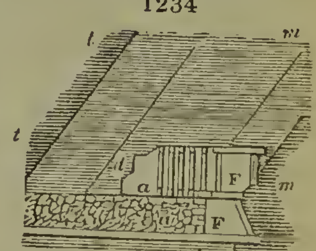
1233



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. *e* is a shaft for extraction, communicating below with the gallery of efflux *k*; *h* 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. *m m*, represents the mass of sparry iron.

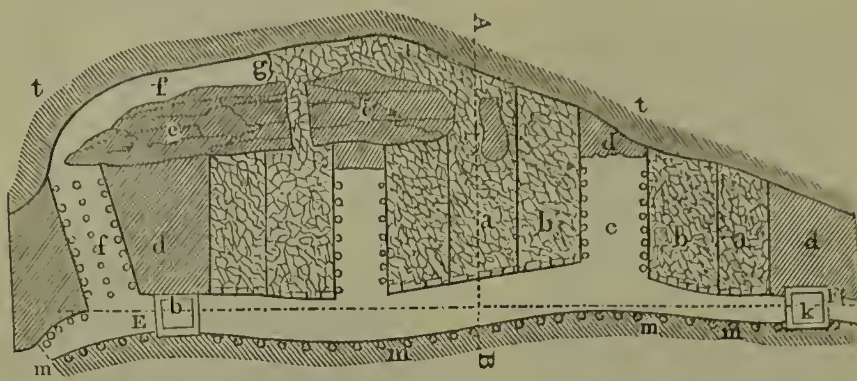
Figs. 1234, 1235, 1236, represent the cross system of mining, which consists in forming galleries through a mineral deposit, from its wall or floor towards its roof, and not, as usual in the direction of its length. This mode was contrived towards the middle of the 18th century, for working the very 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.* 1234, 1236, as well as in the ground plan *fig.* 1235, the wall is denoted by *m m*, and the roof by *t t*. A first gallery of prolongation E F, *fig.* 1235, 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.* 1235. 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.

1234



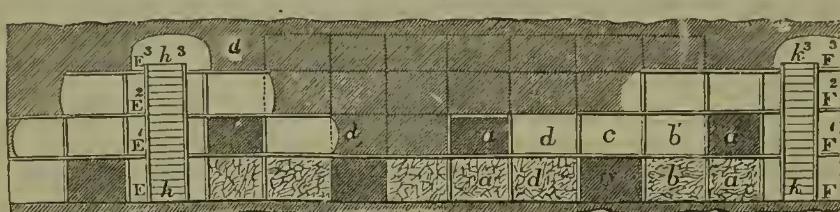
In proportion as the cuts *a*, of the first story E F, are thus filled up, the greater part of the timbering is withdrawn, and made use of elsewhere. The intermediate cuts *b*, *c*, *b*, are next mined in like manner, either beginning with the cuts *c*, or the cuts *b*, according to the localities. From *fig.* 1235 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 E F, *fig.* 1236, and this portion is replaced by rubbish.

1235



The exploration of the upper stories E′ F′, E² F², E³ F³, is now prepared in a similar manner ; with which view shafts *h h*³, *k k*³, are formed from below upwards in the wall

1236



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.* 1236. The following objects may be specified in the figures : —

a a, the first cuts filled up with rubbish, upon the first story E F, *fig.* 1235.

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*.

h h, two shafts leading from the first story E F, 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 E′ F′, the gallery of prolongation F′, *figs.* 1234 and 1236, 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.* 1236 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. 1237 represents a section of the celebrated lead mines of Bleyberg in Carinthia, not far from Villach.

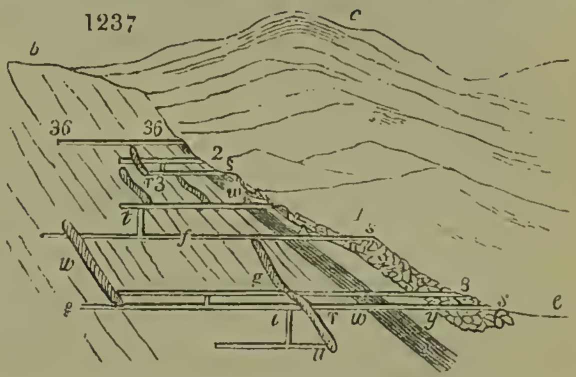
b c, is the ridge of the mountains of compact limestone, in whose bosom the workings are carried on.

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 these 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 1, *s*, it would appear that a great portion of this system of mountains has suffered a slip between 1, *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 fire marble known under the name of the *lumachello of Bleyberg* is quarried.

1237



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^3; 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*.

The 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 faults than elsewhere.

It is in general by galleries cut horizontally in the body of the mountain, and at different levels, *s*, *g*, *sf*, that the miner advances towards the masses of ore *r*, r^3. 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.

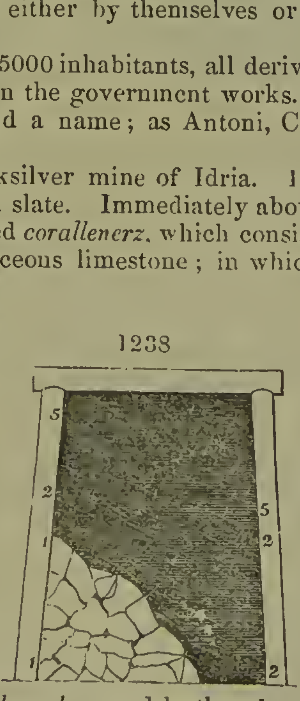
The metalliferous valley contains 5000 inhabitants, all deriving subsistence from the mines; 300 of whom are occupied in the government works.

Each concession has a number and a name; as Antoni, Christoph, Matthæus, Oswaldi, 2, 8, 36, &c.

Fig. 1238 is a section in the quicksilver mine of Idria. 1, is the grey limestone; 2, is a blackish slate; 5, is a greyish 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, 2½ toises cube of rock.

Fig. 1239 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 greyish-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 vein at its side is sand; next is *rauchwacke*; and lastly, the main body of fetid limestone, or *stinkstein*.

1238



1239

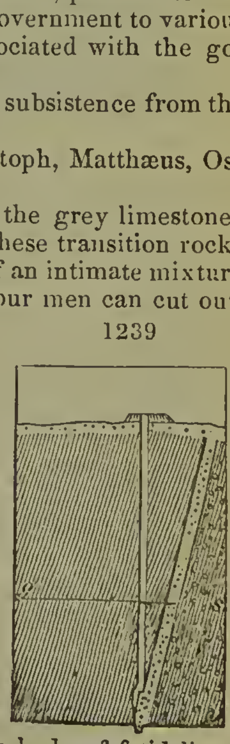


Fig. 1240 represents a section of one of the Mansfeldt copper schist mines in the district called Burgoerner, or Preusshoheit.

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 lueullite.
10. Friable greyish 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 eupriferous 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 (*faüle*) 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:—

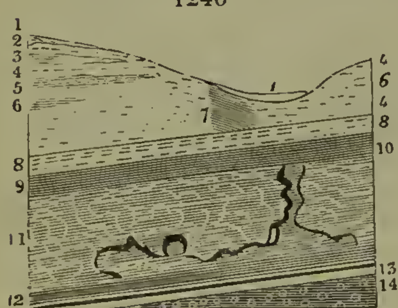
   a, the *lochberg*, a seam 4 inches thick.
   b, the *kammschale*, $\frac{1}{4}$ of an inch thick.
   c, the *kopfschale*, one inch thick.

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.

1240



1241

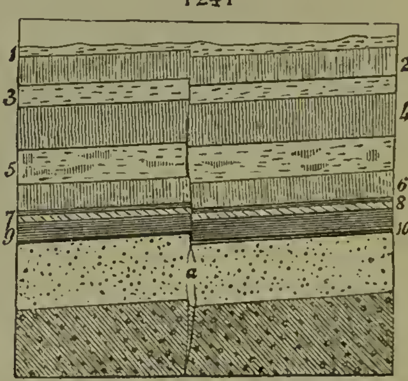


Fig. 1241 is a section of the mines of Kiegelsdorf in Hessia, presenting —

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 grey, or cellular and yellowish grey.
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 greyish-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 Harz, to the south of Goslar, presents a stratified 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 grey 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 A B and E F, in *fig.* 1242, 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.* 1242 the regularity of the vaults previously scooped out above the

1242

level B 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, paralle. to the direction of the future vault, as happens at *b*, there is arranged on the bottom a horizontal layer of billets of firewood, 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 concentred 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.

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, volatilising 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 *débris* 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.

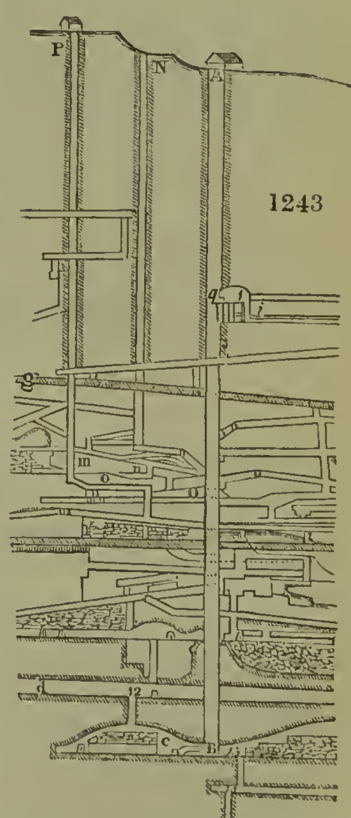
The blasting process is employed when the foremen of the workshop or mine-chamber judge that a hole well placed may separate enough of ore to pay the time, the repair of tools, and the gunpowder expended. But this indemnification is rarely obtained. The following statement will give an idea of the tenacity 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; $6\frac{1}{4}$ 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 importanee, 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 beeome 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 greywacke, a powerful stratum of shells impasted in a ferruginous sandstone. 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 considerable. 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 grey copper (*fahlerz*), sulphuret of zinc, and arsenical pyrites.



1243

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.* 1242, 1243, A B is the shaft of extraction called the *Kahnenkuhler*; N is the ventilation shaft, called *Breïtlingerwettershacht*; P is the extraction shaft, called *Innier-schacht*.

E F, is a new extraction-shaft, called *Neuertreibschacht*, by which also the water is pumped up; by A B, and E F, the whole extraction and draining are carried on. The ores are raised in these shafts to the level of the waggon-gallery (*galerie de roulage*) *i*, by the whims 1, *q*, provided with ropes and buckets. 1, 2, 3, 4, *fig.* 1242, 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*, R, *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;

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*.

Of the instruments and operations of subterranean mining.—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 lode; 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.

Leaving this description of foreign mining operations, we must briefly notice a few practices in our own mines. In order to penetrate into the interior of the earth, and to extract from it the objects of his toils, the miner has at his disposal several means, which may be divided into three classes: 1, *manual tools*; 2, *gunpowder*; 3, *fire*.

The tools used by the miners of Cornwall and Devonshire are the following:

Fig. 1244. The *pick*. It is a light tool, and somewhat varied in shape according to circumstances. 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. 1245. The *gad*. It is a wedge of steel, driven into crevices of rocks, or into small openings made with the point of the pick.

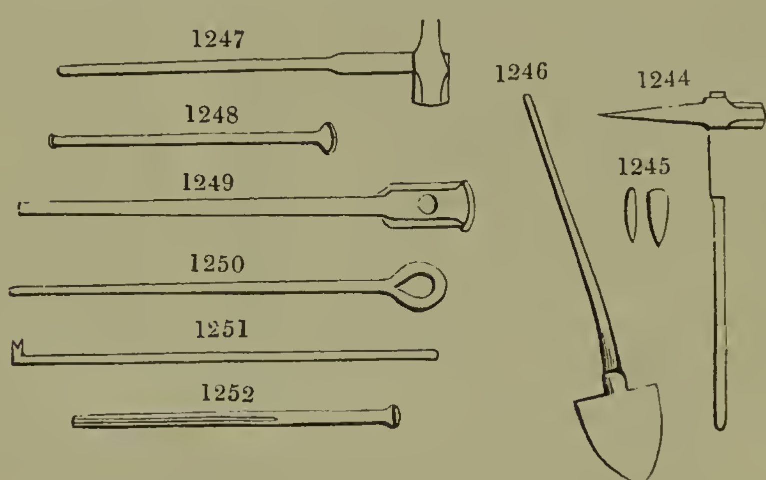


Fig. 1246. The *miner's shovel*. It has a pointed form, to enable it to penetrate among the coarse and hard fragments of the mine rubbish. Its handle being somewhat bent, a man's power may be conveniently applied without bending his body.

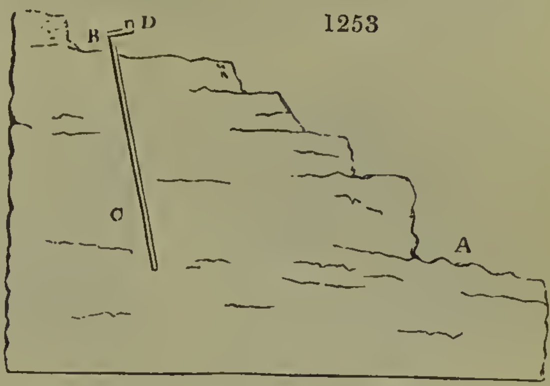
The *blasting* or *shooting* tools are:—a *sledge* or *mallet*, *fig.* 1247; *borer*, *fig.* 1248; *claying bar*, *fig.* 1249; *needle or nail*, *fig.* 1250; *scraper*, *fig.* 1251; *tamping bar*, *fig.* 1252.

Besides these tools the miner requires a powder-horn; he is supplied with safety fuse (see SAFETY FUSE); tin cartridges for occasional use in wetground; now more frequently is he supplied with Copeland's cartridges for this purpose.

The *borer*, *fig.* 1248, 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.* 1247. The hole is cleared out from time to time by the scraper, *fig.* 1251, 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. 1253 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. 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*. 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 safety fuse which communicates the fire.

1253



For conveying the fire, the large and long green rushes which grow in marshy ground were formerly used in our mines, and are still used in quarries. 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. The "safety fuse" is now, however, almost universally employed.

In *fig.* 1253 the portion of the rock which would be dislodged by the explosion, is that included between A and B. 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 old *smift* is shown at D. The safety fuse now supplies its place.

Fig. 1254 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* or *whimseys*, sometimes worked by horses, and frequently by steam power. 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. In place of the kibble, *skips* running in guides fixed on the sides of the shafts are now used in the large and well conducted mines.

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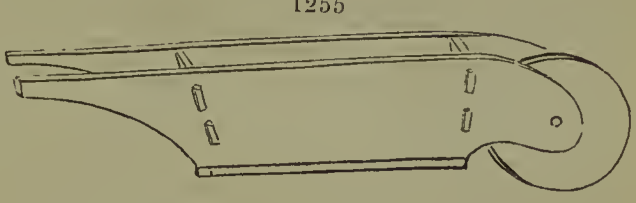

Fig. 1255 represents the wheelbarrow used under ground for conveying ore and waste to the foot of the shafts. It is made of light deal, except the wheel, which has a narrow rim of iron.

In all mines, to a greater or a less extent, there will be found accumulations of water; it is necessary, therefore, to adopt measures to ensure its removal. The mineral treasures, being brought to the surface, necessarily undergo a process of "dressing," that is, the separation of the richer from the poorer portion. For a full account of dressing machinery, &c., see ORE DRESSING and WATER ENGINES.

It sometimes happens that the necessities of mining demand the construction of shafts in places covered with water. Some years since a very extraordinary case of this kind was to be seen at the Wherry Mine, near Penzance, where a cylinder of wood, rising through the sea, formed the entrance to a shaft sunk into the mine. In a storm a ship ran against this timber structure and destroyed it.

M. Triger, engineer in the department of Maine and Loire, had the idea of making a well in the very bed of the Loire by means of compressed air. A cylinder of thin iron, *fig.* 1256, served as a cutting machine, was sunk into the alluvium; it was separated into three compartments by horizontal partitions. The upper compartment remained always open, the lower compartment was the workshop, and between them was the middle one, which served as the chamber of equilibrium, designed to be put in communication with either the compartment above or the one below. The things being so disposed, they forced into the bottom compartment, air compressed by a vapour machine without intermission. This air drove the water up a tube, of which the lower part was buried in the bottom of the excavation, and of which the upper part was raised above the cylinder. The workmen were then able to penetrate the first apartment and open the second, which was afterwards hermetically closed, and in which the air of ordinary pressure was put in communication with the compressed air in the third. Having arrived in the third compartment they excavate the sands, and cause the machine to descend. As they accumulate the sands excavated in the middle compartment, they have only to remove them by shutting the communication with the bottom and opening that of the top. A pressure sufficient to balance the exterior waters was maintained during the work, without sensibly incommoding the workmen. This ingenious proceeding has since received numerous applications. In *fig.* 1255, is represented the apparatus as it was used by M. Triger at the bottom of the Loire.

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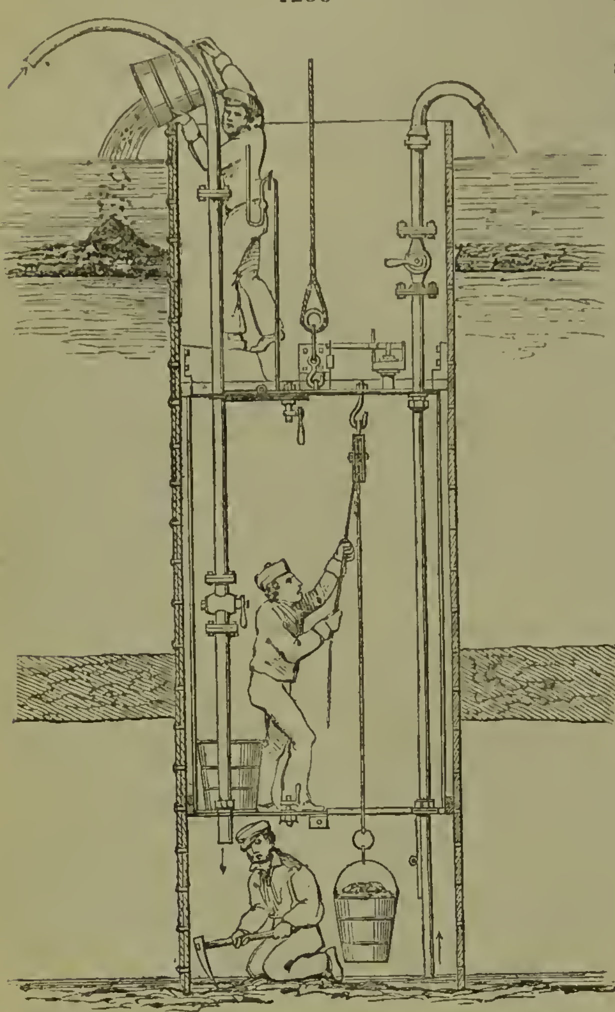

It is evident that wells dug in the water-saturated earths must immediately be cased, that is to say, covered with a casing of wood, solid and impermeable, which is able to resist the infiltration and pressure of the waters at the same time.

A plan similar to this was employed by Mr. Brunel in the construction of one of the piers, in the bed of the river Tamar, for the Royal Albert Bridge at Saltash.

MINING FOR COAL. The processes of boring, by which it is usual to begin, for the purpose of determining the existence and depth of any bed or beds of coal, have been already described. See BORING.

Of 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 natural dam, 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, 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 or pumping 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 at least 5 feet wide, with its bottom gutter for drainage either covered over or open. 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 9 feet in diameter; and they ought to be always cylindrical. *Fig.* 1257 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

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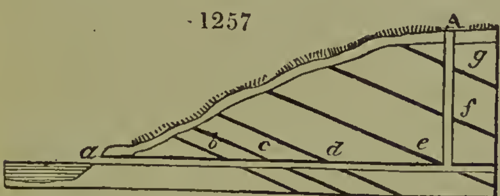

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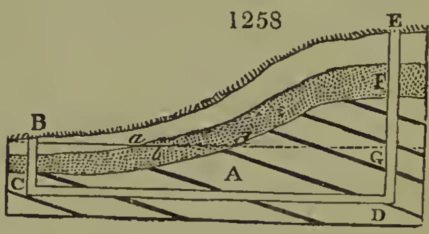

then worked by the pit A. The chief obstacle to the execution of day-levels, is presented by quicksands in the alluvial cover, near the entrance of the gallery. The best expedient to be adopted amid this difficulty is the following:—*Fig.* 1258 represents the strata of a coal-field A, with the alluvial 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 B *d*. But the quicksand makes it impossible to push forward this day-level directly. The pit B 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 E D is put down, after it has been ascertained by boring that the rock-head or bottom of the quicksand at F is a few yards higher than the mouth of the small pit B. During this operation, all the water and mine-stuff are drawn off by the pit B; but whenever the shaft E 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 B. From the surface of the water in the deep shaft at G, 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:—the water-wheel, the water pressure engine, and the steam engine. See WATER RAISING MACHINERY.

The depth at which the coal is to be won, or to be drained of water, 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 20 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 water 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. The pumping machinery of a new colliery should be adequate to pump the water in 8 or 10 hours out of the 24. In the course of years 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 the 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.* 1259, 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

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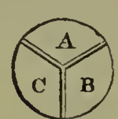

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When the area of a shaft is to be divided into three compartments, one for the engine pumps, and two for raising coals, as in *fig.* 1260, which is denominated a triple pit, it should be 12 feet in diameter. If it is to be divided into four compartments, and made a quadrant shaft, as in *fig.* 1261 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 daily discharge of coals.

If there is a large quantity of water to pump, it is most desirable to appropriate a shaft exclusively for the purpose. Another shaft being used for raising coal, and as an upcast for the ventilation of the mine.

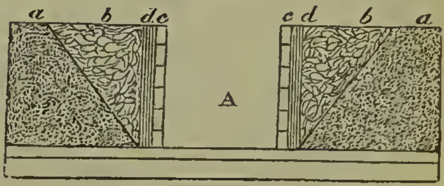
When only one shaft is sunk and divided by wood or stone partitions, the ventilation of the mine is dependent upon these slight divisions of the shaft. If the partitions of a shaft become injured or burnt, which has been the case with wood partitions, the ventilation of the mine may suddenly be destroyed. Many lives have been placed in great jeopardy by the burning of wood partitions, which has destroyed the ventilation and prevented escape up the shaft.

The most approved arrangement of shafts for a large colliery yielding explosive gas, and where water has to be pumped, is to sink a shaft for pumping, another for raising coals, and a third for ventilation or upcast; at the bottom of which is kept burning a large furnace.

The shaft, as it passes through the earthy cover, should be securely faced with masonry of jointed ashler, having its joints accurately bevelled to the centre of the circle.

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.* 1262, represents a bed of quicksand resting on a bed of impervious clay, that immediately covers the rock. A is a finished shaft; *a a*, the quick-sand; *b b*, the excavation necessarily sloping much outwards; *c 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 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.

1262

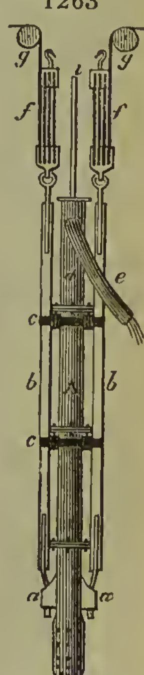


The engine pit being secured, the process of sinking through the rock is ready to be commenced, as soon as the divisions of the pit formed of carpentry, called brattices, are made. In common practice, and where great tightness of joining is not required, for ventilating imflammable air, bars of wood called buntons, 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 bunton 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 buntons 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 buntons stretch across the whole space, but merely meet near the middle, and join at certain angles with each other. As the buntons 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 buntons with those above and below. Thus the carpentry work acquires sufficient strength and stiffness.

In quadrant shafts the buntons 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.* 1259 is a double shaft: A, the pump pit; B, the pit for raising coal. *Fig.* 1260 is a triple shaft; in which A is the pump compartment; B and C are coal pits. *Fig.* 1261 is a quadrant shaft: A, the pump pit; B, pit for ventilation or upcast for the smoke; C and D, pits for raising coals.

1263



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.* 1263; 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; the 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 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.

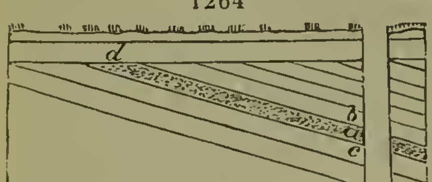
Another method of suspending the pumps in the sinking shaft, in the place of the ropes and blocks, is by two powerful iron screws about 15 feet in length, which are supported at the top of the shaft by strong beams of timber. As the shaft is sunk, the pumps are lowered by the screws; when lowered sufficient for a pump 9 feet in length, the pumps are securely fastened, while the screws are detached and screwed up ready for again lowering the pumps as the shaft is sunk.

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 sometimes 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. The water is more frequently taken down the shaft in pipes to the nearest cistern.

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 modes of keeping back or stopping up these feeders; by plank tubbing; iron tubbing; and by oak cribs. Let *fig.* 1264 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 tubbing 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 the depth (supposed to be 50 fathoms from the surface of the water in the cover); in this case, the tubbing 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 tubbing 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

1264

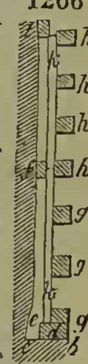


to the bottom the total weight of the hydrostatic column of 100 fathoms; and experience shows, as we have already stated, that whatever water occurs in coal-pits, or in mines, generally speaking, proceeds from the surface of the ground. Hence, if the cover be an impervious bed of clay, very little water 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 tubbing that is to be inserted; the greatest width being needed for plank-tubbing, and the least for iron-tubbing. *Fig.* 1265 represents a shaft excavated for plank-tubbing, where *a*, *a*, *a* are the 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.* 1266. To make room 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.

1265

1266



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, now supersedes 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 ashlar-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.

The weight of the hydrostatic column is not the only pressure to which the tubbing is exposed. There is the pressure from accumulated carburetted hydrogen gas, which considerably exceeds the water pressure. If the tubbing in deep shafts was put in without pressure pipes, it would be liable to be fractured by great pressure from gas. The pressure pipes are usually fixed to each length of tubbing; strong taps or cocks are first screwed into the tubbing, and malleable iron pipes of from 1 to

2 inches in diameter are fixed to the tops and carried up to the surface; and in many cases a eontinual overflow of gas and water issues. By these means the tubbing is only subjeet to the pressure due to the hydrostatic eolumn.

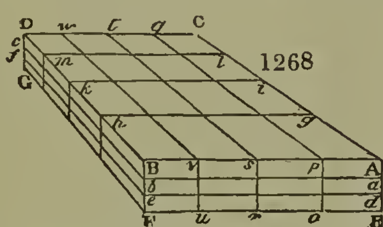
Before tubbing a shaft, it is neeessary to aseertain whether the strata containing water is likely to be disloeated, so as to let down the water by working the coal away; in sueh a ease, tubbing the shaft is unnecessary. The judgment of the mining engineer must decide about this.

When a porous thin bed or parting betwixt two impervious strata, gives out mueh water, or when the fissures of the strata, ealled eutters, are very leaky, the water can be completely stopped up by the improved proeess of wedging. The fissure is cut open with ehisels, to a width of two, and a depth of seven inches, as represented in *fig.* 1267. The lips being rounded off about an inch and a half, pieees of elean deal are then driven in, whose faee projects no further than the eontour of the lips, when the whole is firmly wedged, till the water is entirely stopped. By sloping baek the edges of the fissures, and wedging baek from the faee of the stone, it is not liable to burst or eraek off in the operation, as took plaee in the old way, of driving in the wedge direetly.

1267

Working of Coal.

A stratum, bed, or seam of eoal, is not a solid mass, of uniform texture, nor always of homogeneous quality in burning. It is often divided and intersected, with its eoneomitant strata, by what are named partings, baeks, cutters, reeds, or ends. Besides the ehief partings at the roof and pavement of the eoal seam, there are subordinate lines of parting in the coal mass, parallel to these, of variable dimensions. These divisions are delineated in *fig.* 1268, where A, B, C, D, E F G D, represent a portion of a bed of eoal, the parallelogram A 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 baeks; *o p*, *p q*, *r s*, *s t*, *u v*, and *v w*, the eutters. It is thus manifest that a bed of eoal, according to the number of these natural divisions, is subdivided into solid figures of various dimensions, and of a eubieal or rhomboidal shape.



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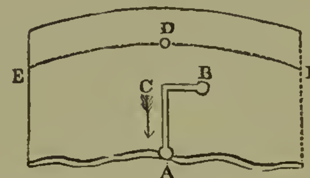
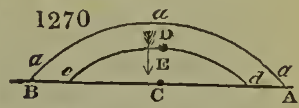
1269



When the engine-pit is sunk, and the lodgement formed, a heading or drift is then made in the eoal to the rise of the field, or a eropping from the engine-pit to the seeond pit. This heading may be 6 or 8 feet wide, and earried either in a line direetly to the pit bottom, or at right angles to the baeks or web of the coal, until it is on a line with the pit, where the heading is set off, upon one side, to the pit bottom. This heading is carried as nearly parallel to the backs as possible, till the pit is gained. *Fig.* 1269 represents this mining operation. A is the engine-pit. B, the seeond or bye-pit. A C, the gallery or heading driven at right angles to the baeks. C B, the gallery set off to the right hand, parallel to the baeks. The next step is to drive the main levels from 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 direetion, 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 level a small quantity of water, like that of a gutter, so as to guide the workmen in driving the level. When the level is driven eorrectly, with the proper depth of water, it is said to have dead water at the faee. In this operation, therefore, the miner pays no regard to the baeks or cutters of the eoal; but is guided in his line of direction entirely by the water-level, whieh he must attend to solely, without regard to slips or disloeations of the strata throwing the coal up or down. In the last figure, the eoal-field is a portion of a basin; so that if the shape be uniform and unbroken, and if any point be assumed on the dip of the crop, as D, the level lines from that point will be parallel to the line of erop, as D E, D F, and the levels from any point, whatever the dip or inclination of strata, will be also parallel to these; and henee, were the eoal-field an entire elliptical basin, the dip-head levels earried from any point would be elliptical, and parallel to the crop. If, as is more commonly the ease, the eoal-field be merely a portion of a basin, formed by a slip of the strata, as represented in *fig.* 1270, where *a*, *a*, *a*, is the crop and A 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 A and at B. 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 *c*, and the level on both sides of the engine-pit will be also cut off by the slip A B. In this figure, the part included between the two curve lines, is the breadth or breast of coal-field won by the engine-pit D; 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.

1270



In British practice, there are four different systems of working coal-mines: —

1. Working with pillars and rooms or boards, 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 and Derbyshire 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 long work method is adopted generally with thin coals; for when the thickness exceeds 6 or 7 feet, and there is only little refuse made in excavating the coal to cart into the excavated part, this mode has been found impracticable.

The following considerations must be had in view in establishing a coal-mine: —

1. The lowest coal stratum 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. There are, however, cases where an upper seam of coal can be worked more advantageously by working a lower seam first on the long wall method.

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 by post and stall: —

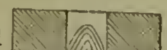
"1. If the coal, pavement, and roof are of ordinary hardness, the pillars and rooms may be proportioned to each other, corresponding to the depth of the superincumbent strata, providing all the coal proposed to be wrought is taken away by the first working, as in the first system; but if the pillars are to be winged or partially worked 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."

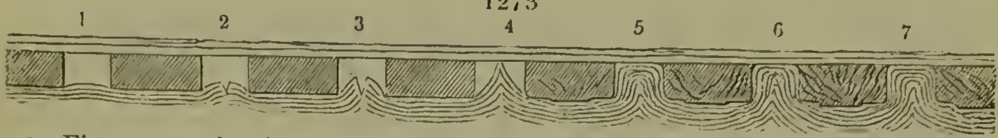
1271 

1272 

Fig. 1271 represents the effects of pillars sinking into the pavement, and producing a creep; and *fig.* 1272 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.

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.* 1273, exhibits the creep in all its progressive

1273



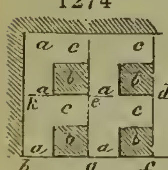
1. First stage of active creep.
2. Second do.
3. Third do.
4. Fourth do.
5. The metal ridge closed, and the creep beginning to settle.
6. The creep settled, the metal ridges being closely compressed, and supporting the roof.

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.

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.* 1274 be a small portion of the pillars, rooms, and thirlings formed in a coal-field; *a*, *a*, are two rooms; *b*, the pillars; *c*, the thirlings (or area worked out). 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*, *k*, *h*, 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.

1274



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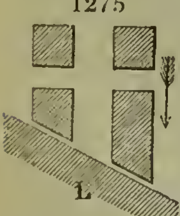


In forming the pillars and carrying forwards the boards with regularity, especially where the backs and cutters are very distinct and numerous, it is of importance to work the rooms at right angles to the backs, and the thirlings in the direction of the cutters, however oblique these may be to the backs, 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.* 1275. 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.* 1276; where A represents the engine-pit, B the bye-pit, C D the dip-head levels, always carried in advance of the rooms, and E 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 E; 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 D. 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 to the crop or rise 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.

1276

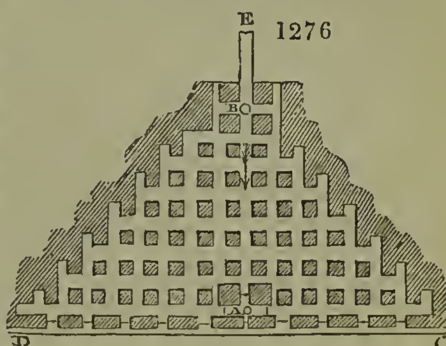
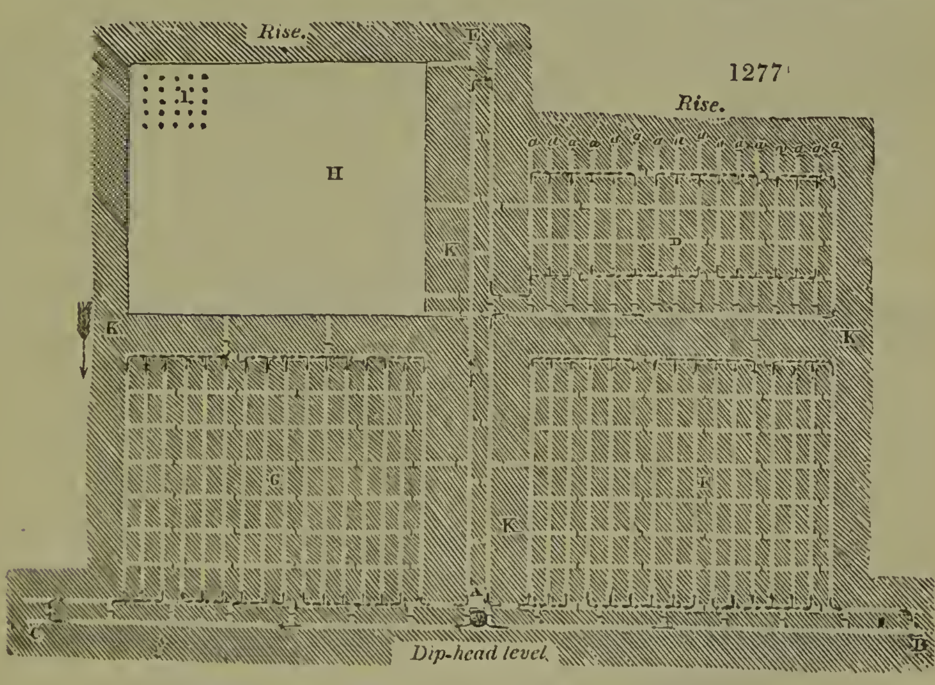


Fig. 1277 represents a part of a colliery laid out in four panels, according to the improved method of the north of England. To render it as distinct as possible, the line of the boards is at right angles with the dip-head level, or level course of the coal. A is the engine-shaft, divided into three compartments, an engine-pit and two coal-pits, like *fig.* 1260. 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. B C, is the dip-head level; A E, the rise or crop gallery; K, K, the panel walls; F, G, are two panels completed as to the first work; D, is a panel, with the rooms *a*, *a*, *a*, in regular progress to the rise; H, is a

1277



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.

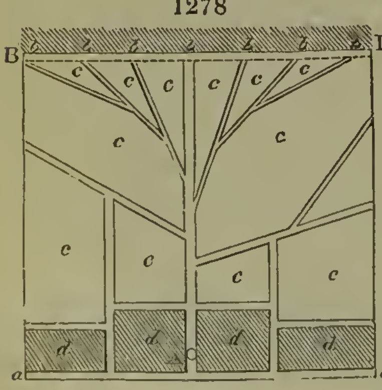
In Mr. Buddle's system the pillars are very large, and the rooms or boards narrow; the pillars being in general 12 yards broad, and 24 yards long; the boards 4 yards wide, and the walls or thirlings cut through the pillars from one board to another, only 5 feet wide, for the purpose of ventilation. In 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 I (in II), 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 *goaf*. The only use of the prop-wood is to prevent the stratum, 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 goaf. If any props are left in the goaf it causes an irregular subsidence of the strata, and throws more pressure on the adjacent pillars. The miners next proceed to cut away the pillars nearest to the sides of the goaf, 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 goaf 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.

The fourth system of working coal, is called the *long way*, the long-wall, or the Shropshire and Derbyshire method.

The object of this system, is to begin at the pit-bottom, 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, 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.

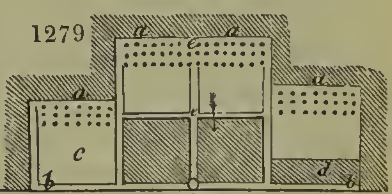
1278



When the operation is commenced by working on the long wall plan, the dip-head levels are driven in the usual manner, and very large bottom pillars are formed, as represented in *fig.* 1278. Along the rise side of the dip-head level, chains of wall, or long pillars, are also made, from 8 to 10 yards and upwards 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 deep 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. Whenever 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 *gobb* or waste; and gobbin, or gobb-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 gob or goaf to the working face, pillars of stone, called packs, are formed along each side of the road of several feet in width; and the strata over head along this road, is blasted down of sufficient height, so that when the superincumbent strata have sunk, there may be ample height to convey the coals with ponies. In many cases these roads are 6 to 7 feet high, and seldom less than 4 feet. In some coal fields stone cannot be got in the mine to build the road pillars or packs; but a substitute is found in cord wood, which is formed into a pillar on each side of the road by building it up, and making it as solid as possible with small coal and other small refuse. The pressure of the strata soon makes this a very compact pillar. This method is common in the Leicestershire coal field.

There are two principal modifications of the long wall 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.* 1278). 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.* 1278, A represents the shaft; B B, 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.

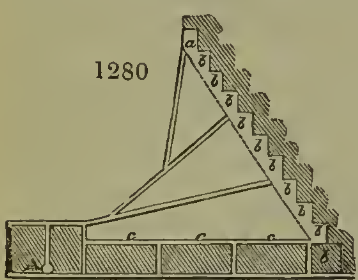
The other plan is represented in *fig.* 1279, where A shows the pit, with the bottom pillars; *b*, the dip-head levels; *c*, the off-break from the level, where no pillars are left; *d*, the off-break, where pillars remain to secure the level. All roads are protected in the sides by stone buildings, 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 Shropshire as in Derbyshire.

1279


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, holes, 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, called spragging. 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*, or sprags, 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 will 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 gob set the trees, or props, 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.* 1280, 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.

1280

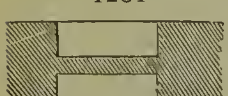


B

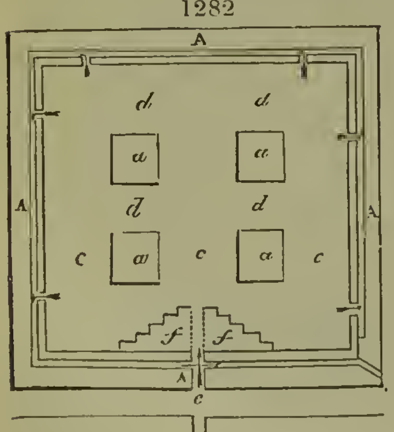
It is estimated that from one-eighth to one-twelfth part only of the coals remains underground by the long wall plan; nay, in favourable circumstances, almost every inch of coal may be taken out, as its principle is to leave no solid pillars nor any coal below, except what may be indispensable for securing the gob. Indeed this system might be applied to coal seams of almost any ordinary thickness, providing stuff to fill up the gobb could be conveniently procured.

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.* 1281. 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 frequently prove 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-stone crushing down.

1281



1282



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 panel, 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.

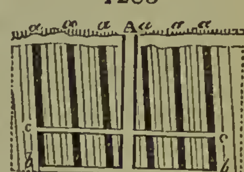
Let *fig.* 1282 represent a side of work; A, the ribs or walls of coal left standing round, constituting the side of work; *a*, the pillars, 8 yards square; *c*, the stalls, 11 yards wide; *d*, the cross openings, or through puts, also 11 yards wide; *e*, the bolt-hole, cut through the rib from the main 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.

The thick or ten yard coal has, however, been worked on the long wall method by Mr. Gibbons, near Dudley, with great advantage in the yield. He works 12 to 14 feet of the upper part of the seam first; and after allowing the strata to become somewhat consolidated, the lower part is worked, leaving 2 to 3 feet of coal for a roof, some portion of which is picked out of the gob. About 12 per cent. of the coal is left by this method.

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.

1283



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.* 1283, 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 conveniency of working the coal. The principal edge coal works in Great Britain lie in the neighbourhood of Edinburgh.

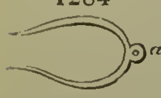
The modes of carrying coals from the point where they are excavated to the pit bottom, are nearly as diversified as the systems of working.

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. This method is now almost entirely extinct.

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 Carr 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 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 libers, the purpose of which is to prevent the carriage from overrunning them. One of these shafts is represented in *fig.* 1284. 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. Where the roads are well constructed, a horse will convey a load of 7 to 8 tons on the level.

1284



We shall now describe briefly the modes of working coal dip of or on the deep of the engine-pit bottom. Headings are driven either on the full dip of the mine, or any convenient angle to it, the requisite distance. The water is pumped up these dip headings by the pumping engine on the surface. A pump rod or spear passes down the side of the shaft, and is attached to a quadrant at the bottom of the shaft, which quadrant transfers the perpendicular motion of the spears in the shaft to the spears or pump rods in the dip headings. The quadrant is constructed so that the stroke of the pump in the dip headings can be lengthened or shortened as required.

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).

When the above arrangements are applied for pumping, the coals are drawn from the deep either by horses or an engine placed on the surface.

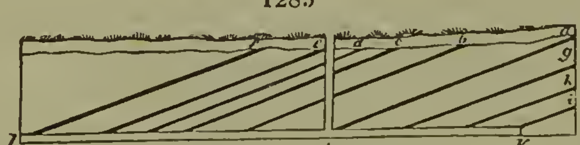
Where operations are very extensive, some mining engineers place the engine underground for working the dip coal; and it both pumps the water and draws the coal to the bottom of the shaft.

High pressure engines are employed for this purpose, working at a pressure of from 30 to 50 lbs. per 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 and isolated from the coal, and the air used for the furnace under the boiler, is the returned air of the mine ventilation if the mine is free from explosive gas. If the mine yields explosive gas, the boiler furnace is supplied with fresh air. In the dip road 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, dip workings have been already executed more than an English mile to the dip of the engine-pit bottom in the Newcastle coal fields. 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 dip coal will in future be worked by means of the pits sunk on the rise. In the Newcastle district, coals are now working in an engine-pit 115 fathoms deep, and dip of the engine-pit bottom, above 1600 yards, and fully 80 fathoms of perpendicular depth more than the bottom of the pit.

The most extensive dip working of the present day, is that of Mr. Astley's at Ashton-under-Lyne, Lancashire. The shaft is about 700 yards deep; from the bottom of this shaft the engine plane to the dip is about 1 mile in length. The deep workings are 500 yards deeper than the bottom of the shaft, and 1200 yards below the surface.

At the most extensive collieries in the south of England, engine-power is not only applied for the transit of coals from the dip, but along the main level roads of the

1285



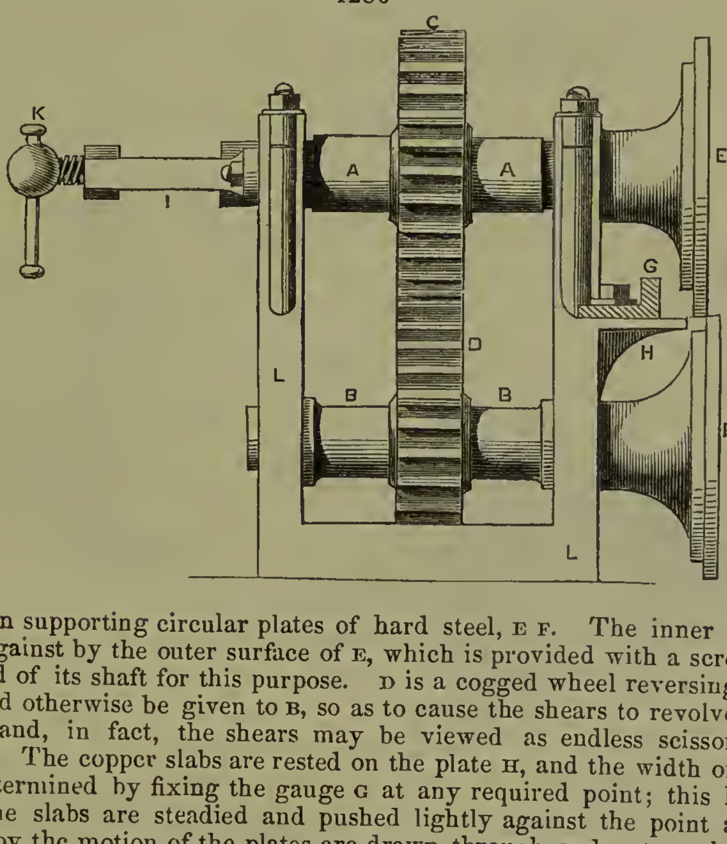
mine, by means of endless wire ropes. The economy of steam power has superseded horses at many collieries. Steam power can only be applied with advantage where large quantities of coal have to be removed.

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.* 1285, 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. See COAL; COAL-GAS.

MINIUM. Red oxide of lead.

MINT. At the Mint, gold, silver, and copper are converted into coin of the realm, but as the processes are nearly similar, it is only necessary to describe the coining of gold, and to point out briefly the difference in the manufacture of copper coin, because silver undergoes precisely the same operations as gold, the same machinery being used for all three metals. Copper is rolled from red-hot slabs of copper, about 12 inches long by 10 inches broad, and 1 inch thick, by five pinches, down to a slab between 3 and 4 feet long, by 14 inches broad, and 0·20 of an inch thick; the slab is then cut in half, digested for 10 minutes in beer grounds, and heated to redness; it is then plunged into cold water as rapidly as possible, by which means the thick scale of red oxide of copper, which forms during the rolling, is separated; but as small particles of the scale still remain, the slabs are scratched by men with brushes made of brass wire until perfectly clean; it is then cut into ribbons or fillets of a convenient width, by a pair of circular shears. *Fig.* 1286 shows these shears, A and B being cogged wheels supported on shafts, which each terminate in

1286

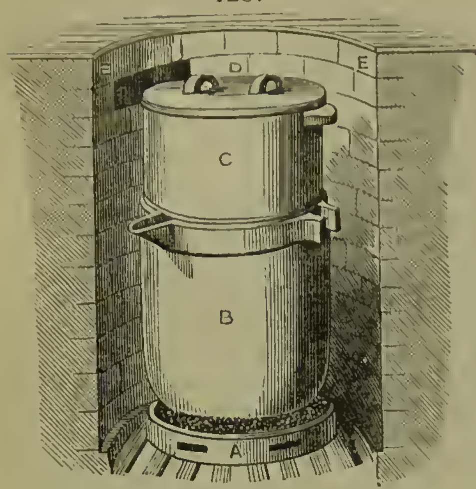


plates of iron supporting circular plates of hard steel, E F. The inner surface of F is pressed against by the outer surface of E, which is provided with a screw, K, at the extreme end of its shaft for this purpose. D is a cogged wheel reversing the motion which would otherwise be given to B, so as to cause the shears to revolve in opposite directions, and, in fact, the shears may be viewed as endless scissors driven by machinery. The copper slabs are rested on the plate H, and the width of the fillet to be cut is determined by fixing the gauge G at any required point; this having been arranged, the slabs are steadied and pushed lightly against the point at which E F touch, and by the motion of the plates are drawn through and cut or sheared at the same time. Copper fillets do not pass through the drag bench, as is presently explained, for gold. The only other difference in the processes copper undergoes, is that it is blanched by a bath of from 20 to 30 hours in cold diluted sulphuric acid.

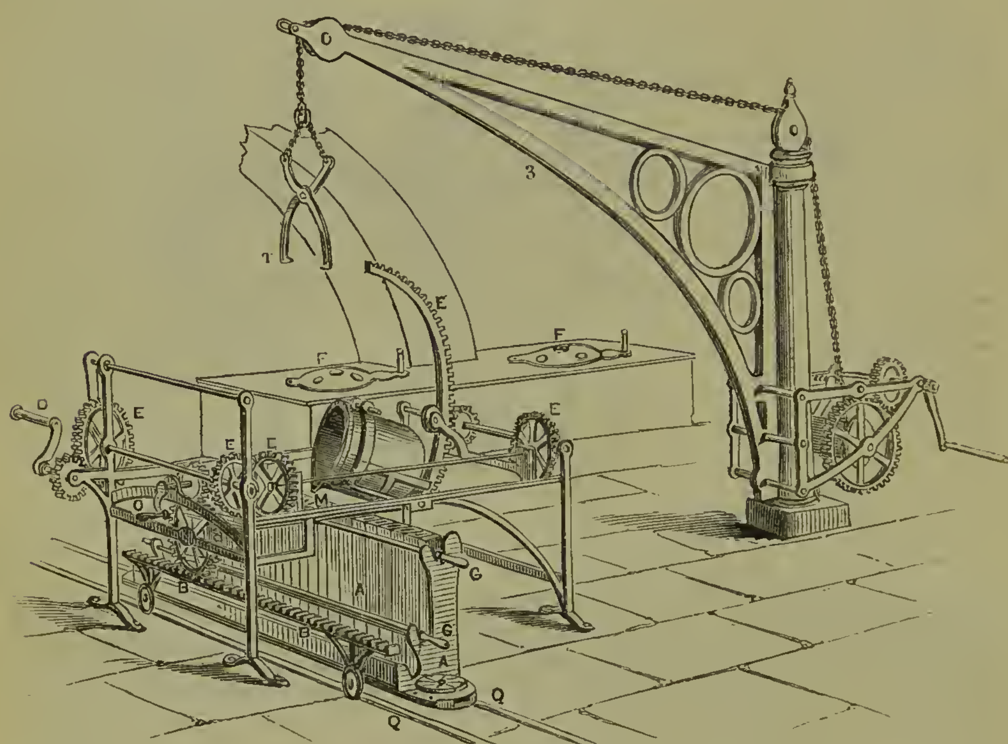
Silver is bought, through the brokers, by the Master of the Mint, either in the form of foreign coin (5 franc pieces are preferred) or ingots, and to the silver so obtained is added so much copper or pure silver, as shall bring the whole mass up to the standard silver of the realm, which consists of 222 parts of silver and 18 parts of copper. The metal so arranged is weighed out into charges of about 4000 ounces for the wrought-iron melting pot, which is represented in *fig.* 1287, as seen in the furnace

E standing on the "bottom A," which rests on the fire bars, and is made partially cup shaped and filled with powdered coke, that the bottom of the pot B may be perfectly supported, while at the same time it is protected from the current of air which is supplied to the furnace. Powdered coke, being a bad conductor, prevents the free passage of heat from the base of the pot to the "bottom," and the consequent probable fusion of the two through the agency of the oxide of iron, which forms and accumulates whenever iron is repeatedly heated. D is the lid of the pot, and C the muffle or funnel, against the sides of which the metal rests during the process of fusion, to prevent its falling over into the burning coke. The pot, when charged, is allowed to remain in the furnace till the metal has fused, and the temperature has risen to a point little short of that which would so far soften the wrought iron pot as to cause it to lose its shape. The pot is lifted by the tongs T, of the crane, 3, from the furnace F (after the fire has been removed by displacing some of the fire-bars), swung round and dropped into the cradle M, of *fig.* 1288, when it is secured by a screw, which draws tight the band at the top. The

1287



1288



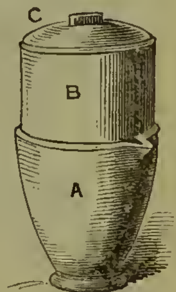
melted silver is then thoroughly stirred with an iron rod, and all being ready, the frame of moulds, A (fully described under Gold Melting), is run under the cradle stand so far as to allow the rack B to work into the wheel N. The foreman then, by means of the handle D, which communicates by E with the cradle in which the pot is fixed, raises the pot, and tilts it so much as is necessary to pour the fluid silver into the mould until it is filled; he then lowers the pot, and waits while an assistant by the handle O, connected with the cog-wheel N, moves the moulds forward as they are required to be filled. The moulds are ranged side by side in the frame, and pressed firmly together by screws at the ends of the mould-frames, and secured in front by two bars of iron, G, which fit into wedge-shaped grooves, slanting forwards.

The metal solidifies immediately, and the pot having been emptied, the carriage of moulds is run on its wheels Q, from under the cradle frame, and the screws having been loosened, the moulds are caused to fall to pieces, and each bar, as it is exposed, is taken by tongs and plunged into cold water, as much to save time as to soften the bar by sudden cooling. The bars produced from the whole pot of metal are numbered with a distinctive figure to designate the pot, and with two letters to indicate the day's melting; assay pieces are then cut from the first, middle, and last bars of the set. The assay pieces are properly secured, certified, and sent to the non-resident assayers of the Mint. (For an account of this process, see ASSAYING.) In the event of the assay being unsatisfactory the pot is stopped, and the metal is adjusted as to quality, and remelted. The assays being satisfactory, the bars are forwarded to the coining department, where they undergo the same process of manufacture as gold is subjected to.

Gold is sent by the Bank of England to the Mint in the form of ingots, which average about 180 ounces each, and are assayed by the resident assayers in the Mint, who make a report to the Master. The Master directs the addition of so much pure copper, or pure gold, as will make the whole into standard gold, which consists of 22 parts of pure gold and 2 parts of pure copper, making what is technically termed standard gold, and in these proportions the gold, with its alloy, is sent to the melting house.

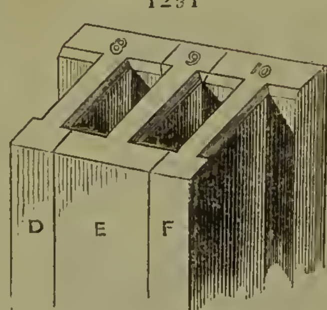
Since gold requires so high a temperature for its fusion, it would be unwise to attempt to fuse it in iron pots, consequently the so-called black-lead pots (for a description of which see CRUCIBLE) are used. *Fig.* 1289 demonstrates the position of the pot as it would appear if in the furnace; D represents the "bottom," which is usually obtained by breaking a worn-out pot into a convenient form; A is the pot, B the muffle, which, as in the case of silver, answers the purpose of a funnel, to guide the metal during the time of fusion into the pot; C is the top, or lid of the pot. Care is required in using black-lead pots, else the small amount of moisture which they absorb from the atmosphere causes the fracture of the pot when it is suddenly heated, therefore the pot is dried carefully before it is used; and when required for use is placed in the furnace with a small fire, which gradually increases in temperature to a full white heat, the pot becoming by this process annealed, and is then seldom liable to fracture unless badly used. The pot and furnace being ready, the gold and its alloy previously weighed out in charges of about 1,200 ounces, but varying slightly according to the size of the ingots which compose the charges, are placed carefully in the pot. As fusion ensues, the molten mass is stirred with a rod made of the same substance as the pot itself. In fusing both standard gold and standard silver, it is customary to place either small pieces of charcoal or powdered charcoal at the bottom of the pot before placing the metal in the pot; then as the metal fuses it runs down and rests upon the fine particles of charcoal; when the fusion is complete, the charcoal is released from the bottom of the pot by the process of stirring, and as it rises balloon-like through the fused or molten mass, it reduces any oxide of copper which may have been formed during fusion, and resting on the surface of the fluid metal protects it from the atmosphere during the time of pouring. The pot is lifted from the furnace after the removal of the firing by a hand crane, and it is then taken by a pair of long tongs, as shown in *fig.* 1290, by the foreman, who passes the little button at the end of the tongs through a loop of iron, A, suspended by a rope which passes to the ceiling and through a pulley down to an assistant, who by this means bears the weight, and regulates the height of the pot, while the foreman pours the metal into the moulds

1289



1290

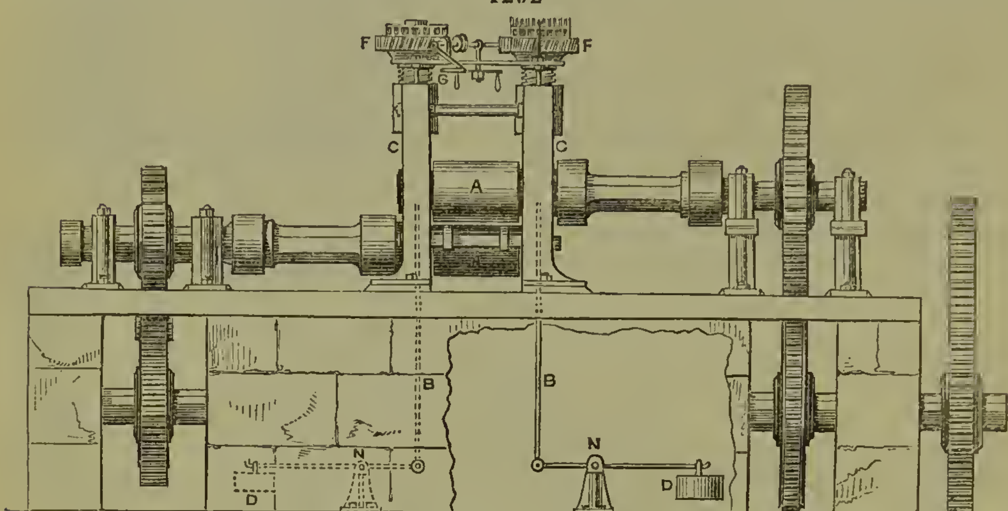
1291



B, fixed in the frame C, which runs on wheels in a tramway. Three pieces of planed iron form two moulds, as shown in *fig.* 1291, where D_8,E_9,F_{10}, show the form of these planed pieces, and the manner of placing them together. The bars are solidified immediately, and when all the moulds have been filled, they are taken to pieces and the bars plunged into cold water, with the same object as in the case of silver. From the bars obtained from each pot, two pieces are cut off for assaying, by the non-resident assayers, the bars being numbered according to the pot from which they were poured, and lettered distinctively, according to the day on which they were melted. Should the assay prove unsatisfactory, the metal is adjusted and remelted. If the assays are satisfactory, the bars are forwarded to the coining depôt.

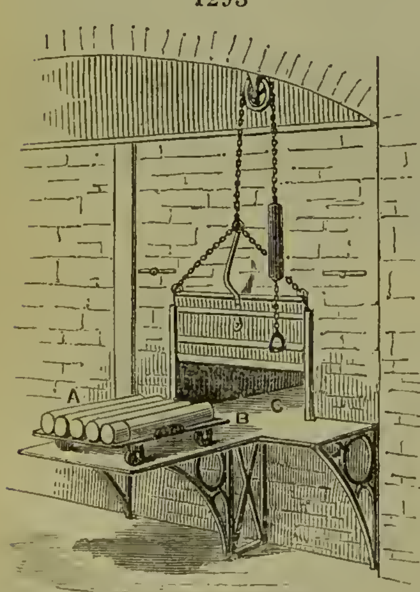
In the coining department the first operations are performed in the rolling room, which is provided with very powerful machinery for driving six pairs of rollers made of chilled cast iron. *Fig.* 1292 represents one pair of these rollers, which are used for

1292



breaking down the bars partially to the form of fillets or ribbons ; they are driven by a 40 horse steam-engine, and revolve in opposite directions. A represents the rollers, which are of 14 inches diameter. The upper one is supported by a pair of strong brasses bolted together, F F. From the lower brass proceeds, as may be seen in *fig.* 1292, a rod B, which passes through the solid masonry, and communicates with a counterpoise weight D, placed on a long lever whose fulcrum is N. The object in counterpoising the upper roller is to ensure the removal of all pressure which is not intentionally applied in the process of rolling. F shows a capstan head, the copper ring on which is divided into 50 parts, an indicator being fixed to the main frame of the mill. The handle G moves two endless screws which work into the teeth of the wheels F, which are supported by powerful screws, passing through the main frame of the mill, and touching the upper brass of the upper roller at C. By this means any pressure which is deemed wise can be exerted on a bar placed between the rollers. The sovereign bars are wrought in pairs, and five pairs make one batch, a number of bars which is found most convenient to work at the same time. A sovereign bar is 21 inches long, 1·375 inch broad, and 1 inch thick. The first process is to submit the bars to six pinches between the rollers, by which they are reduced to 0·194 inch thick, and become 1·712 inch broad, at which stage the hollow ends are sheared off, and the bars are cut into lengths of 18 inches ; they are then placed in 5 copper tubes A, as shown in *fig.* 1293, the tops of which are carefully luted on with clay, and the copper tubes are then placed on a small cast-iron carriage B, and run into the annealing furnace C. After

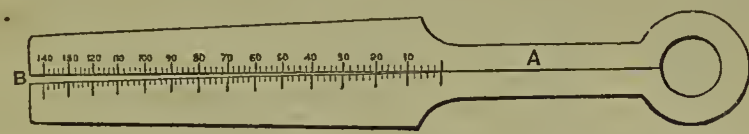
1293



20 minutes' annealing at a full red heat, the carriage is withdrawn; the tubes

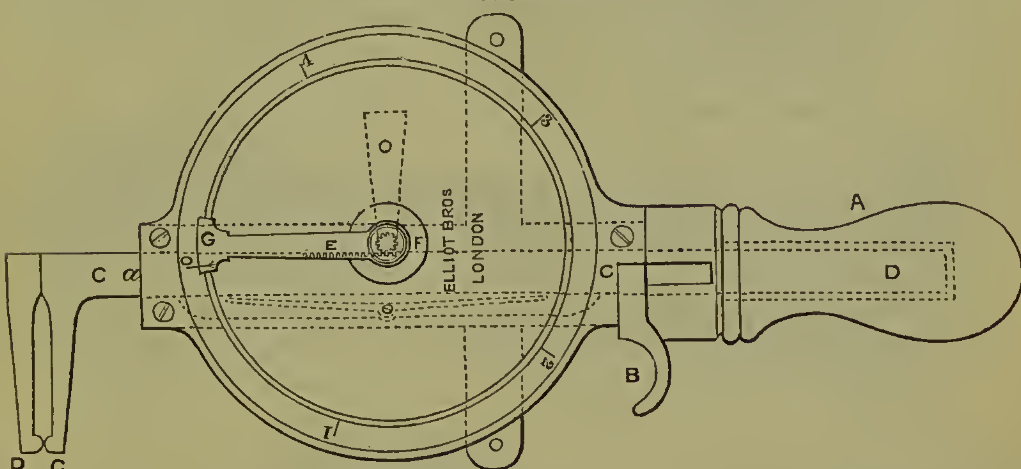
taken one by one in tongs, and plunged as rapidly as possible into cold water. It is found that rapidly cooling renders gold, silver, and copper soft and tough, while it renders iron and steel hard and brittle. Therefore the more rapidly the gold is cooled, the greater the result as to the softening of the bars. After annealing, the bars go back to the breaking-down mill, and receive six pinches, by which they are reduced to 0·120 inch thick, and 1·778 inch wide, and are now called fillets, and are gauged by a wedge-shaped instrument shown in *fig.* 1294, which is

1294



simply a hollow wedge, graduated into thousandths of an inch, the great object being to ascertain if both sides of the fillets are of the same thickness, which is done by placing a fillet in the graduated opening between A and B. The bars reduced to 0·120 inch thick, are passed to a finer pair of rollers, under which they receive six pinches, and are then passed to a still finer pair of rollors, until at last, after 11 pinches, they arrive at the gauging mill, which is as accurate as rollers can be made to be; but at this stage the officer in charge frequently overlooks the professional gauger, and by his gauge tests the fillet in every part, so as to determine that it is of the same thickness throughout its entire length and breadth. *Figs.* 1295, 1296 show a plan of the gauge, which is

1295



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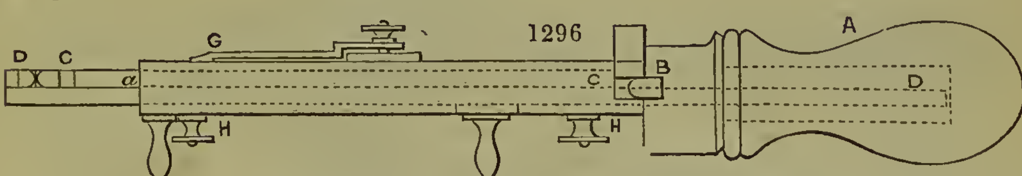
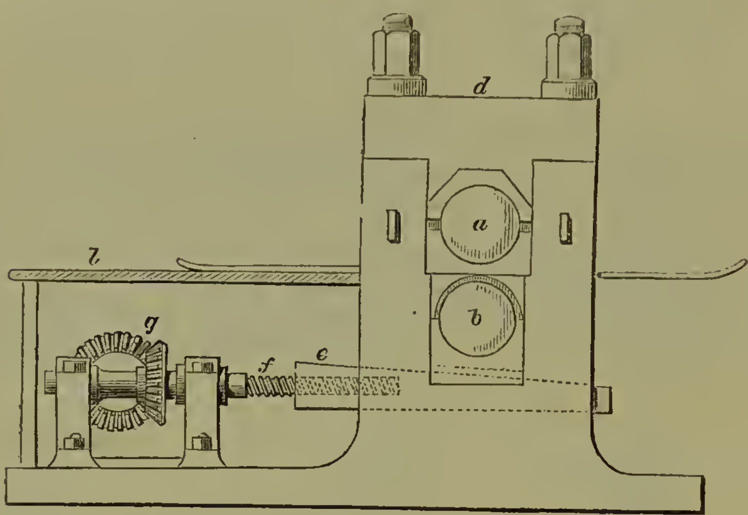


used only by the officer in charge, because it is a most delicate instrument, and is capable of measuring to one ten-thousandth part of an inch, which it gives by a single reading. The instrument was made with great care by Mr. Becker, of the firm of Messrs. Elliott, 30, Strand, and is found practically to give most accurate results. D C shows the point at which any substance to be measured is placed. The upper rod of steel C, rests upon the lower one D, and passes to the handle of the instrument, terminating in a lever B, by which it can at any moment be drawn backward if the lever be pressed by the thumb while the handle A is firmly held by the same hand. The rod C is provided at F with a rack, into which a small pinion works, carrying an indicator E, which traverses over an accuratcly divided scale with 500 divisions. If now the space of the point D C be opened 0·50 an inch, the indicator travels over the whole 500 divisions on the face, and as the hand itself carries a vernier G, which gives the tenth of a thousandth of an inch, we have by the first reading the division of one inch which indicates the 0·0001 part. The gauge can be used to measure up to 3 inches by drawing back the lever B, until the zero of G points to 500, when the rod C is secured by a clamp at *a*, and the rods C D are drawn out till the zero of G points to the zero of the dial plate; the screws H are then again secured, and he proceeds as before. When the fillets leave the gauging mill they must be 2 inches broad, and must not vary 0·0001 of an inch in thickness from one part to another. Besides the examination by the officer, the gauger strikes out occasionally one or two blanks from the fillets, to see that the rollers have not altered; great danger of alteration arising from the fact that the middle of the fillet wears away the roller more than its sides do, so that the middle is evidently liable to become thicker than the sides; and if this fault once arises, it is found to give great trouble in future operations. As the greatest delicacy is required at the gauging mills, another and more accurate system of adjusting is adopted. *Fig.* 1297 shows a side view of the gauging mill: *a*, *b*, the rollers; *e* is

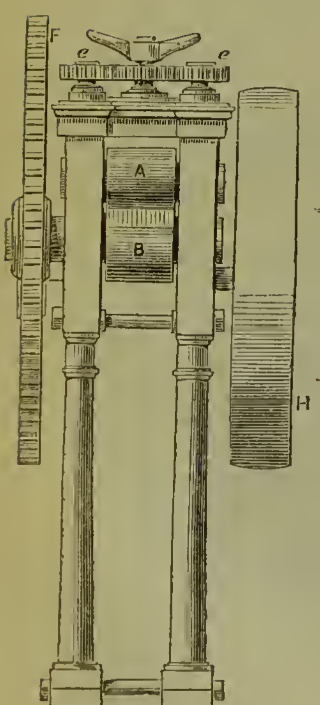
1297



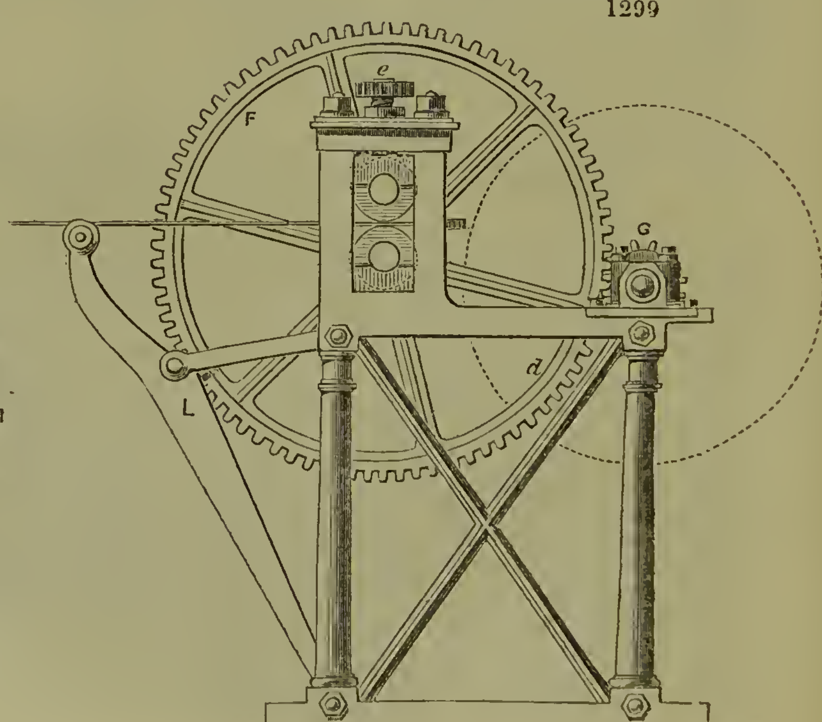
a wedge which travels under the brass of the lower roller, which is cut to fit the wedge exactly. The wedge *e* is forced forward by the gear work *g*, which sets the screw *f* in motion, giving the most minute adjustment. At *d* is an opening to allow the supply of oil to the neck of the upper roller. The fillet as it travels onwards rests on the apron *l*.

The fillets are now so accurate that a blank struck from any part of them seldom varies more than 0·40 or 0·60 grain, but are left so thick that a blank weighs 8 grains

1298



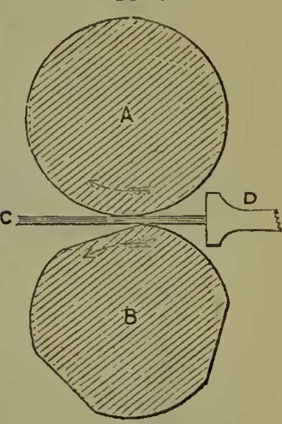
1299



more than a coined sovereign should weigh; the object in leaving it so heavy being that it may undergo far more delicate operations, so as to reduce the variations of thickness as much as possible.

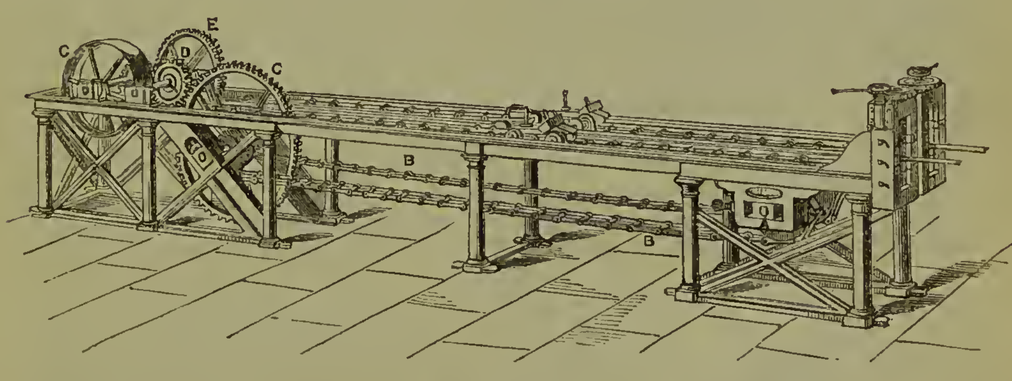
The fillets now pass on to the drag room, where a boy passes them twice through a pair of very delicate adjusting rollers, and another boy trims one end of each fillet by a pair of shears, and passes the end so trimmed into an opening between a pair of rollers, shown at *figs.* 1298, 1299, and 1300, where the fillet is shown in C as being passed between the revolving rollers A B, at the time that the surface of B which is cut away presents itself and admits of the free passage of the fillets to the stop or gauge D. As the roller B revolves towards C, it carries the fillet with it, and at the same time reduces the thickness as much as is required. The distance between the rollers A B is regulated by the pinions *e*, which turn screws resting on the brasses of A. The flatting mill, for so it is called, is driven by a strap passing over the drum H. The shaft of which carries a small pinion G working into F. To relieve the weight the fillet is rested on L. The end which is called flatted becomes by this pressure about one third thinner than the other part of the fillet, and it is usual to flat about three inches of the fillet.

1300



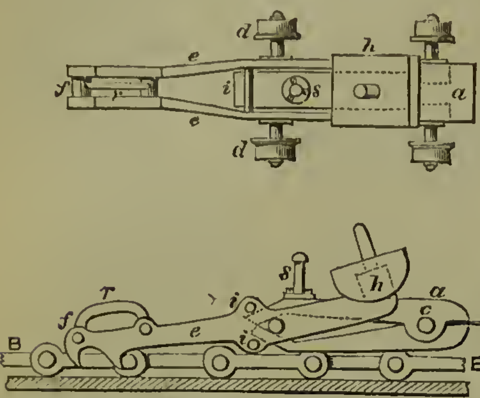
The flatted fillets are then taken to the drag bench, where they are made to pass by main force through an opening, in which is fixed a pair of small cylinders of the hardest steel, exactly fitting into beds which hold them rigidly, and prevent the most minute movement. *Figs.* 1301 and 1302, give a full view of the drag bench; A represents drums, over which the endless chain B passes; the drum A, at the end where

1301

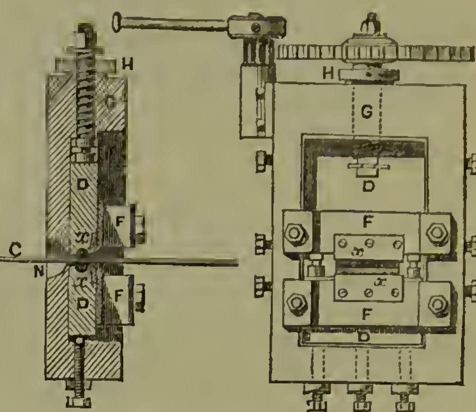


it is shown as moved by the cogged wheel C, is cut in deep grooves to the depth of about two inches, and into these grooves the bar of the chain fits so that as the drum revolves it drags the chain with it. The drum at the other end is plain and is therefore simply a carrier of the chain, which, as it travels on the upper surface of the bench, fits into a trench provided for it. The machine is driven by the drum G, which is connected by its shaft with F, which drives the wheel E, having on its shaft the small wheel D, which finally drives C. There are two drag benches, and each has two chains so that the wheel E becomes a common motion for two chains. *Fig.* 1302 shows a section of the drag head with the dog in the act of dragging a fillet through the opening N. In using the drag bench the flatted end of the fillet is passed by the hand into the opening between the bars F where the small cylinders are shown at x to be fixed in the blocks D in the opening N; the dog is now brought up by the handle S, until the mouth a is pressed into the opening N, when the rods i open the jaws, which are cut with a good set of teeth, and seize the end of the fillet as it protrudes. The handle attached to the weight h is then lifted, and e is depressed until its hook catches into a cross bar of the travelling chain B, when it is drawn on. The dog travels on wheels d, whose axle here becomes a wedge acting upon the long end of e, and so causes the fillet to be held tight in proportion to the resistance offered to its passage between the cylinders. The handle of r is never used, because it is too far for the dragsmen to reach with convenience, but the hooks which catch the chain are shown at f. *Fig.* 1303 gives a further view of the drag head; it consists of a very firm frame of iron provided at the top with an horizontal wheel H which works a fine cut screw. The cylinders are fixed in the blocks D which are held to their positions by screws at the side; the lower block D is regulated as to height by screws from below and the upper block D becomes the only movable one. If it is required to bring the cylinders closer together the dragsman does it by moving the handle O, which com-

1302



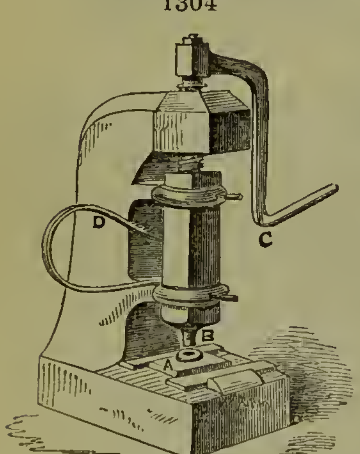
1303



municates by its pinion P with the wheel H. It is almost needless to say that by this arrangement the most minute alterations can be made in the thickness of the fillet, and it frequently happens that so minute an adjustment is made as to show a difference of only half a grain upon 47 sovereign blanks; and if it be remembered that a thickness of 0·001 inch on a sovereign blank equals 0·125 of a grain it will be conceived that the distance which the cylinder is made to travel by this most-beautiful micrometric arrangement is very small. The drag bench was invented by the late Mr. Barton, and may be viewed as the greatest addition to the machinery of the Mint ever yet or ever likely to be introduced; for by its agency, when intelligently managed, the fillets of silver coming from it are so perfect that for days together the blanks cut from them are found to contain only 1 in 400 out of remedy, and it is quite a common occurrence to find only 1 in 800, and from gold fillets blanks are cut in which only 1 in 100 and even 1 in 200 are rejected as being out of remedy.

To the drag bench are fixed two pairs of hand shears, by which the fillets are cut into four lengths. They are then passed on to the tryer, who, by the hand cutter shown at *fig.* 1304 punches out one or more blanks from each piece of fillet, and weighs it in a delicate balance placed close beside him. The fillet is placed on the bolster A, and the tryer, holding it in the left hand, takes the handle C in his right, and by pulling it towards him causes the screw with which it is provided to depress the cutter B, which, as it travels, cuts a blank and pushes it through A, the tryer at the same moment placing his hand under the bench to catch the blank as it falls. The spring D is so powerful as to carry back the handle to its original position while the tryer is catching the falling blank. The tryer has the most important office in the Mint, and it requires a man with fortitude and a very calm judgment, for although he places the blanks in the scale pan, and goes through the operation of weighing it, he cannot of course spare time to see the exact weight; he therefore forms an opinion of the weight, and so accurate is this opinion that he is never known to produce sovereign blanks which vary more than one grain if forty-seven are weighed at the same time at any time of the day. The result of more than thirty tons of gold coined lately, came out within a very small number (it is believed 8 sovereigns) of the whole value.

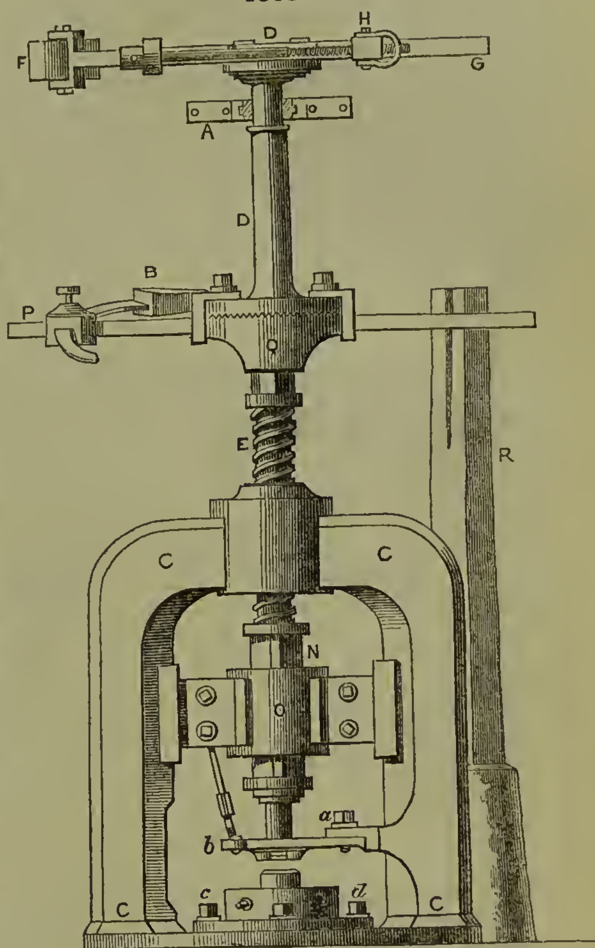
1304



After leaving the hands of the tryer the fillets are wiped with cotton waste to free them from oil, which is found necessary to prevent the friction of the metal at the time of passing between the cylinders, else it happens that the cylinders get so hot as to cause the skimming off of the surface of the fillet.

The fillets having been cleaned are taken into the cutting out room, and are there cut by machinery into blanks and scissel. *Fig.* 1305 represents one of 12 cutting out presses. It stands on a firm bed, and the frame C is made of solid iron bolted to the bed. Quite independent of the frame of the press, there are a series of iron supports which sustain a strong iron ring, a part of which is shown as having a brass let into it at A. Above this frame is a heavy fly wheel laid horizontally; between this fly wheel and the ring or frame is a wheel driven on the same shaft as the fly wheel, provided with a series of cams or protruding parts. As the wheel revolves the cams strike the wheel F at the end of the lever D. The lever D at its middle is fixed to an upright spindle which passes through the brass A, and through the frame C, where it is provided with a screw terminating in a socket N, by which the twisting motion of the screw is done away with. The lower end of the socket N is provided with a screw arrangement by which the cutter can at convenience be fixed or removed. At Q there is an arrangement by which the screw E, and consequently the socket N, with its cutter, can be brought nearer to or farther from the bolster which is held in a steel ring secured to the solid base of the press by the screws *c*, *d*.

1305



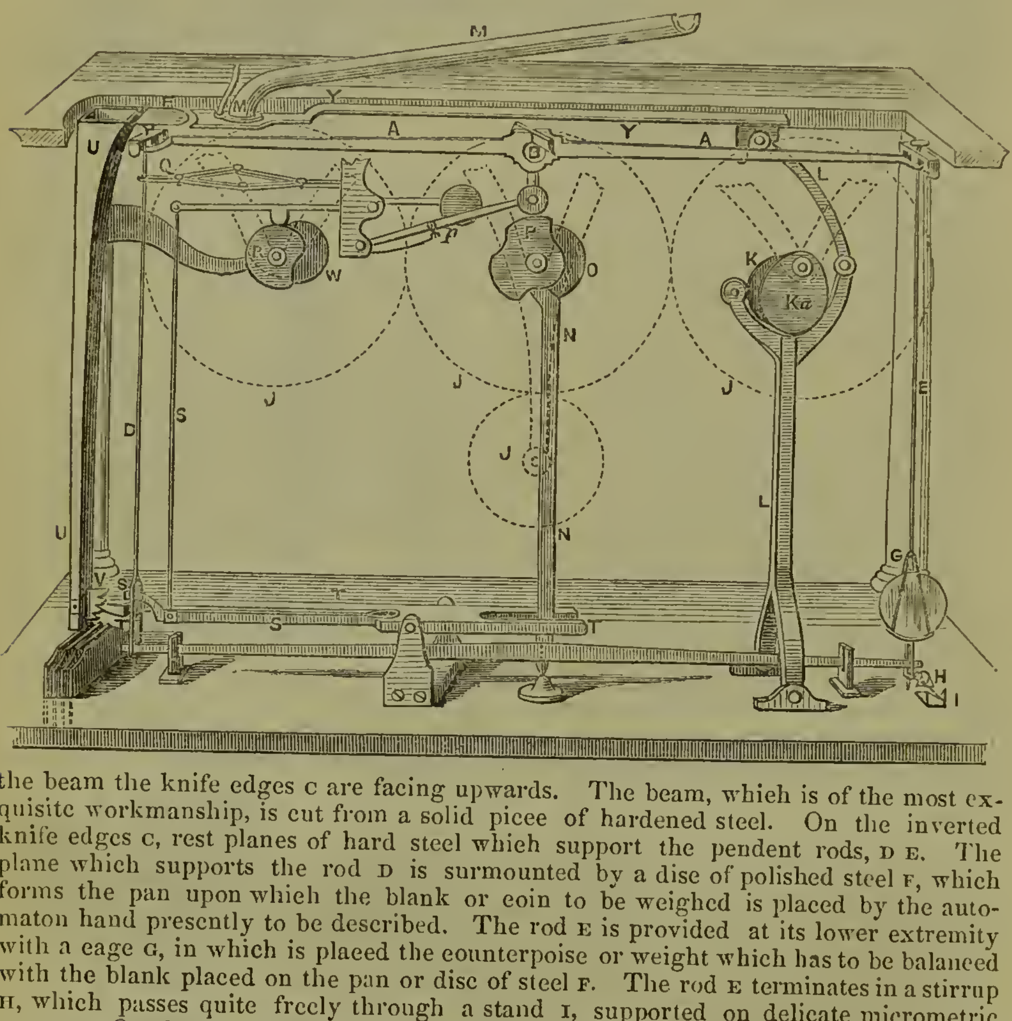
When the press is set in motion by the striking of the cam against F, the cutter is raised from the bolster. To bring the cutter down again there is an arrangement by which a rod is attached to the ring H, and terminates in a system of levers which lift a piston fitting in a cylinder hermetically closed (but not shown in the figure); if therefore the piston be raised, a vacuum is formed by which means the atmosphere becomes the weight by which the cutter is driven down. The cutter-out is so fixed that when it comes down it just enters the bolster sufficiently to cause the cutting out of the blank with a clean edge. When required for work, the fillet is placed on the bolster, and the workman by his foot touches a treddle which releases the lever D at G, and allows the cutter to come down and punch out a blank, which falls into a box below the bolster, while the fillet from which the blank has been punched or cut travels up till it reaches the guard supported by the screws *a*, *b*, which detaches it from the cutter. At the end of the lever P is an arrangement supporting B, a block cut wedge-shaped, which travels in a circular direction, the distance to which it reaches being regulated by the screw shown near to P. R is a spring made of wood and cut with a slit, into which B passes just at the time that the blank is punched out, when the spring gives the reverse motion, a start which prepares the machine for the blow which will follow by the cam upon F.

The tryer and the officer in charge take samples of the blanks from each cutter at frequent intervals and test them in bulk against a standard weight, and if the blanks exceed or fall short of this standard, he makes such alterations of the machinery as are necessary, the object being to produce blanks which are as nearly as possible standard in weight and not to avail himself of the "remedy" allowed. By the study of this principle the work, as it is called, is brought to the highest perfection. The fillets from which blanks have been cut represent ribbons punched full of round holes, and are now called seissel, which is tied up by a machine worked with a rack and pinion in bundles of 180 ounces, and returned to the melting house.

The blanks are turned out of the boxes into bags and sent to the weighing room, where each blank is weighed by the automaton balance and its value is determined by weight within a certain limit. See Balance.

The Automaton Balance is the most perfect piece of machinery yet invented, and owes its origin entirely to Mr. Wm. Cotton, of the Bank of England; but it has been adapted to the purposes of the Mint by Messrs. D. Napier and Sons, who have carried its details of manufacture to great perfection. These gentlemen have adopted several improvements which were proposed by Mr. Pilcher, who by his practical use and study of the machines was fitted to point out minute details still wanting to complete the simplicity of the operations to be performed by the machines, that they might give the most accurate results in the shortest possible time. To give an idea of the magnificent workmanship of Messrs. Napier, it is only necessary to say that after seven years' daily work the most delicate parts of the balances are still as perfect as when first delivered from their manufactory. For the ordinary purposes of life, the pans of a pair of scales are suspended from the opposite ends of the beam; but if, as is the case in Mr. Cotton's balances, the centres of action are on a line with the centre of gravity, it does not matter at what place the pans are placed so that they are exactly equi-distant from the fulcrum or centre knife edge of the beam; therefore, in *figs.* 1306, 1307, 1308, the beam A will be seen to rest on its centre knife edge B, while at the extreme ends of

1306



the beam the knife edges C are facing upwards. The beam, which is of the most exquisite workmanship, is cut from a solid piece of hardened steel. On the inverted knife edges C, rest planes of hard steel which support the pendent rods, D E. The plane which supports the rod D is surmounted by a disc of polished steel F, which forms the pan upon which the blank or coin to be weighed is placed by the automaton hand presently to be described. The rod E is provided at its lower extremity with a cage G, in which is placed the counterpoise or weight which has to be balanced with the blank placed on the pan or disc of steel F. The rod E terminates in a stirrup H, which passes quite freely through a stand I, supported on delicate micrometric screws. On the stand I is placed a small weight, made of platinum wire, which rests on the stand I, after having been passed through the stirrups H. The stand I is then regulated by its micrometric screws until the weight of platinum wire just touches the upper surface of the stirrup, so that there may be no blow given when the stirrup is not in motion by the beam. When the machine is set in motion by the driving wheels J, the cam K forces forward the lever L, which moves on pins passed through blocks fixed to the table or base of the machine. At the upper end of the lever L is a provision by which it forces forward an automaton hand or shovel, the end of which is cut into a semicircle, and is flattened, that it may pass under a gauge into a space or hopper M, which is continued to the height of about two feet, and passes at an angle of about 30° over the top of the machine. When the automaton hand is forced forward the blanks to be weighed are placed in the hopper or shute M, and the bottom blank rests on the flattened portion of the hand, but as the cam K *a* forces back the hand or shovel by the lever L, while at the same instant the forceps Q, presently described, release the rod D, the bottom blank falls to the next support, and rests there until the hand or shovel returns, when it is pushed on to the disc F, which is unable to move, because the perpendicular rod N, which is provided at its lower extremity with a horizontal rod, the ends of which pass through a notch or slit cut into the rods D E, shown between G and H on the rod E and on the corresponding point of the rod D. At the moment that the blank has been placed on the disc F, the cam O lifts the rod N and sets the rods D E at liberty, thus enabling the beam A to assume the position which it should occupy to indicate the weight of the blank placed on F. The weight having been determined, the motion continues, when the cam P by a lever *p* closes a pair of

1307

forceps Q, which secure the rod D, while the cam R allows the indicating finger S to carry down the indicator T until the indicating finger S touches a point provided for it in the rod D. T is balanced so that its finger has a continual inclination to rise, and is of service to determine the compartment into which the blank shall fall when it is weighed and pushed off by the next blank. The blank falls into and through a shute U, the lower end of which just reaches to three openings on the table on which the machine stands; but at V it is provided with three inverted steps, one of which steps falls on to the indicating finger T, when the shute is forced outwards by the cam W.

In use the machines weigh to the 0·01 of a grain with certainty, and at the rate of 23 blanks per minute. There are 12 machines driven from a shaft common to all the machines by a small atmospheric engine; but there is attached to each machine at the point where the pulley is connected with the driving wheels J, an arrangement by which the machine throws itself out of motion immediately should any cause arise which would injure or disarrange the works.

The standard weight of a sovereign is 123·274 grains; but the Mint is allowed to issue sovereigns which exceed and fall short of this weight to the extent of 0·2568 grain, which is called *the remedy*, and is allowed because, as before stated, it is impossible to produce coins weighing exactly equal.

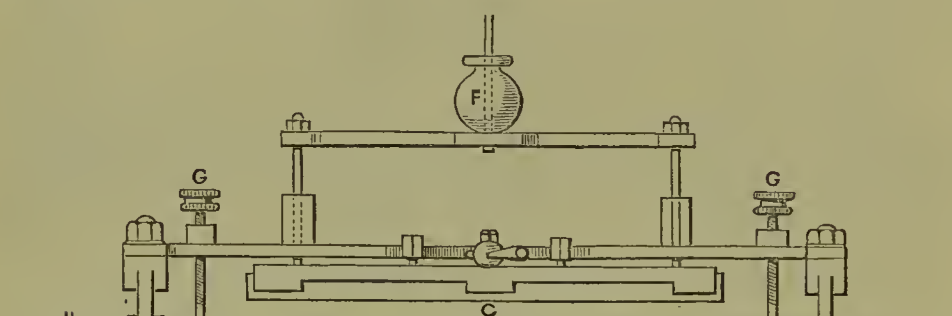
Mr. Pilcher suggested that since it is necessary to determine the weights on both sides of the standard, it would be easy to do this without providing the beam with two remedy weights, as was originally done. The plan now adopted is to reduce the weight used in the cage G to 123·0172 grains, which enables the blanks as heavy as this weight to pass; but all which will raise this weight, and yet are not sufficiently heavy to raise with it the weight of platinum wire placed through the stirrups H, and resting on the stand I, are known to be within the weight of the given remedy. Blanks which are too light allow the weight in G to carry the disc F upwards, and the forceps Q, fixing the point to which the indicating finger will allow the shute to settle, the blank is pushed off by its follower and falls into the shute, which conducts it into the compartment reserved for light blanks. Blanks which are so heavy as to lift the weight in G and the remedy weight, carry the disc F downwards, and they are consequently sent into the compartment reserved for heavy blanks. Blanks which are not standard, but which are nevertheless within the latitude of remedy, are called medium, and pass on to be coined.

The three denominations of blanks are frequently tested by a delicate hand balance, to see that the automaton balances are performing their work properly; but in seven years no instance of failure has been detected.

Each machine stands on a planed iron table, and is enclosed by glass sides, which fit down grooves cut in the brass pillars which support the roof of the machine. The roof is made of brass, and supports all the important parts of the machinery.

Thus a standard coin should weigh 123·274 grains to be intrinsically worth a sovereign in value; but since the machinery is not capable of producing two coins in a million of this exact weight, a certain limit or remedy is allowed, and in manufacture the coin may exceed or fall short of the standard weight to the extent of 0·2568 grain. All blanks that come within this limit on either side of the standard are called medium, and presently pass on to be coined, but those which exceed these limits are termed light and heavy rejected; and if the work of the tryer has been well performed, these two species of rejected are equal in weight, and the medium if weighed in bulk would be found to be within a few pieces of the standard weight if a million were weighed in bulk and then counted. It is the weighing room which determines the value of the tryer's work. The light blanks are returned to the melting house, but the heavy blanks are reduced to the medium weight by a filing machine recently invented by Mr. Pilcher, the officer in charge of this room, and which was made by Mr. Jones in the Mint, under Mr. Pilcher's directions. *Fig.* 1309 shows this machine.

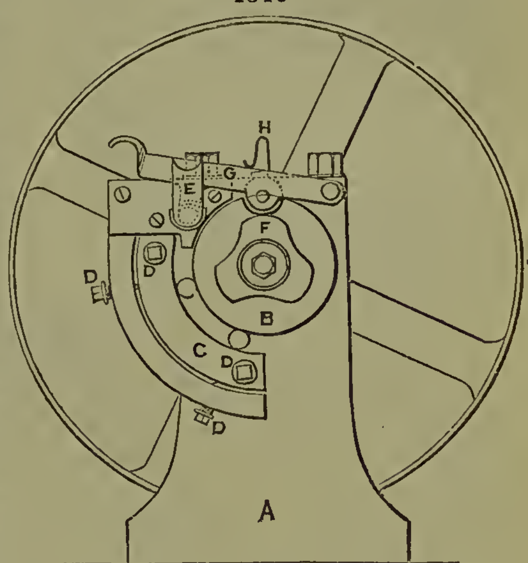
1309



E is a hopper made of brass, and indicated by the dotted lines; it serves to prevent the scattering of the gold dust by the rapid motion of the file. B is a tube with a slit cut in its upper and in its lower half; A is a circular file which is made to revolve very rapidly; C is a knife edge which offers resistance to the circulating blanks when in motion; D is a glass dish into which the gold dust as it is filed from the blanks falls. The blanks are arranged *en rouleaux* in a long scoop, by which they are placed in the tube B. The screws G are then depressed upon pieces of ebony, previously passed into B, until they just touch the blanks (as shown by the dotted lines in B). The knife edge C, whose weight has been previously adjusted by the weight F, is now allowed to descend on to the blanks and carry them down partly through the tube on to the file. When the file is set in motion the friction gives to the blanks a revolving motion, which is greatly restrained by the weighted knife edge resting on the top of the blanks, and the resistance offered causes the file to cut the gold away, while the motion of the blanks insures the non-interference with their already perfectly circular form, and the perfect separation of the dust from the blanks. 1400 blanks are reduced in one minute; and as the dust is carefully collected loss is unknown.

The medium blanks are carefully rung by being thrown one by one with some force upon a block of iron, and those which do not yield a musical sound are called dumb, and are returned with the light rejected and dust to the melting house. About 2 per cent. is the average yield from all causes, therefore 98 out of every 100 blank struck out in the cutting room ultimately become coined money.

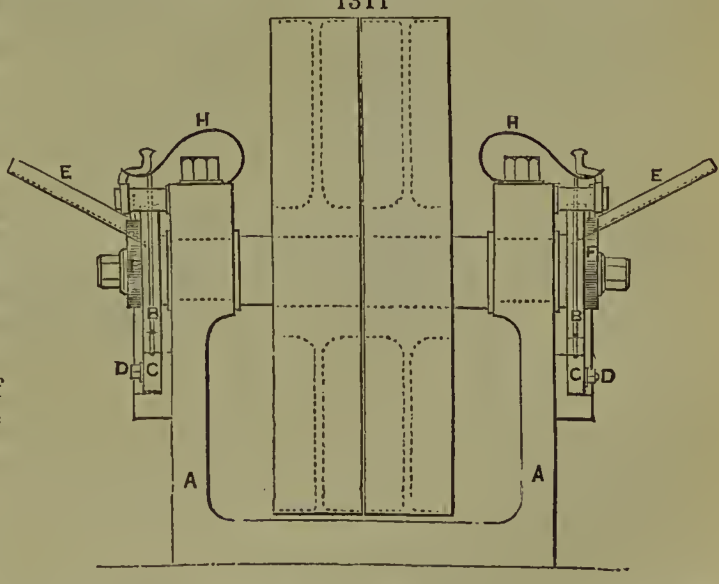
1310



The medium blanks which are now determined to be of the legal weight and sound are forwarded to the marking room, where they are made to undergo a peculiar pressure, which is necessary to raise the edge of the blank preparatory to its receiving the milled edge, because it is found in practice that unless the edge is prepared the milling of the edge is not so perfectly effected as is required for the protection of the public or the appearance and good wearing of the coin.

The machine in use at the Mint has answered its purpose for many years, but it is peculiarly liable to get out of order, and as it is probable that it may be replaced, it is thought wise to give a description of the best machine for this purpose, which was invented by Messrs. Ralph Heaton and Sons, of Birmingham, and is now most successfully used by them. *Figs.* 1310, 1311 are views of this marking machine; A A is an iron frame in which is a horizontal shaft carrying a driving and a loose pulley and a fly wheel; B is a flat circular plate with a groove turned in the edge. Fixed to the frame A is a plate C, with a groove cut in its inner edge corresponding to the groove in the plate B. The plate C is adjusted to B by the screws D; E is a hopper into which the blanks to be marked are put; F is a circular plate on which are a series of cams, which, as they revolve, push back the feeder G, and so allow the blanks to fall from the hopper E. The spring H then brings down the feeder G, which pushes a blank from the bottom of the hopper. The blanks fall down an inclined plane until their edges come between the steel plates B and C. The circular plate B revolves, and the pressure of its edge against the blanks carries them forward, and at the same time raises their edges all round to about one-third increased thickness. The parts of this machine are made very rigid, because the blanks as they leave the machine must be perfectly round, or they will not pass freely through the collar in the subsequent process of coining. The marking machine of Messrs. Heaton marks 400 blanks per minute.

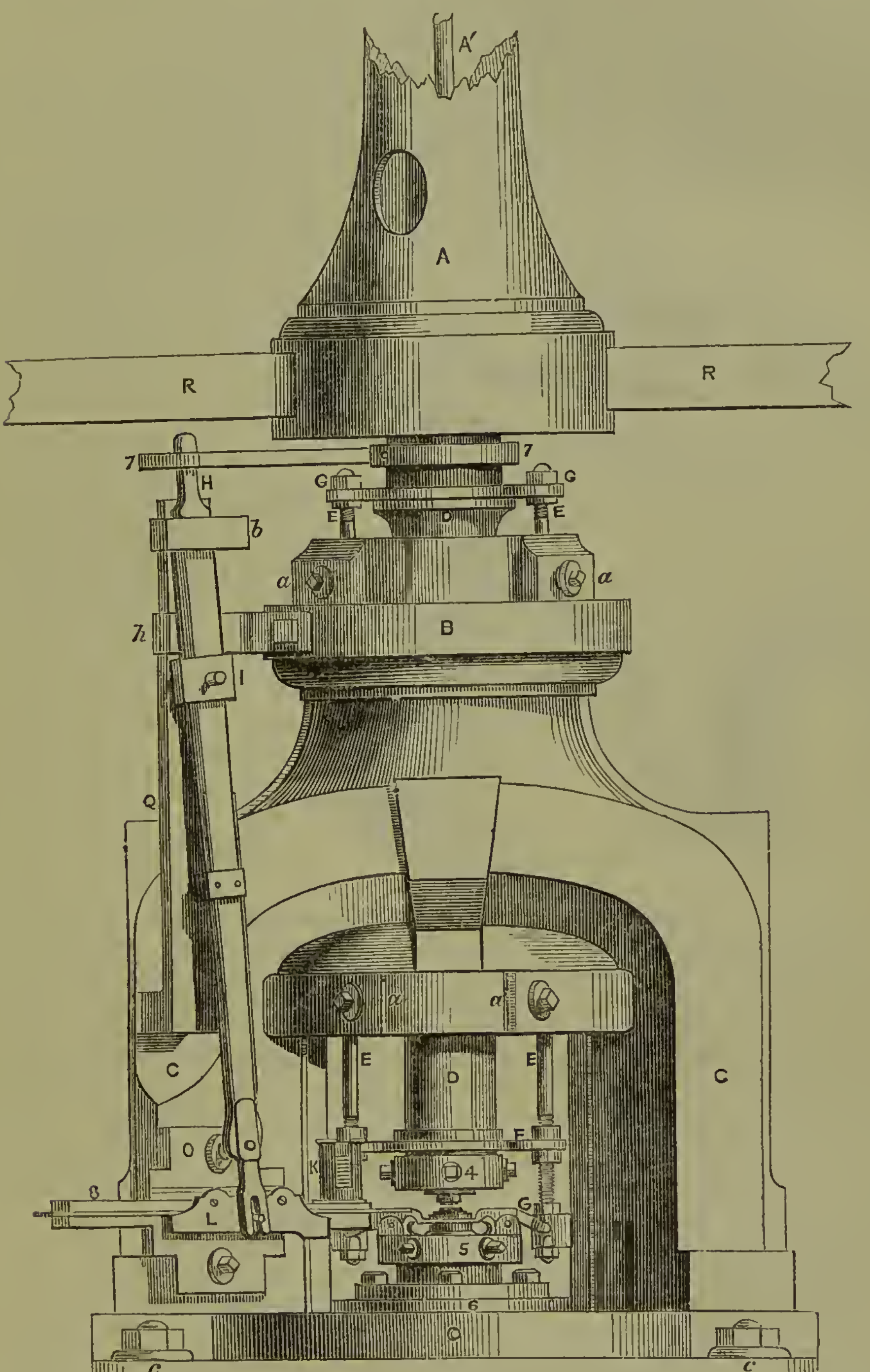
1311



The blanks after having been marked are forwarded to the annealing room to be softened by heat, because they have become, by the processes of manufacture, so hard that unless annealed and softened (it is thought) they would break the dies rather than receive the impression from them. The blanks are placed *en rouleaux* in iron trays. Each tray holds 2804 blanks; and when the tray is filled the blanks are covered by an iron plate, which is carefully luted down with clay and then covered with another iron plate which is also luted down. The tray is then placed on a cast-iron carriage and run into the annealing furnace, which is in every respect similar to the furnace shown by *fig.* 1294 in the rolling room. The annealing pans full of blanks are left in the furnace until they have sustained a full red heat for 20 minutes, and are then withdrawn and placed on the floor until the iron pan has lost its red heat, when the tops are removed and the blanks are turned out into a copper pan and carried to the blanching room, where they are thrown into a colander in cold water, that they may be softened by the rapid cooling. They are then lifted in the colander into a leaden boiler of boiling sulphuric acid diluted with 9 parts of water. They remain in this bath of diluted sulphuric acid for a few minutes, until the surface of the blanks has become bright and free from the black oxide of copper which has been formed in the course of the process of annealing. At the time of melting a fixed amount of copper is added in addition to the amount of copper which is used to bring the gold to the standard, and this copper, which is called extra alloy, is the exact amount which is removed from the surface of the blanks (forming sulphate of copper) by the process of blanching in dilute sulphuric acid; but, as will be readily understood, if we remove copper from the surface by dissolving it out from an alloy of gold and copper, the gold which remains on the surface must be in a honey-comb or spongy condition, and this thin surface of spongy gold gives to the coin when struck the beautiful bloom which is observed on new coin. In the case of some peculiar gold, the process of annealing the blanks was omitted; and it is probable that this process may ultimately be wholly abolished. After blanching, the blanks are freely washed with cold water to remove all the sulphate of copper from their surfaces, and after washing they are dried by rubbing in a bath of hot box-wood sawdust, which absorbs the wet just as a sponge would; and as the sawdust is thrown upon hot iron plates it soon again becomes dry, and is then ready for the next set of blanks. It is found that sawdust will not remove the last trace of moisture which evidently lurks in the substance of the spongy surface of gold, the blanks are therefore thrown into a revolving copper colander, which fits into a kind of oven, heated to a temperature rather higher than boiling water. They are shaken in this heated atmosphere for about 10 minutes, and are then perfectly dry. It is necessary that the blanks should be absolutely dry before going to the coining room, else they not only make dirty coin, but spoil the dies by destroying the polish on their surface.

The blanks, after leaving the hot air bath just described, are taken into the press room to receive the impression which renders them the coin of the realm. Next to the weighing machines, invented by Mr. Cotton, the coining press is the most beautiful piece of mechanism in the Mint. It is automaton, and does all that is required of it without the aid of man, and it may even be said to talk, for it is the most noisy of all the Mint machinery. When the eight presses are at work it is quite hopeless to hear a word spoken. *Fig.* 1312 is a representation of one of these presses. It stands on a solid bed of masonry, and is firmly bolted down. The massive frame work C is made of cast iron, and is perforated from the top to admit of the passage of a powerful screw which is represented by D as travelling through the solid mass. D is continued upwards through the ceiling of the room by a rod of iron which is enclosed by a trumpet-shaped case of iron, represented by A. At the top of A is fitted a lever, which drives the press by the agency of the air pump. The iron rod which continues from D through A, passes freely through an eye hole in the lever of A, and is then provided with a swivel joint, which terminates its horizontal motion, while the rod which carries the swivel joint is attached to a long lever, the farther end of which is connected with a piston working in a partly exhausted cylinder, so that when D is forced down by the action of the air pump, it of necessity lifts this piston from the bottom of its cylinder, thereby causing a partial vacuum; the atmosphere then pressing on the piston overbalances the weight of D, and returns it to its position, that its lever may again come under the influence of the air pump. On the bars B are fitted blocks of iron, wood, wood lined with iron, or iron lined with wood, according to the force of blow required to be given. These blocks simply answer the purpose of a fly wheel, but striking against a buffer at the moment that the dies have exerted sufficient force on the blanks, they prevent the destruction of the dies, and give the press a start back again to its original position. At 7 is fixed on D a piece of brass of an eccentric form, which would be best understood if it were described as of the shape a shilling would assume if it were pierced at the point which is supposed to represent the nose of her Majesty, and a slit were then cut in the place of the inscription at the back of the head of the same figure, extending from the A of GRATIA to the D of the F. D. In the slit so described the lever H travels but as it is fixed on a pivot at 1, that part which travels through the slit becomes the short end of the lever, and in consequence that part which

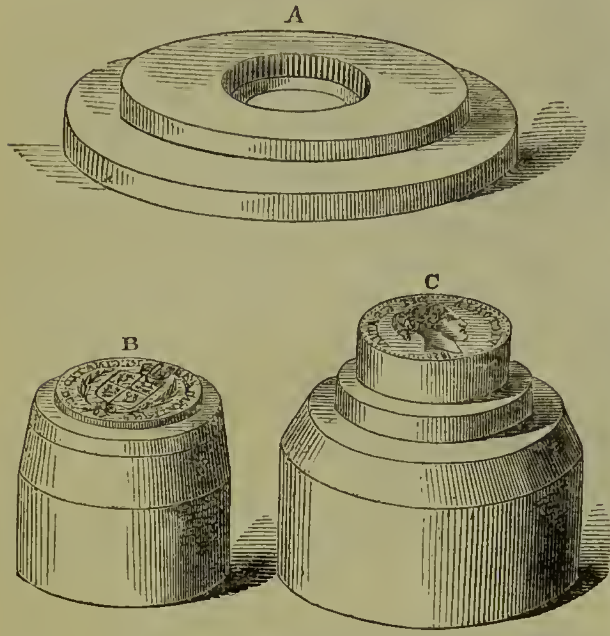
1312



is below 1 is the longest; therefore, when D descends with its circular motion, it also gives the eccentric brass plate 7 a twirl and throws the long end of the lever through a considerable proportionate distance. At the lower end of the lever at L, is a brass frame which carries an automaton hand through the slide 8. When the automaton hand is set in motion, it carries a blank from the lower end of the tube K and deposits it in the collar which fits over the lower die, and returns to fetch another blank while the upper die descends to coin the blank just deposited. D receives a motion which carries it through half a circle; but if this twisting motion were given to the upper die it would render the coin to be produced imperfect, therefore the strong rods E travel through the main frame C, and at their lower ends are provided with brasses, the outer surfaces of which are grooved to fit the wedge shape into which C is cut at this point. The rods E are fixed to D and travel with it, carrying at F an arrangement by which the block 4 is prevented from twisting round. D fits into a socket provided with a brass at 3. The lower die is fixed in a block 5, provided with adjusting screws, and resting on the base 6. The upper die is fixed in the block 4, which, in fact, becomes literally a part of D. When the press is in downward motion, the springs resting on the block 5 lift the milled collar which fits over the neck of the lower die, and causes it to enclose the blocks already placed there while the blow is given; but directly the press starts on its upward journey, the rod E catches a small lever G and forces the collar down on to the shoulder of the lower die, while the automaton hand comes forward and displaces the coin, while it places another blank on the die ready for the next blow of the press.

Fig. 1313 gives a view of the milled collar A. B being a representation of the lower die, with its long neck which fits nicely into the milled collar A. C, the upper die, also passes to a small distance into the collar, so that at the moment of the blow the blank is absolutely enclosed. The blow which is estimated at 40 tons, forces the metal into every engraved part of the collar and dies. The press, which has been described with as few technical terms as possible, coins from 60 to 80 blanks per minute, finishing by one blow the obverse and reverse impressions, and adding the milled edge. (For the manufacture of dies, see DIES.)

1313



The coins when struck are collected at frequent intervals and carefully overlooked to find any which may be defective, for with all the beauty of the mechanism of the press, accidents cannot be avoided, and it is found that about one coin in 200 is imperfect in its finish whatever its size or value. The imperfect coins are returned with the ends cut from the bars, the scissel, and the imperfect and out of remedy blanks to the melting house every morning. The coins are weighed into bags, each containing 701 sovereigns, and at intervals, depending on the requirements of the Bank, sent to the Mint office, where they undergo that time-honoured process of the Pyx, which means that the sovereigns are weighed out into pounds Troy, and their difference plus or minus upon the standard weight is noted, two pieces being taken from each bag. One of these two is placed in a strong box and reserved for the "trial of the Pyx" at Westminster Hall, and the other is divided and sent to the non-resident assayers, who report upon its purity. The coins which are taken are not selected but culled indiscriminately from the bag full. After assaying (unless the assay should be unsatisfactory) notice is sent to the Bank of England, and at a fixed time an officer comes with a waggon and two porters and fetches the gold coin.

It is only necessary to repeat that silver and gold undergo precisely similar treatment, but it has been omitted to say that the bars for different denominations of coin are of different widths but all of the same length and thickness as regards silver.

Notwithstanding the inference implied by the company of moneyers, and the evidence to be found in Blue Books, it is untrue to state that there must be a loss by coining the precious metals. At this present time loss in the coining department is utterly unknown, and this cannot be surprising if the great chemical fact that "matter cannot be lost" be kept in mind; for, however much we may divide a substance, the aggregate of its pieces must again make up the total; so it is with minting, and the minute particles which escape the watchful eyes of the workmen and their officers are recovered in the dust and sweepings of the mint. In the process of melting, there is an apparent loss to a small extent, but this is nearly balanced by the money obtained for the sweepings.

When it is stated that there is no loss by coining, it must not be understood that the coining department receives a definite weight of bars and returns an exactly equivalent weight of coin; as this is not intended to be stated; for it is evident that the extra alloy which is added, that it may be removed by the process of blanching or pickling, must be taken into account, as also must the value of the sweepings. But it is distinctly stated, that if to the coin delivered, the calculated amount of extra alloy and the value of the sweep be added, there is then no loss by coining, although a small margin must be allowed for minute differences in weighing between the different departments. This is positively true as regards gold, but there are some elements of calculation which are omitted, and make it appear that there is a very trifling loss in coining silver; it is nevertheless probable that some of the silver is volatilised by the many annealings it is submitted to, and its bulk probably gives a greater latitude for differences of weighing. It has long been observed that when gold coins, which have circulated till they have become "light," are melted and assayed, the ingots are almost invariably below the standard of fineness. This has been attributed to the introduction of base coins; but it seems to be more probably owing to the removal of the surface of pure gold, which is left at the time of blanching, by the wear to which the coins are subjected in circulation.

It must be borne in mind, that the foregoing is not intended for a descriptive account of the Mint machinery, but simply as a faithful relation of the processes adopted to convert bullion into coin — minting as it is at this date, 1859. — G. F. A.

MIRRORS. Under glass manufacture, the process of casting the large plates for mirrors has been described. We have therefore only to describe the preparation of the plate glass and its silvering in this place.

The smoothing of the plates is effected by the use of moist emery washed to successive degrees of fineness, for the various stages of the operation; and the polishing process is performed by rubbers of hat-felt and a thin paste of colcothar and water. The colcothar, called also crocus, is red oxide of iron prepared by the ignition of copperas, with grinding and elutriation of the residuum.

The last part, the polishing process, is performed by hand. This is managed by females, who slide one plate over another, while a little moistened putty of tin finely levigated is thrown between.

Large mirror-plates are now the indispensable ornaments of every large and sumptuous apartment; they diffuse lustre and gaiety round them, by reflecting the rays of light in a thousand lines, and by multiplying indefinitely the images of objects placed between opposite parallel planes.

The *silvering* of *plane* mirrors consists in applying a layer of tin-foil alloyed with mercury to their posterior surface. The workshop for executing this operation is provided with a great many smooth tables of fine freestone or marble, truly levelled, having round their contour a rising ledge, within which there is a gutter or groove which terminates by a slight slope in a spout at one of the corners. These tables rest upon an axis of wood or iron which runs along the middle of their length; so that they may be inclined easily into an angle with the horizon of 12 or 13 degrees, by means of a hand-screw fixed below. They are also furnished with brushes, with glass rules, with rolls of woollen stuff, several pieces of flannel, and a great many weights of stone or cast-iron.

The glass-tinner, standing towards one angle of his table, sweeps and wipes its surface with the greatest care, along the whole surface to be occupied by the mirror-plate; then taking a sheet of tin-foil adapted to his purpose, he spreads it on the table, and applies it closely with a brush, which removes any folds or wrinkles. The table being horizontal, he pours over the tin a small quantity of quicksilver, and spreads it with a roll of woollen stuff; so that the tin-foil is penetrated and apparently dissolved by the mercury. Placing now two rules, to the right and to the left, on the borders of the sheet, he pours on the middle a quantity of mercury sufficient to form every where a layer about the thickness of a crown piece; then removing with a linen rag the oxide or other impurities, he applies to it the edge of a sheet of paper, and advances it about half an inch. Meanwhile another workman is occupied in drying very nicely the surface of the glass that is to be silvered, and then hands it to the master workman, who, laying it flat, places its anterior edge first on the table, and then on the slip of paper; now pushing the glass forwards, he takes care to slide it along so that neither air, nor any coat of oxide on the mercury can remain beneath the plate. When this has reached its position, he fixes it there by a weight applied on its side, and gives the table a gentle slope, to run off all the loose quicksilver by the gutter and spout. At the end of five minutes he covers the mirror with a piece of flannel, and loads it with a great many weights, which are left upon it for 24 hours, under a gradually increased inclination of the table. By this time the plate is ready to be taken off the marble table, and laid on a wooden one sloped like a reading desk, with its under edge resting on the ground, while the upper is raised successively to different elevations by means of a cord passing over a pulley in the ceiling of the room. Thus the mirror has its slope graduated from day to day, till it finally arrives at a vertical position. About a month is required for draining out the superfluous mercury from large mirrors; and from 18 to 20 days from those of moderate size. The sheets of tin-foil being always somewhat larger than the glass-plate, their edges must be pared smooth off, before the plate is lifted off the marble table.

Process for silvering concave mirrors.— Having prepared some very fine Paris plaster by passing it through a silk sieve, and some a little coarser passed through hair-cloth, the first is to be made into a creamy liquor with water, and after smearing the concave surface of the glass with a film of olive oil, the fine plaster is to be poured into it, and spread by turning about, till a layer of plaster be formed about a tenth of an inch thick. The second or coarse plaster, being now made into a thin paste, poured over the first, and moved about, readily incorporates with it, in its imperfectly hardened state. Thus an exact mould is obtained of the concave surface of the glass, which lies about three-quarters of an inch thick upon it, but is not allowed to rise above its outer edge.

The mould being perfectly dried, must be marked with a point of coincidence on the glass, in order to permit of its being exactly replaced in the same position, after it has been lifted out. The mould is now removed, and a round sheet of tin-foil is applied to it, so large that an inch of its edge may project beyond the plaster all round; this border being necessary for fixing the tin to the contour of the mould by pellets of white wax softened a little with some Venice turpentine. Before fixing the tin-foil, however, it must be properly spread over the mould, so as to remove every wrinkle; which the pliancy of the foil easily admits of, by uniform and well directed pressure with the fingers.

The glass being placed in the hollow bed of a tight sack filled with fine sand, set in a well-jointed box capable of retaining quicksilver, its concave surface must be dusted with sifted wood-ashes, or Spanish white contained in a small cotton bag, and then well wiped with clean linen rags to free it from all adhering impurity, and particularly the moisture of the breath. The concavity must be now filled with quicksilver to the very lip, and the mould being dipped a little way into it, is withdrawn, and the adhering mercury is spread over the tin with a soft flannel roll, so as to amalgamate and brighten its whole surface, taking every precaution against breathing on it. Whenever this brightening seems complete, the mould is to be immersed, not vertically, but one edge at first, and thus obliquely downwards till the centres coincide; the mercury meanwhile being slowly displaced, and the mark on the mould being brought finally into coincidence with the mark on the glass. The mould is now left to operate by its own weight in expelling the superfluous mercury, which runs out upon the sand-bag and thence into a groove in the bottom of the box, whence it overflows by a spout into a leather bag of reception. After half an hour's repose, the whole is cautiously inverted, to drain off the quicksilver more completely. For this purpose, a box like the first is provided with a central support rising an inch above its edges; the upper surface of the support being nearly equal in diameter to that of the mould. Two workmen are required to execute the following operation. Each steadies the mould with the one hand, and raises the box with the other, taking care not to let the mould be deranged, which they rest on the (convex) support of the second box. Before inverting the first apparatus, however, the reception bag must be removed, for fear of spilling its mercury. The redundant quicksilver now drains off; and if the weight of the sand bag is not thought sufficient, supplementary weights are added at pleasure. The whole is left in this position for two or three days. Before separating the mirror from its mould, the border of tin-foil, fixed to it with wax, must be pared off with a knife. Then the weight and sand-bag being removed, the glass is lifted up with its interior coating of tin-amalgam.

For silvering a convex surface. — A concave plaster mould is made on the convex glass, and their points of coincidence are defined by marks. This mould is to be lined with tin-foil, with the precautions above described; and the tin surface being first brightened with a little mercury, the mould is then filled with the liquid metal. The glass is to be well cleaned, and immersed in the quicksilver bath, which will expel the greater part of the metal. A sand-bag is now to be laid on the glass, and the whole is to be inverted as in the former case on a support; when weights are to be applied to the mould, and the mercury is left to d ain off for several days.

If the glass be of large dimensions, 30 or 40 inches, for example, another method is adopted. A circular frame or hollow ring of wood or iron is prepared, of twice the diameter of the mirror, supported on three feet. A circular piece of new linen cloth of close texture is cut out, of equal diameter to the ring, which is hemmed stoutly at the border, and furnished round the edge with a row of small holes, for lacing the cloth to the ring, so as to leave no folds in it, but without bracing it so tightly as to deprive it of the elasticity necessary for making it into a mould. This apparatus being set horizontally, a leaf of tin-foil is spread over it, of sufficient size to cover the surface of the glass; the tin is first brightened with mercury, and then as much of the liquid metal is poured on as a plane mirror requires. The convex glass, well cleaned, is now set down on the cloth, and its own weight, joined to some additional weights, gradually presses down the cloth, and causes it to assume the form of the glass, which thus comes into close contact with the tin submersed under the quicksilver. The redundant quicksilver is afterwards drained off by inversion, as in common cases.

The following recipe has been given for silvering the inside of glass globes. Melt in an iron ladle or a crucible, equal parts of tin and lead, adding to the fused alloy one part of bruised bismuth. Stir the mixture well and pour into it as it cools two parts of dry mercury; agitating anew and skimming off the drossy film from the surface of the amalgam. The inside of the glass globe being freed from all adhering dust and humidity, is to be gently heated, while a little of the semi-fluid amalgam is introduced. The liquidity being increased by the slight degree of heat, the metallic coating is applied to all the points of the glass, by turning round the globe in every direction, but so slowly as to favour the adhesion of the alloy. This silvering is not so substantial as that of plane mirrors: but the form of the vessel, whether a globe, an ovoid, or a cylinder, conceals or palliates the defects by counter reflection from the opposite surfaces.

Several processes have been introduced, and some of them patented, for precipitating silver on glass. These have not been entirely successful, consequently they are but little employed. The phenomena involved, are, however, of such an interesting character, that this article would be incomplete without some notice of them.

Mr. Drayton patented a process of the following character. A solution of nitrate of silver, rendered neutral by the addition of a little ammonia, was floated over a plate of glass; or a vessel intended to be silvered was filled with this fluid; some spirits of wine was mixed with it, and then a small quantity of the oils of cloves and cassia added. By a complicated action, partly physical and partly chemical, metallic silver was separated from the salt in solution, and precipitated over the entire surface of the glass. The metallic film being of sufficient thickness, the solution was poured off, the coating well washed, dried, and protected from abrasion by a thick varnish or paint laid on the back. The defect in mirrors thus prepared, was that small specks appeared in the silver, which became little centres of chemical action; the silver tarnishing, and circular spots extending from these points; so that the mirror, either for use or ornament, was ruined. The cause of this may be traced to the compound character of the solutions employed. Nitrate of silver, ammonia, spirits of wine, and essential oils, with water, form a very mechanical mixture, and as the silver fell, it no doubt entangled some of the organic matter, and this, however small, became the starting point of those stains which eventually destroyed the mirror. Dr. Stenhouse shows that a large number of bodies possess the singular power of precipitating silver from its solution. Amongst others, the following:—gum-arabic, starch, salicine, gum-guaiacum, saccharic acid, aldehyde, oils of pimento, turpentine, or laurel, and especially grape sugar.

Mr. Hale Thomson patented a silvering process which involved the use of grape sugar. A certain portion of grape sugar is put into a solution of nitrate of silver, rendered as neutral as possible, and a little heat is applied. By this means a beautiful film of very pure silver is spread over the glass. By a process analogous to this, Foucault proposes to silver reflectors for lighthouses, and for telescopes. A process has been recently patented, involving the use of tartaric acid as the precipitating agent, but it has not yet made its way as a process of manufacture, and it therefore requires no further notice in this place.

MISPICKEL is arsenical pyrites. See PYRITES, ARSENIC, &c.

MOCHA STONE. See AGATE.

MOHAIR is the hair of a goat which inhabits the mountains in the vicinity of Angora, in Asia Minor.

We are indebted for this account of mohair to the *History of the Worsted Manufacture of England* by James.

Very much akin to, and in Yorkshire rising into importance about the same time as that of alpaca, the mohair manufacture demands attention.

The goat is amongst the earliest animals domesticated by man, and undoubtedly, from the very earliest ages, the fabrication of stuffs from its hair was practised by the nations of antiquity. Throughout the middle ages the art of making beautiful stuffs from the covering of the goat prevailed.

After the Angora goats have completed their first year, they are clipped annually in April and May, and yield progressively from one to about four pounds weight of hair. That of the female is considered better than the male's, but both are mixed together for the market, with the exception of the *two-year-old shegoat's fleece*; which is kept with the picked hair of other white goats (of which, perhaps, 5 lbs. may be chosen out of 1000), for the native manufacture of the most delicate articles; none being ever exported in any unwrought state. Common hair sold in the Angora bazaar, for 9 piastres, or about 1*s.* 8½*d.* the oke (that is, 2¾lbs.), whilst the finest picked wool of the same growth fetched 14 piastres the oke. When the fleeces are shorn, the women separate the clean hair from the dirty, and the latter only is washed. After which, the whole is mixed together, and sent to the market. That which is not exported raw is bought by the women of the labouring families, who, after pulling portions loose with their fingers, pass them successively through a large and fine toothed comb, and spin it into skeins of yarn, of which six qualities are made. An oke of Nos. 1 to 3 fetched in the Angora bazaar from 24 to 25 piastres, and the like weight of Nos. 3 to 6 from 38 to 40 piastres. Threads of the first 3 Nos. had been usually sent to France, Holland, and Germany; those of the last 3 qualities to England. The women of Angora moisten the hair with much spittle before they draw it from the distaff, and they assert that the quality of the thread greatly depends upon this operation.

Formerly there was a prohibition against the export from Turkey of the Angora hair except when wrought, or in the form of homespun yarn; but about the time of the Greek revolution, this prohibition was removed. Up to that period, however, there had been little demand for the raw material in Europe, so that it sold in the year 1820, at only 10*d.* per pound in England. The reason of the raw material not being in request arose from the belief that, owing to the peculiarity of the fibre, it could not be spun by machinery. It soon, however, became apparent that mohair could be thus spun in England, and this was more to be desired, because the Angora spun yarn had so many imperfections, from being thick and uneven, as to detract greatly from its value. This object, however, has been obtained, mainly by the perseverance of Mr. Southey, the eminent London wool-broker. Since then the use of the Angora wool has much extended, whilst the importation has much decreased, the English spun yarn being preferred.

The demand for Angora hand-spun yarn has almost ceased, and its value in Turkey has fallen to one half. Mohair is transmitted to England chiefly from the ports of Smyrna and Constantinople. In colour it is the whitest known in the trade, and is, consequently, peculiarly adapted for the fabrication of a certain class of goods. Besides Angora, quantities of an inferior sort of mohair are received from other parts of Asiatic Turkey: a very fine description of goat's hair is also sent from that country.

In England, mohair is mostly spun, and to some extent manufactured at Bradford, and also in a less degree spun at Norwich. Scotland is also engaged in working up mohair yarn. At first great difficulty occurred in sorting and preparing the material for spinning, but by patient experiment this has been effectually surmounted, and a fine and even thread produced, fitted for the most delicate webs.

The price of Angora goats' hair has, since its importation into this country, fluctuated very much, partly from the variations in demand, and partly owing to the supply. When the wool was first introduced, it realised only 1*s.* 3*d.* or 1*s.* 4*d.* per pound. During the years 1845 and 1846, it ranged from 1*s.* 3*d.* to 1*s.* 8*d.* per pound; and about the year 1850 it sold for 1*s.* 9*d.* to 1*s.* 10*d.* per pound; and now it is sold on the average at 1*s.* 10*d.* per pound.

Numerous articles are manufactured from mohair. For instance, many kinds of camblets, which, when watered, exhibit a beauty and brilliance of surface unapproached by fabrics made from English wools. It is also manufactured into plush, as well as for coach and decorative laces, and also extensively for buttons, braidings, and other trimmings for gentlemen's coats. Besides, it is made up into a light and fashionable cloth, suitable for paletots and such like coats, combining elegance of texture with the advantages of repelling wet. A few years since, mohair striped and checked textures for ladies' dresses, possessing unrivalled glossiness of appearance, were in request; but of late these have been superseded by alpaca. For many years the export of English mohair yarn has been considerable to France.

This trade is enjoyed at Bradford and Norwich, but chiefly by the former place. This yarn is manufactured in France into a new kind of lace, which, in a great measure, is substituted for the costly fabrics of Valenciennes and Chantilly. The Angora goats' hair lace is as brilliant as that made from silk, and costing only about 1*s.*2*d.* the piece, has come into every general wear among the middle classes. Mohair is also manufactured into fine shawls, selling from 4*l.* to 16*l.* each. Also large quantities of what is termed Utrecht velvet, suitable for hangings, and furniture linings for carriages are made from it abroad. Recently this kind of velvet has begun to be manufactured at Coventry, and it is fully anticipated that the English made article will successfully compete with the foreign one in every essential quality.

When Captain Conolly wrote in the year 1839, the export from the East of mohair yarn had almost ceased, whilst that of the hair had very greatly increased, as thus shown.

In 1836, only 538 bales of mohair yarn were exported, whilst that of the hair amounted to 3841 bales.

In 1837, the export of the yarn had decreased to 8 bales, and the mohair to 2261 bales; and in 1838, the large amount of 5528 bales of mohair was exported; and only 21 bales of yarn.

In 1839 no yarn was exported, but about 5679 bales of hair.

There is no separate account furnished of the quantity of mohair imported into the kingdom before the year 1843; since then the returns give the following result:—

Years.	Imported.	Re-exported.	Years.	Imported.	Re-exported.
	lbs.	lbs.		lbs.	lbs.
1843	575,523		1850	2,805,685	961,661
1844	1,290,771	99,529	1851	2,124,600	96,044
1845	1,241,623	114,001	1852	2,564,330	71,734
1846	1,287,320	48,093	1853	3,251,806	81,725
1848	896,865	97,977	1854	1,335,319	107,169
1849	2,536,039	130,145			

The following is a statement furnished by the Board of Trade, of the import and export of mohair during the year 1856.

Imported from:—

	lbs.
Prussia - - - -	14,448
Turkey - - - -	2,871,011
Egypt - - - -	10,416
British East Indies - -	4,198
United States - -	19,861
Other parts - - -	8,477
Total - -	2,928,411

Re-exported to:—

	lbs.
Hanse Towns - - -	60,162
Belgium - - - -	10,404
France - - - -	130,512
Other parts - - -	3,588
	204,666

It is evident that the re-export of mohair is insignificant.

MOIRE is the name given to the best watered silks. These silks are made in the same way as ordinary silks, but always much stouter, sometimes weighing, for equal surface, several times heavier than the best ordinary silks. They are always made of double width, and this is indispensable in obtaining the bold waterings, for these depend not only on the quality of the silk, but greatly on the way in which they are folded when subjected to the enormous pressure in watering. They should be folded in such a manner, that the air which is contained between the folds of it, should not be able to ecapes easily; then when the pressure is applied the air, in trying to effect its escape, drives before it the little moisture which is used, and hence causes the watering. Care must also be taken so to fold it, that every thread may be perfectly parallel, for if they ride one across the other, the watering will be spoiled. The pressure used, is from 60 to 100 tons.—H. K. B.

MOIRÉE METALLIQUE, called in this country crystallised 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 uncrystallisable liquor, which drains from cane sugar in the colonies. It is employed for the preparation of spirits of wine. See SUGAR.

MOLYBDENUM (*Molybdène*, Fr.; *Molybdan*, Germ.) is a rare metal which occurs in nature sometimes as a sulphide, 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-grey 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, oxidises 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. This metal is too rare at present to be used in any manufacture.

MOONSTONE, a transparent or translucent variety of felspar. It contains bluish white spots, which, when held to the light, present a pearly or silvery play of colour, not unlike that of the moon. The most valued specimens are those which, when cut in a very low oval, exhibit the silvery spot in the centre. The moonstone is held in some estimation as an ornamental stone, but, in common with the other varieties of felspar, it is so soft that few lapidaries know how to work it to the greatest advantage. The finest moonstones are brought from Ceylon. — H. W. B.

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 certain colouring substances, constituting them dyes. In order properly to appreciate the utility and the true functions of mordants, we must bear in mind that many colouring matters, even those forming dark coloured solutions, have no affinity for the fibre to be dyed. When the goods are passed through such a coloured solution, they become stained only to the extent in which they retain the solution, and if they are afterwards put into water, the colour, being soluble, is all washed out. Suppose the coloured solution to be a decoction of logwood, and that the stuff is passed into it. It may be slightly coloured; but on being washed with water all the colour is removed. But if, previous to being put through the logwood solution, the stuff be passed through a solution of protochloride of tin, a portion of the tin is retained by it, in virtue of an influence (a condition of capillarity) between the fibre and the salt. There will now be formed a beautiful wine-coloured compound between the logwood and the tin upon the goods, when they are placed in the logwood bath, which washing with water will not remove, the compound being insoluble. The tin in this case constitutes the mordant. It is not always essential that the mordant be put upon the fibre previous to being put into the coloured solution; they may be mixed together, and the goods placed in the mixture, when much of the coloured compound will combine with or adhere to the fibre; but, in general, this mode of applying the mordant is not so effective. 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 dye house.

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.

It will be observed from the above remarks, that the mordant serves a higher purpose than the mere bond of union between the colour and fibre; that it, in fact, constitutes a principal element in the colour. The colour forming the dye, in the case with the logwood and tin, is not that of hæmatoxylin, the colouring matter of logwood; but of the compound formed between it and tin, and thus logwood, by different mordant bases, gives a variety of colours, from a grey to a black, and from a light lavender to a deep purple, &c. When an organic colouring matter is imparted to any fibre without the intervention of a mordant, it can only produce one tint, which cannot be varied except in being light and dark.

Experience has proved, that of all the bases, those which succeed best as mordants are alumina, tin, and oxide of iron.

Blue-black dye. — The mordant much employed in some parts of Germany for this dye, with logwood, galls, sumach, &c., is *Iron-alum*, so called on account of its having the crystalline form of alum, though it contains no alumina. It is prepared by dissolving 78 pounds of red oxide of iron in 117 pounds of sulphuric acid, diluting this compound with water, adding to the mixture 87 pounds of sulphate of potash, evaporating the solution to the crystallising point. This potassa-sulphate of iron has a fine amethyst colour when recently prepared; and though it gets coated in the air with a yellowish crust, it is none the worse on this account. As a mordant, a solution of this salt, in from 6 to 60 parts of water, serves to communicate and fix a great variety of uniform ground colours, from light grey to brown, blue, or jet black, with quercitron, galls, logwood, sumach, &c., separate or combined. The above solution may be usefully modified by adding to every 10 pounds of the *iron-alum*, dissolved in 8 gallons (80 pounds) of warm water, 10 pounds of acetate (sugar) of lead, and leaving the mixture, after careful stirring, to settle. Sulphate of lead falls, and the oxide of iron remains combined with the acetic acid and the potash. After passing through the above mordant, the cotton goods should be quickly dried.

Colours of the above class are, however, mostly insoluble in water, and have to be dissolved or extracted by an alkaline solvent: and in this state have no affinity either for the fibre or a mordant. Safflower is an instance of this kind; the red colouring matter of this vegetable is extracted by a weak alkaline lye, into which the goods to be dyed are afterwards put; and the alkali being neutralised by an acid, the colouring matter is thus rendered insoluble in the liquor, in a state of minute division, and is gradually absorbed by the fibre, which becomes dyed of a red colour in depth according to the quantity of colour absorbed.

Indigo is another dye of this sort requiring an alkaline solvent, and not dyed with mordants. (See Dyeing.)

The following remarks will illustrate some of the necessary requirements of a mordant, which should be attended to by the dyer, in their application.

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 stuffs. 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 purest; and it is not many years since 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 it 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 crystallised 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 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 the 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 realised by varying the proportions of the watery vehicle. (See CALICO-PRINTING 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 minutiæ 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. 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. See CALICO PRINTING.

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 large 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.

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 a variety of dyes, and also of dye-drugs, as sapan and Brazil-wood, madder, and logwood, and especially in the dye Adrianople or Turkey 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 fixes a greater quantity of the base upon it, and thus adds depth to the colour, as well as certain peculiarities of tint; 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. See CALICO PRINTING, Vol. I. p. 524, and the various MORDANTS there particularised under their respective heads. — J. N.

MOREEN. A stout woollen stuff, which is chiefly employed for curtains.

MORINE. This is the name given by Gerhardt to the principal colouring matter of the *Morus tinctoria* or *old fustic*, a large tree which grows in many parts of the West Indies, and on the American Continent. It is used principally for dyeing woollens and silks, seldom or ever as a solitary colour, but as a ground work for other colours, as in the dyeing of wools and silks black, in which process, it greatly improves the black. It is used with indigo to form a green, and with salts of iron to yield an olive hue. The colouring matter was first separated by Chevreul. It is extracted from the wood by boiling water, which on cooling, when concentrated, deposits it as yellow crystalline powder, which must be purified by several crystallisations. It has the composition ($C^{36}H^{16}O^{20}$). It possesses a sweetish and astringent taste; one part dissolves in 6·4 parts of cold water and in 2·14 parts of boiling water. The solution is slightly acid, and precipitates salts of iron of a dark green colour; with salts of lead and protochloride of tin, it forms deep yellow precipitates. It is not precipitated by alum until after the addition of carbonate of potash, when a yellow lake is formed.

Concentrated sulphuric acid dissolves it in the cold, forming a yellow solution, from which it is again precipitated by diluting with water. It is readily soluble in alcohol and ether; insoluble in spirits of turpentine and the fatty oils. Alkalies deepen the colour of its solutions.—H. K. B.

MORINGA. The seeds of the *Moringha Pterygasperma* have been used for the oil they contain. These have been examined and reported on by Mr. Dugald Campbell, who says of the oil they yield: — "This oil is the very opposite to a dry oil, being extremely rich in fatty substances, and is of specific gravity 915·60 at 60° Fah., water taken as 1·000. When it is kept cooled for a short time to 44° it becomes opaque from crystals of the fatty substances forming throughout it, and it is now very viscid and thick. In this state it may be heated up to 65° before it assumes its original brightness. It is nearly tasteless, and almost without odour."

MOROCCO. See LEATHER.

MORPHINE. *Syn.* Morphia. (*Morphine*, Fr.; *Morphin*, Germ.) $C^{34}H^{19}NO^{6} + 2$ aq. An organic base, contained (amongst others) in opium. As it is the substance upon which the sedative properties of opium depend, great attention has been paid to its extraction. Numerous processes have been devised for the purpose; but perhaps that of Gregory is, in facility and economy, as good as any. The aqueous infusion is precipitated by chloride of calcium to remove the meconic and sulphuric acids present. The filtered fluid is evaporated until the hydrochlorate of morphine crystallises out, so as to form a nearly solid mass, which is then strongly pressed: the liquid exuding contains the colouring matters and several alkaloids. The pressed mass is crystallised and squeezed repeatedly, and, if necessary, bleached with animal charcoal. The hydrochlorate, which contains a little codeine, is to be dissolved in water and precipitated by ammonia; pure morphia precipitates, and the codeine remains in solution. The salts of morphia most employed in medicine are the hydrochlorate, the acetate, and the sulphate. A solution of 5 grains of morphia in 1 ounce of water is about the same strength as laudanum.— C. C. W.

Imports, 1857.—Morphia and its salts, 159 lbs.

MORTAR. A mixture of lime with water and sand.

The sand used in making mortar should be *sharp*,—that is angular, not round,—and *clean*, that is, free from all earthy matter, or other than siliceous particles. Hence *road scrapings*, always, as being a mixture of sand and mud, and *pit sand* generally, as being scarcely ever without a portion of clay, should be washed before they are used, which is seldom necessary with *river sand*, this being cleaned by the flowing water. "I have ascertained by repeated experiments, that 1 cubic foot of well burned chalk lime fresh from the kiln, weighing 35 lbs., when well mixed with $3\frac{1}{2}$ cubic feet of good river sand, and about $1\frac{1}{2}$ cubic foot of water, produced above $3\frac{1}{4}$ cubic feet of as good mortar as this kind of lime is capable of forming. A smaller proportion of sand such as two parts to one of lime, is however often used, which the workmen generally prefer, but because it requires less time and labour in mixing, which saves trouble to the labourers, and it also suits the convenience of the masons and bricklayers better, being what is termed *tougher*, that is, more easily worked, but it does not by any means make such good mortar. If on the other hand the sand be increased to more than the above proportion of $3\frac{1}{2}$, it renders the mortar *too short*, that is, not plastic enough for use, and causes it also to be too friable, for excess of sand prevents mortar from setting into a compact adhesive mass. In short, there is a certain just proportion, between these two ingredients which produces the best mortar, which I should say ought not to be less than 3, nor more than 3½ parts of sand, to 1 of lime; that is when common chalk lime, or other pure limes are used, for different limes require different proportions. When the proportion of sand to lime is stated in the above manner, which is done by architects as a part of their specification, or general directions for the execution of a building, it is always understood, when nothing is expressed to the contrary, that the parts stated are by fair level measure of the lime, and by stricken measure for the sand; and that the lime is to be measured in lumps, in the same state in which it comes from the kiln, without slaking, or even breaking it into smaller pieces." — *Pasley.*

MORTAR, HYDRAULIC, 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, such as contain from 8 to 25 per cent. of foreign matter, in silica, alumina, magnesia, &c., are best adapted for this purpose. All the water limestones are of a bluish grey or brown colour, which is communicated to them by the oxide of iron. They are usually termed *stone-lime* by the builders of the metropolis, to distinguish them from common chalk lime, but so far improperly, that the Dorking limestone is not much harder than chalk, and the Halling limestone is actually a chalk, and not harder than the pure chalk of the same neighbourhood, from which it is only distinguished in appearance by being a little darker. These, though calcined, do not slake when moistened; but if pulverised 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.

The following analyses of different hydraulic limestones are by Berthier.

	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	18·0
Oxide of iron	1·0	1·5	1·2		
	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

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, trass or tarras, pumice-stone, basalt-tuff, slate-clay. Puzzolana is a volcanic product, which forms hills of considerable 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 argillaecous 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-grey or brown colour, interspersed with veins of calc-spar, and sometimes contain cavities bestudded with crystals. Their specific gravity is 2·59.

The Blue Lias cement-stones are considered the strongest water limes of this country, and are found on opposite sides of the Bristol Channel, near Watchet in Somersetshire, and Aberthaw in Glamorganshire, and also in North Wales and at Lyme Regis in Dorsetshire. The Dorking or Merstham lime and the Halling lime, so termed from a village on the left bank of the Medway above Rochester, but which is also found near Burnham on the opposite side of the river, though not possessing such strong hydraulic properties as the lias, are also much esteemed.

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	- -		
— manganese	1·6	- -	- -	4·3	11·6
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 analysed by Berthier; No. 2, Boulogne stone, by Drapiez; No. 3, English ditto, by Davy; No. 4, reniform 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 usually 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 a 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.

Professor Kuhlmann, of Lisle, has made certain improvements in the manufacture of lime-cement, and he has prepared artificial stone possessed of a hardness and solidity fit for the sculptor. See STONE, ARTIFICIAL.

In operating by the dry method, instead of calcining the limestone with sand and clay alone, as has been hitherto commonly 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 achitectural ornaments, by making a paste of pulverised 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 gelatinise in acids. Quartzose sand, however fine its powder may be, will form no water-mortar or 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.

Hamelin's Cement 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. Considerable dexterity is required to make good work with it.

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 to 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 substanee, and should, after being pulverised, be mixed up with good lime, to make a water mortar. If the marls in any loeality differ mueh in their relative proportions of lime and alumina, then the several kinds should be mixed in sueh due proportions as to produce the most speedily setting, and most highly indurating hydraulie cement.

Hydraulic limes, or eements require the presenee of carbonate of lime with silica, or silicate of alumina, or magnesia. It is stated the dolomite ealcined at a moderate heat exhibits the property of a hydraulic lime.

If earbonate of lime be mixed with gelatinous silica, it forms a good hydraulic cement. See SILICA and SILICATISATION.

If a hydraulie lime be ealcined at too high a temperature, the silieate undergoes partial fusion, and will not set afterwards under water. The heat therefore employed for burning the hydraulie limestones should only be just high enough to expel the water from the clay and the greater part of the earbonie aeid from the earbonate of lime.

Neither clay (*silicate of alumina*) nor lime alone will set under water, but if we carefully mix chalk and clay together and then ealcine them at a moderate heat a good hydraulic eement is obtained.

It is impossible in this work to do full justiee to this very important subjeet, we must therefore refer our readers to General Pasley's works on *Limes and Cements*, to the papers of Mr. Timperly in the *Transactions of the Institution of Civil Engineers* and to the works espeeially of M. M. Vieat and Belidor. See, besides the articles already referred to, PUZZOLANA, ROMAN CEMENT, STONE CEMENT.

MOSAIC. (*Mosaïque*, Fr.; *Mosaisch*, Germ.) There are several kinds of mosaic, but all of them eonsist in imbedding fragments of different eoloured substanees, usually glass or stones, in a cement, so as to produee the effeet of a pieture. The beautiful chapel of Saint Lawrence in Florenee, whieh contains the tombs of the Medici, has been greatly admired by artists, on account of the vast multitude of preeious marbles, jaspers, agates, aventurines, malachites, &c., applied in mosaic upon its walls. The detailed diseussion of this subject belongs to a treatise upon the fine arts. The progress-of the invention is so eurious that some brief notiec of mosaic work in general will not be out of plaee.

When, with his advaneing intelligenee, man began to construet ornamental articles to deeorate his dwelling, or to adorn his person, we find him taking natural produetions, ehiefly from the mineral kingdom, and eombining them in sueh a manner as will afford, by their contrasts of eolour, the most pleasing effeets. From this arose the art of mosaic, whieh appears, in the first instance, to have been applied only to the combination of diee-shaped stones (*tesseræ*) in patterns. This was the *opus musivum* of the Romans; improving upon whieh, we have the Italians introdueing the more elaborate and artistic *pietra dura*, now commonly known as Florentine-work. It is not our purpose to treat of any of the ancient forms of mosaic-work, further than it is necessary to illustrate the subjeet before us. The *opus tesselatum* eonsisted of small cubes of marble, worked by hand into simple geometrical figures. The *opus sectile* was formed of different crusts or sliecs of marble, of whieh figures and ornaments were made. The *opus vermiculatum* was of a far higher order than these: by the employment of differently-eoloured marbles, and, where great brillianey of tint was required, by the aid of gems, the artists produced imitations of figures, ornaments, and pictures, the whole object being portrayed in all its true colours and shades.

The advance from the *opus vermiculatum* to the fine mosaie work, which had its origin in Rome, and is, therefore, especially termed Roman mosaic, was easy; and we find this delieate manufaeture arising to a high degree of exeellenee in the city where it originated, and to whieh it has been almost entirely eonfined, Venice being the only city whieh has attempted to eompete with Rome. To this Art-manufacture we more espeeially direet attention, sinee a deseription of it will aid us in rendering intelligible the most interesting and peeuliarly novel manufacture of mosaie rug-work, as practised by the Messrs. Crossleys. Roman, and also Venetian enamels, are made of small rods of glass, called indiseriminately *paste* and *smalt*. In the first place cakes of glass are manufaetured in every variety of eolour and shade that are likely to be required. These cakes are drawn out into rods more or less attenuated, as they are intended to be used for finer or for eoarser works, a great number being aetually threads of glass. These rods and threads are kept in bundles, and arranged in sets eorresponding to their eolours, eaeh division of a set presenting every desired shade. A piece of dark slate or marble is prepared, by being hollowed out like a box, and this is filled with plaster of Paris. Upon this plaster the pattern is drawn by the artist, and the *mosaicisti* proceeds with his work by removing small squares of the plaster, and filling in these with pieces eut from the rods of glass. Gradually, in this manner, all the plaster is removed, and a picture is formed by the *ends of the filaments of coloured glass*; these are carefully cemented together by a kind of mastic, and polished. In this way is formed, not only those exquisitely delicate mosaics which were, at one time, very fashionable for ladies' brooches, but tolerably large, and often highly artistic pictures. Many of our readers will remember the mosaic landscapes which rendered the Italian Court of the Great Exhibition so attractive; and in the Museum of Practical Geology will be found a portrait of the late Emperor of Russia, which is a remarkably good illustration of mosaic-work on a large scale. We may remark, in passing, that the whole process of glass mosaic is well illustrated in this collection.

The next description of mosaic work to which we will direct attention is the manufacture of Tunbridge. The wood mosaics of Tunbridge are formed of rods of wood, varying in colour, laid one upon the other, and cemented together, so that the pattern, as with the glass mosaics, is produced by the ends of the rods.

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 became 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 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. See Alloys.

MOSAIC WOOL WORK. There is no branch of manufacture which is of a more curious character than the mosaic wool work of the Messrs. Crossleys of Halifax.

By referring to the article Mosaic, there will be no difficulty in understanding how a block of wood, which has been constructed of hundreds of lengths of coloured specimens, will, if cut transversely, produce a great number of repetitions of the original design. Suppose, when we look at the transverse section presented by the end of a Tunbridge block, we see a very accurately formed geometric pattern; this is rendered perfectly smooth, and a slab of wood is glued to it. When the adhesion is secure, as in a piece of veneering for ordinary cabinet-work, a very thin slice is cut off by means of a circular saw, and then we have the pattern presented to us in a state which admits of its being fashioned into any article which may be desired by the cabinet-maker. In this way, from one block, a very large number of slices can be cut off, every one of them presenting exactly the same design. If lengths of worsted are substituted for those of glass or of wood, it will be evident that the result will be in many respects similar. By a process of this kind the mosaic rugs — with very remarkable copies from the works of some of our best artists — are produced. In connection with this manufacture, a few words on the origin of this kind of work will not be out of place.

The tapestries of France have been long celebrated for the artistic excellence of the designs, and for the brilliancy and permanence of the colours. These originated in France, about the time of Henry IV., and the manufacture was much patronised by that monarch and his minister Sully. Louis XIV. and Colbert, however, were the great patrons of the beautiful productions of the loom. The minister of Louis bought from the Brothers Gobelins their manufactory, and transformed it into a royal establishment, under the title of *Le Teinturier Parfait*. A work was published in 1746, in which it was seriously told that the dyes of the Gobelins had acquired such superiority that their contemporaries attributed the talent of these celebrated artists to a paction which one or the other of them had made with the devil.

In the Gobelin and Beauvais Tapestry we have examples of the most artistic productions, executed with a *mechanical* skill of the highest order, when we consider the material in which the work is executed. The method of manufacture involving artistic power on the part of the workman, great manipulatory skill, and the expenditure of much time, necessarily removes those productions from the reach of any but the wealthy. Various attempts have been made, from time to time, to produce a textile fabric which should equal those tapestries in beauty, and which should be sold to the public at much lower prices. None of those appear to have been successful, until the increasing applications of india-rubber pointed to a plan by which high artistic excellence might be combined with moderate cost. In Berlin, and subsequently in Paris, plans—in most respects similar to the plan we are about to describe—were tried, but in neither instance with complete success. Of course, there cannot now be many of our readers who have not been attracted by the very life-like representations of lions and dogs which have for the last few years been exhibited in the carpet warehouses of the metropolis, and other large cities. While we admit the perfection of the manufacture, we are compelled to remark that the designs which have been chosen are not such as appear to us to be quite appropriate, when we consider the purposes for which a rug is intended. Doubtless from their very attractive character, and moderate cost, those rugs find a large number of purchasers, by whom they are doubtless greatly admired. It will, however, be obvious to our readers, that they are not consistent with the principles of design, and that there is a want of consistency in the idea of treading upon the "monarch of the forest," copied with that remarkable life-likeness which distinguishes the productions of Sir Edwin Landseer; or in placing one's feet in the midst of dogs or of poultry, when the resemblances are sufficiently striking to impress you with the idea that the dogs will bark, and that the cock will crow. We believe that less picturesque subjects, in accordance with the law—which we conceive to be the true one—which gives true beauty only to that which is, in its applications, consistent and harmonious, would be yet greater favourites than those rugs now manufactured by the Messrs. Crossleys. And amidst the amount of good which these excellent men are doing to all who come within their influence, we are certain they might, with the means at their command, introduce an arrangement of colours which might delight by their harmonious blending, and a system of designs which, pure and consistent, should ever charm the eye, without attempting to deceive either it, or any of the senses. Every attempt to advance the taste of a people is worthy of all honour; and having the power, as the manufacturers of the mosaic rugs have, of producing works of the highest artistic excellence, we should be rejoiced to see them employing that power to cultivate amongst all classes a correct perception of the true and the beautiful.

With these remarks we proceed to a description of the manufacture.

Every lady who has devoted herself for a season, when it was the fashion to do so, to Berlin wool-work, will appreciate the importance of a careful arrangement of all the coloured worsteds which are to be used in the composition of her design. Here, where many hundreds of colours, combinations of colours, and shades are required, in great quantities and in long lengths, the utmost order is necessary; and the system adopted in this establishment is in this respect excellent. We have, for example, grouped under each of the primary colours, all the tints of each respective colour that the dyer can produce, and between each large division the mixtures of colour producing the neutral tones, and the interblending shades which may be required to copy the artist with fidelity. Skeins of worsted thus arranged are ever ready for the English *mosaicisti* in rug-work. Such is the material. Now to describe the manner of proceeding. In the first place an artist is employed to copy, of the exact size required for the rug, a work of Landseer's, or any other master, which may be selected for the purpose. Although the process of copying is in this case mechanical, considerable skill is required to produce the desired result. This will be familiar to all who have observed the peculiar characteristics of the Berlin wool-work patterns. The picture being completed, it is ruled over in square, each of about twelve inches These are again interruled with small squares, which correspond with the threads of which the finished work is to consist. This original being completed, it is copied upon lined paper by girls who are trained to the work, each girl having a square of about twelve inches to work on. These are the copies which go into the manufactory. A square is given to a young woman whose duty it is to match all the colours in wool. This is a task of great delicacy, requiring a very fine appreciation of colour. It becomes necessary in many cases to combine two threads of wool, especially to produce the neutral tints. It is very interesting to observe the care with which every variety of colour is matched. The skeins of worsted are taken, and a knot or knob being formed, so as to increase the quantity of coloured surface, it is brought down on the coloured picture; and, when the right shades have been selected, they are numbered, and a corresponding system of numbers are put on the pattern. In many of the rugs one hundred colours are employed. The selector of colours works under the guidance of a master, who was in this case a German gentleman, and to his obliging and painstaking kindness we are much indebted. Without his very exact description of every stage of the process, it would not have been easy to render this rare mosaic-work intelligible to our readers. When all the coloured wools have been selected, they are handed, with the patterns, to young women, who are termed the "mistresses of a frame," each one having under her charge three little girls.

The "frame" consists of three iron stands, the two extreme ones being about 200 inches apart, and the other exactly in the middle. These stands are made of stout cast iron, and may be said to consist of two bowed legs, with two cross pieces of iron, one at the top of the legs, and the other about fifteen inches below, the space between them being that which is to be occupied by the threads of wool which are to form the required square block of wool. These frames are united together by means of cast iron tubes, running from end to end. The observer is struck with the degree of strength which has been given to these frames. It appears that, for the purpose of merely holding together a few threads of wool, a much slighter frame might have been employed; and we certainly were surprised when we were informed that, at first, many frames were broken, and that they were compelled to have the stronger ones at present in use. The cause of this will be obvious, when we have proceeded a little further with our description. At one end of these frames sits the "mistress," with a stand before her, on which the pattern allotted to her is placed, and a vertical frame, over which the long coloured worsteds are arranged. By the side of this young woman sits a little girl, who receives each worsted from the mistress, and hands it to one of two children, who are on either side of the frame.

Commencing at one corner of the pattern, a thread is selected of the required colour, and handed to the first girl, who passes it to the second, whose duty it is to fasten it to a stiff, but slight bar of steel, about half an inch in width, which passes from the upper to the under bar of the frame. The third girl receives the thread, and carries it to the lower end of the frame, and fastens it to a similar bar of steel at that end. The length of each thread of worsted is rather more than 200 inches. It is well known that twisted wool does not lie quite straight, without some force is applied to it; and of course the finished pattern would be incomplete, if all the threads did not observe the truest parallelism to each other. To effect this, a stretching force equal to four pounds is required to every thread. The child who carries the thread, therefore, pulls the worsted with this degree of force, and fastens it over the steel bar. Every block, forming a foot-square of rug-work, consists of fifty thousand threads; therefore, since every thread pulls upon the frame with a force equal to four pounds, there is a direct strain to the extent of 250,000 pounds upon the frame. When this is known, our surprise is no longer excited at the strength of the iron-work; indeed, the bars of hardened steel, set edgeways, were evidently bent by the force exerted.

Thread after thread, in this way, the work proceeds, every tenth thread being marked by having a piece of white thread tied to it. By this means, if the foreman, when he examines the work, finds that an error has been committed, he is enabled to have it corrected, by removing only a few of the threads, instead of a great number, which would have been the case, if the system of marking had not been adopted.

This work, requiring much care, does not proceed with much rapidity, and the constant repetition of all the same motions through a long period would become exceedingly monotonous, especially as talking cannot be allowed, because the attention would be withdrawn from the task in hand. Singing has therefore been encouraged, and it is exceedingly pleasing to see so many young, happy, and healthy faces performing a clean and easy task, in unison with some song, in which they all take a part. Harmonious arrangements of colour are produced, under the cheerful influence of harmonious sounds. Yorkshire has long been celebrated for its choristers, and some of the voices which we heard in the room devoted to the construction of the wool-mosaics bore evidence of this natural gift, and of a considerable degree of cultivation.

The "block," as it is called, is eventually completed. This, as we have already stated, is about a foot square, and it is 200 inches long. Being bound, so as to prevent the disturbance of any of the threads, the block is cut by means of a very sharp knife into ten parts, so that each division will have a depth of about 20 inches. Hearth-rugs are ordinarily about eight feet long, by about two feet wide, often, however, varying from these dimensions. Supposing, however, this to represent the usual size, twelve blocks, from as many different frames, are placed in a box, with the threads in a vertical position, so that, looking down upon the ends, we see the pattern. These threads are merely sustained in their vertical order by their juxtaposition. Each box therefore, will contain 800,000 threads. The rug is now, so far as the construction of the pattern is required completed; and the cost of producing the "block," of 200 inches in depth, eight feet in length, and two feet wide, including the cost of wool, and the payment for labour, is little short of 800*l.* When, however, it is known that these threads are subsequently cut into the length required to form the rug, and that these lengths are but the three-sixteenths of an inch in depth, it will be evident that the number of those beautiful carpets which can thus be obtained, renders the manufacture fairly remunerative. The boxes into which the rugs are placed are fixed on wheels, and they have movable bottoms, the object of which will be presently understood. From the upper part of the immense building devoted to carpet manufacture, in which this mosaic rug-work is carried on, we descend with our rug to the basement story. Here we find, in the first place, steam chests, in which india-rubber is dissolved in camphine. It may not be out of place to observe that camphine is actually spirits of turpentine, carefully rectified, and deprived of much of its smell, by being distilled from either potash or soda. Recently prepared camphine has but little of the terebinthinous odour, but if it is kept long, and especially if it is exposed to the air, it again acquires, with the absorption of oxygen, its original smell. This is of course avoided in the manufacture of such an article as an hearth-rug as much as possible. The camphine is used as fresh as possible, and in it the India-rubber is dissolved, until we have a fluid about the consistence of, and in appearance like, carpenter's glue.

In an adjoining room were numerous boxes, each one containing the rug-work in some of the stages of manufacture. It must now be remembered that each box represents a completed rug—the upper ends of the threads being shaved off, to present as smooth a surface as possible. In every stage of the process now all damp must be avoided, as wool, like all other porous bodies, has a tendency to absorb and retain moisture from the atmosphere. The boxes, therefore, are placed in heated chambers, and they remain there until all moisture is dispelled; when this is effected, a layer of India-rubber solution is laid over the surface, care being taken, in the application, that every thread receives the proper quantity of the caoutchouc; this is dried in the warm chamber, and a second and a third coat is given to the fibres. While the last coat is being kept in the warm chamber, free from all dust, sufficiently long to dissipate some of the camphine, the surface on which the rug is to be placed receives similar treatment. In some cases ordinary carpet canvass only is employed; in others, a rug made by weaving in the ordinary manner is employed, so that either side of the rug can be turned up in the room in which it is placed. However this may be, both surfaces are properly covered with soft caoutchouc, and the "backing" is carefully placed on the ends of worsted forming the rug in the box. By a scraping motion, the object of which is to remove all air-bubbles, the union is perfectly effected; it is then placed aside for some little time, to secure by rest that absolute union of parts, between the two india-rubber surfaces, which is necessary. The separation of the two parts is after this attended with the utmost difficulty; the worsted may be broken by a forcible pull, but it cannot be removed from the india-rubber. The next operation is that of cutting off the rug; for this purpose a very admirable, but a somewhat formidable machine is required. It is, in principle, a circular knife, of twelve feet diameter, mounted horizontally, which is driven, by steam-power, at the rate of 170 revolutions in a minute.

The rug in its box is brought to the required distance above the edge of the box, by screwing up the bottom. The box is then placed on a rail, and connected with a tolerably fine endless screw. The machine being in motion, the box is carried by the screw under the knife, and by the rapid circular motion, the knife having a razor-like edge, a very clean cut is effected. As soon as the rug is cut off, to the extent of a few inches, it is fastened by hooks to strings which wind over cylinders, and thus raise the rug as regularly as it is cut. This goes on until the entire rug is cut off to the thickness of three sixteenths of an inch. The other portion in the box is now ready to receive another coating, and the application of another surface, to form a second rug, and so on, until about one thousand rugs are cut from the block prepared as we have described.

The establishment of the Messrs. Crossley, which gives employment to four thousand people, is one of those vast manufactories of which England may proudly boast, as examples of the industry and skill of her sons. Here we have steam engines urging, by their gigantic throes, thousands of spindles, and hundreds of shuttles, and yet, notwithstanding the human labour which has been saved, there is room for the exertion of four thousand people. The manner in which this great mass of men, women, and children is treated, is marked in all the arrangements for their comfort, not merely in the great workshop itself, but in every division of that hill-encompassed town, Halifax. Church, schools, and park proclaim the high and liberal character of those great carpet manufacturers, one division, and that a small one, of whose works we have described.

MOSS AGATE, or MOCHA STONE. A variety of chalcedony enclosing dendritic or moss-like markings of an opaque brownish-yellow colour, which are produced by oxide of manganese or iron. It was the dendrachates of the ancients.

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 *pentadinæ* 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.

Imports of mother of pearl shells in 1857.

	cwts.	Value.
Holland	657	£2,385
France	476	1,970
Egypt	477	1,903
Philippine Islands	893	3,840
South Sea Islands	2,200	6,000
United States	450	780
New Grenada	20,442	18,103
Chili	1,025	2,450
British East Indies	3,029	6,058
Australia	4,319	14,195
Other parts	356	135
Total	34,324	57,819

	cwts.	£
Exports of mother of pearl shells	9,624	20,512

MOTHER-WATER is the name of the liquid which remains after all the salts that will regularly crystallise have been extracted, by evaporation and cooling, from any saline solution.

MOULDS, ELASTIC. Being much engaged in taking casts from anatomical preparations, Mr. Douglas Fox, surgeon, Derby, found great difficulty, principally with hard bodies, which, when undercut, or having considerable overlaps, did not admit of the removal of moulds of the ordinary kind, except with injury. These difficulties suggested to him the use of elastic moulds, which, giving way as they were withdrawn from complicated parts would return to their proper shape; and he ultimately succeeded in making such moulds of glue, which not only relieved him from all his difficulties, but were attended with great advantages, in consequence of the small number of pieces into which it was necessary to divide the mould.

The body to be moulded, previously oiled, must be secured one inch above the surface of a board, and then surrounded by a wall of clay, about an inch distant from its sides. The clay must also extend rather higher than the contained body: into this, warm melted glue, as thick as possible so that it will run, is to be poured, so as to completely cover the body to be moulded: the glue is to remain till cold, when it will have set into an elastic mass, just such as is required.

Having removed the clay, the glue is to be cut into as many pieces as may be necessary for its removal, either by a sharp-pointed knife, or by having placed threads in the requisite situations of the body to be moulded, which may be drawn away when the glue is set, so as to cut it out in any direction.

The portions of the glue mould having been removed from the original, are to be placed together and bound round by tape.

In some instances it is well to run small wooden pegs through the portions of glue, so as to keep them exactly in their proper positions. If the mould be of considerable size, it is better to let it be bound with moderate tightness upon a board to prevent it bending whilst in use; having done as above described, the plaster of Paris, as in common casting, is to be poured into the mould, and left to set.

In many instances wax may also be cast in glue, if it is not poured in whilst too hot; as the wax cools so rapidly when applied to the cold glue, that the sharpness of the impression is not injured.

Glue has been described as succeeding well where the elastic mould is alone applicable; but many modifications are admissible. When the moulds are not used soon after being made, treacle should be previously mixed with the glue (as employed by printers), to prevent it becoming hard.

The description thus given is with reference to moulding those bodies which cannot be so done by any other than an elastic mould; but glue moulds will be found greatly to facilitate casting in many departments, as a mould may be frequently taken by this method in two or three pieces, which would, on any other principle, require many.

MOUNTAIN LEATHER. Asbestus is so called when it is so interlaced that the fibrous structure is not apparent. It is sometimes called *Mountain Cork.* See ASBESTUS.

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.; *Schleimsaüre*, Germ.) is the same as the saclactic 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, METALLURGY.

MULBERRY TREE. One of the many varieties of the *Morus* is the yellow fustic, which is imported in considerable quantities from Rio de Janeiro.

MUNDIC is the name of iron or arsenical pyrites among Cornish miners.

MUNGO (sometimes also termed *Shoddy*) is the artificial wool formed by tearing to pieces, and completely disintegrating old woollen cloths or garments, or even pieces of new cloth, such as tailors' clippings. It varies much in value; at present, 1858, from 3*d.* to 9*d.*, or even 11*d.* per pound, the price of new wool being 1*s.* 4*d.* to 3*s.* per pound.

MUNJEET is a kind of madder grown in several parts of India.

MUNTZ'S METAL. A brass composed of 40 parts of zinc to 60 of copper. These proportions may be somewhat varied, but the above are commonly regarded as the most favourable for rolling into sheets. The metal being properly melted is cast into ingots, heated to a red heat, and rolled into sheathing, and worked into ships bolts at that heat. It will not work well at a lower heat. See BRASS.

MUREX. This genus, belonging to the Mollusca, contains many rare and beautiful shells, from which the celebrated Tyrian purple of the ancients was in all probability obtained.

MUREXANE. The purpuric acid of Prout. It is prepared by dissolving the purpurate of ammonia in potash by heat until the blue colour disappears, and saturating with *sulphuric acid.*

It crystallises in silky scales insoluble in water; its formula is C^6N^2,H^4O^5.

MUREXIDE. Syn. *Purpurate of Ammonia.* $C^{16}H^8N^6O^{12}$. Murexide is one of those substances which, although investigated by many chemists of great reputation, has long been regarded as of uncertain constitution. This is the more remarkable from the fact that, owing to its extreme beauty, it has always attracted a large amount of attention. It is invariably formed when the product of the action of moderately strong nitric acid on uric acid is treated with ammonia. This process, however, is rather valuable as a test of the presence of uric acid, than as a method of procuring murexide. Dr. Gregory, who has given much attention to the best methods of preparing the substance in question, has published the following formula for working on the small scale:—"Four grains of alloxantine and seven grains of hydrated alloxan are dissolved together in half an ounce by measure of water by boiling, and the hot solution is added to one-sixth of an ounce by measure of a saturated or nearly saturated solution of carbonate of ammonia, the latter being cold. This mixture has exactly the proper temperature for the formation of murexide; and it does not, owing to its small bulk, remain too long hot. It instantly becomes intensely purple, while carbonic acid is expelled; and as soon as it begins to cool the beautiful green and metallic looking crystals of murexide begin to appear. As soon as the liquid is cold, these may be collected, washed with a little cold water, and dried on filtering paper."

The analyses of murexide are rather discordant, the carbon in all of them being in excess. This arises from the very large amount of nitrogen present, a certain portion becoming acidified passes into the potash apparatus, causing an undue increase in its weight. The following are the analyses as yet made:—

	Liebig and Wöhler.	Liebig.	Fritzsche.	Beilstein.	Calculation.
Carbon - -	34·08	34·40	34·93	34·18	C^{16} 33·80
Nitrogen -	32·90	31·80	30·80	30·35	N^6 29·58
Hydrogen -	3·00	3·00	2·83	3·11	H^8 2·82
Oxygen - -	30·02	30·80	31·44	32·36	O^{12} 33·80

There appears no doubt whatever that the formula $C^{16}N^{6}H^{8}O^{12}$ represents its true composition. Murexide is formed when uramile, murexane, or dialuramide, as it is sometimes called, is boiled with peroxide of mercury. Dr. Gregory regarded murexane as a separate substance, and as identical with purpuric acid: he also considered $C^{6}N^{2}H^{4}O^{5}$ as its probable formula. This appears from more recent researches to be incorrect, as murexane is doubtless the same substance as uramile, while purpuric acid, which is bibasic, is represented by the formula $C^{16}H^{5}N^{5}O^{12}$. The formulæ above given for murexide and uramile renders the reaction of peroxide of mercury with the latter easily intelligible; it is, in fact, a very simple case of oxidation, thus:—

$$\underbrace{2C^{8}N^{3}H^{5}O^{6}}_{\text{Uramile.}} + 2O = \underbrace{C^{16}N^{6}H^{8}O^{12}}_{\text{Murexide.}} + 2HO$$

The limits of this work preclude any further notice of the scientific relations of murexide, but it is necessary that we should consider it in its character as a dye stuff. It has been found that murexide forms a series of beautiful compounds with certain metallic oxides, more especially lead and mercury, and these compounds have been employed to a very large extent in the dyeing, and more especially printing, of cotton goods. It is plain that if uric acid were only obtainable from the urine of serpents or the sediments from the urine of mammalia, it could never be made use of in the arts. It happens, however, that the solid urine of birds contains it in large quantity, and since we have become acquainted with the vast deposits of guano existing in various parts of the globe, the manufacture of murexide has been carried out on a scale which would, a few years ago, have appeared impossible. We must, in order to be clear, divide the process into two parts, one being the preparation of uric acid from guano, the other the conversion of the acid into murexide.

Preparation of uric acid from guano.—In order to get rid, as much as possible, of the impurities contained in the guano, it is in the first place to be treated with muriatic acid, which will remove carbonate and oxalate of ammonia, carbonate and phosphate of lime, and ammonio-magnesian phosphate. The uric acid will also be liberated from the substances with which it may be in combination. The operation may be performed in a leaden vessel, heated with a leaden coil, through which steam passes. It is essential to success that the guano be added slowly, otherwise the violent effervescence, which is caused by the decomposition of the carbonates by the acid, would cause the liquid to escape from the vessel. The mixture of guano and muriatic acid is then to be heated for an hour, after which it may be run off into tubs, to be washed with water by decantation. The first washings contain a large quantity of ammonia in the state of sal ammoniac; it should be worked up in some way, in order to prevent the loss of so valuable a salt. As soon as the residue of the guano is sufficiently washed, it may be transferred to cloth filters and allowed to drain. The residue from the action of muriatic acid upon 200 lbs. of guano can now be treated by Braun's process for the extraction of the uric acid. It is to be placed in a copper boiler of sufficient capacity, and boiled for an hour with 8 pounds of caustic soda and 120 gallons of water. It must be constantly stirred. Two or three pounds of quicklime are now to be slaked, enough water is then to be added to make the whole into a thin paste, which is to be poured into the mixture of caustic soda and guano residue. After a quarter of an hour's boiling the fire is to be removed and the whole allowed to repose until clear. The bright liquid having been siphoned off from the residue, the latter is to be treated with 120 gallons more water and 6 pounds of soda; 2 pounds of slaked lime are also to be added in the same manner as in the first operation. The lime is for the purpose of removing extractive matter, and it has been found that it does not do to use it in any other manner than that described. If the soda and lime be allowed to react upon the guano residue at the same time, urate of lime is formed, which, owing to its comparative insolubility, causes much trouble in the subsequent operations.

The two alkaline fluids containing the urate of soda are to be precipitated while warm by a moderate excess of hydrochloric acid. The precipitated uric acid is then to be washed with water and dried.

Conversion of the uric acid into murexide by Braun's process.—In the first place, a very large bath of cold water must be provided, having a number of earthenware basins floating upon it. Into each of these basins $2\frac{1}{8}$ pounds of nitric acid are to be poured, the strength of the acid being 36° Beaumé. One pound and three quarters of the uric acid, prepared as above, is now to be added by very small quantities at a time. If the temperature rises above 90° F. the whole is to be allowed to cool before adding any more uric acid. If the water in the bath be so cold that the temperature falls so low as to stop the reaction, it may be set up again by adding warm water to the bath, or, more conveniently, by sending some steam into it for a short time. At first the uric acid need only be added to the nitric acid by sprinkling it on the surface, towards the end of the operation; when the nitric acid has become enfeebled, it is necessary to stir it in. The quantity of mixture contained in two basins is now to be placed in an enamelled iron pot on a sand bath. As the heat increases the fluid will boil up in the pot, and to prevent loss the vessel must be removed from the fire for a short time. The heating is to be repeated in this manner until the temperature rises to 248° F., and, after removing the pot to the coolest part of the sand bath, half a pound of liquid ammonia is to be stirred in quickly. In a few minutes the whole is converted into what is called in commerce by the name of *Murexide en pâte*. To convert this into the purer product known as *Murexide en poudre*, it is to be repeatedly stirred up with water and filtered, to remove the saline and extractive matters.

In dyeing cotton by means of murexide, it is necessary to use lead and mercury as mordants. Lauth's process consists in fixing oxide of lead upon the fibre by first immersing it in a bath of acetate of lead, and then in ammonia, or by a bath of oxide of lead and lime. The dye is then mixed with pernitrate or perchloride of mercury and a little acetate of soda, and the cotton goods are worked in it for a sufficient time.

For printing, the murexide is mixed with thickened nitrate of lead, and the cloth after printing is dried and subsequently passed through a bath, containing 100 litres of water, 1 kilogramme of corrosive sublimate, and 1 kilogramme of acetate of soda.

In Sagar and Schultz's patent process they pad the cotton goods in a solution of murexide with 6 pounds of nitrate of lead in 8 gallons of water, to which when cold 6 ounces of corrosive sublimate dissolved in 2 gallons of water are added. The goods are dried after dyeing in the above solution, and the colour is fixed by again padding in a solution of wheaten starch, gum, gum substitute, or any similar substance.

Silk may easily be dyed in a bath of murexide mixed with corrosive sublimate. Wool, after being well washed and rinsed, is to be dyed in a strong bath of murexide, and then dried. It is after this to be treated, at a temperature of 104° to 122° F., with a bath containing 60 grammes of corrosive sublimate, 75 grammes of acetate of soda, and 10 litres of water.—C. G. W.

MURIATES were, till the great chemical era of Sir H. Davy's researches upon chlorine, considered to be compounds of an undecompounded 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 bichloride of mercury*, see MERCURY; and *muriate of soda*, or *chloride of sodium*, see SALT; *muriate of tin*, see CALICO PRINTING and TIN.

MURIATIC ACID. See HYDROCHLORIC ACID.

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 Linnæus *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-grey 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 Kirgesian and Langorian steppes of the Altaï, on the river Irtish, extending eastwards as far as the river Yenesei and Lake Baikal; and generally of the mountains of Eastern Asia, between 30° 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.

Imports, 1857 :—Musk, 10,728 ounces.

MUSLIN is a fine cotton fabric, used for ladies' robes ; which is worn either white, dyed, or printed.

MUSLIN. *To render it and other fabrics non-inflammable.* This very important inquiry was committed by Professor Graham, at the desire of Her Majesty, to the care of Dr. Oppenheim and Mr. Frederick Versmann, from whose report the following important conclusions have been abstracted. After naming many salts found to be useless or nearly so, they proceed : — "With regard to sulphate of ammonia, the cheapest salt of ammonia, a solution containing 7 per cent. of the crystals, or 6·2 per cent. of anhydrous salt, is a perfect anti-flammable. In 1839, the Bavarian embassy at Paris caused M. Chevalier to make experiments before them with a mixture of borax and sulphate of ammonia, as recommended by Chevalier, in preference to the sulphate alone. He thought the sulphate would lose part of its ammonia, and thereby give rise to the action of sulphuric acid upon the fabric. This opinion seems to be confirmed by the fact that a solution of sulphate of ammonia gives off ammonia, as observed by Dr. R. A. Smith in his paper on substances which prevent fabrics from flaring ; but on the other hand, this may be easily counteracted by adding a little carbonate of ammonia, and besides, the solid salt remains perfectly undecomposed. The authors say that they now have kept for six months whole pieces of muslin prepared in various ways with this salt, some having been even ironed ; but cannot find that the texture was in the least degree weakened. Chevalier's mixture, on the contrary, became injurious to the fabric, not only at temperatures above 212°, but even at summer heat; and this can easily be explained, because he did not actually apply sulphate of ammonia and borax, but biborate of ammonia and sulphate of soda."

Another drawback of Chevalier's mixture is the roughness which it gives to the fabric, and which could only be overcome by calendering the pieces, while sulphate of ammonia by itself has not this effect.

The use of this salt must therefore be strongly recommended.

Of all the salts experimented upon, only four appear to be applicable for light fabrics.

These salts are the

1. Phosphate of ammonia.
2. The mixture of phosphate of ammonia and chloride of ammonium.
3. Sulphate of ammonia.
4. Tungstate of soda.

The sulphate of ammonia is by far the cheapest and the most efficacious salt, and it was therefore tried on a large scale. Whole pieces of muslin (eight to sixteen yards long) were finished, and then dipped into a solution containing 10 per cent. of the salt, and dried in the hydro-extractor. This was done with printed muslins, as well as with white ones, and none of the colour gave way, with the sole exception of madder purple, which became pale. But even this change might be avoided, if care be taken not to expose the piece while wet to a higher than ordinary temperature. Most of these experiments were made at the works of Mr. Crum and of Mr. Cochran. The pieces had a good finish, and some of them were afterwards submitted to Her Majesty for inspection, who was pleased to express her satisfaction.

Mr. Crum, who prepared some dresses with phosphate and some with sulphate of ammonia, arrives at the result, that, with the phosphate, the finish is chalky, and not transparent enough, whereas the finish with the sulphate is successful.

Other pieces, prepared with the sulphate, were exhibited in the Exhibition of Inventions of the Society of Arts, and at the Conversazione of the Pharmaceutical Society, in July last. During the space of six months none of the fabrics prepared with sulphate of ammonia have changed either in colour or in texture ; it may therefore be considered as an established fact that the sulphate of ammonia may be most advantageously applied in the finishing of muslins and similar highly inflammable fabrics.

The authors felt, however, the necessity of inquiring further into the effect which ironing would have upon fabrics thus prepared ; for all the above mentioned salts, being soluble in water, require to be renewed after the prepared fabrics have been washed.

Now, the sulphate of ammonia does not interfere with the ironing so much as other salts do, because a comparatively small portion is required : but still, the difficulty is unpleasant, and sometimes a prepared piece, after being ironed, showed brown spots

TABLE I.

Showing the smallest percentage of Salts required in Solution, for rendering Muslin Non-Inflammable; A, *of Crystallised;* B, *of Anhydrous Salts. Twelve square inches of the Muslin employed weighed* 33·4 *grains.*

Name of Salts.	A.	B.	Remarks.
Caustic soda	8	6·2	Injurious to the fabrics.
Carbonate of Soda	27	10	
Carbonate of potash	12·6	10	
Bicarbonate of soda	6	5·4	Not sufficiently efficacious; too volatile.
Borax	25	13·2	Destroys the fabrics above 212° Fahr.
Silicate of soda	- -	15·5	Injures the appearance of the fabrics.
Phosphate of soda	80	32	Not sufficiently efficacious.
Sulphate of soda	- -	- -	A concentrated 72 p. c. solution is insufficient.
Bisulphate of soda	20	18·5	Destroys the fabrics.
Sulphite of soda	25	10·3	
Tungstate of soda	20	16	*Recommended on account of its being the only salt not interfering with the ironing of the fabrics.*
Stannate of soda	20	15·9	Injurious.
Chloride of sodium	- -	- -	Concentrated solutions are insufficient.
Chloride of potassium	- -	- -	
Cyanide of potassium	- -	10	Poisonous.
Sesquicarbonate of ammonia			Not available.
Oxalate of ammonia	- -	- -	
Biborate of ammonia	5	3·6	Destroys the fabrics above 212°.
Phosphate of ammonia	- -	10	Efficient but expensive.
Phosp. of ammonia and soda	15	9·8	Expensive and scarcely sufficiently efficacious.
Sulphate of ammonia	7	6·2	*Very efficient, and recommended on account of its low price.*
Sulphite of ammonia	10	9	Deliquescent.
Chloride of ammonium	- -	25	Not sufficiently efficacious.
Iodide of ammonium	- -	5	Too expensive.
Bromide of ammonium	- -	5	
Urea	- -	40	
Thouret's mixture	- -	12	Efficient, but expensive.
Chloride of barium	- -	50	Not sufficiently efficacious.
Chloride of calcium	19·7	10	Deliquescent.
Sulphate of magnesia	50	24·3	Not sufficiently efficacious.
Sulphate of alumina	15	7·7	Destroys the fabric.
Potash — alum	33	18	Not efficacious enough, and destroys the fabric.
Ammonia — alum	25	13	
Sulphate of iron	54	28·8	Not sufficiently efficacious.
Sulphate of copper	18	10	Poisonous.
Sulphate of zinc	20	11·2	
Chloride of zinc	8	5·8	Deliquescent.
Protochloride of tin	5	4·6	Deliquescent.
Protochloride of tin and ammonium	5	4·7	Becomes yellow, when exposed to the air.
Pinksalt	- -	7	Injures the fabric.

like iron-moulds. On covering the iron with plates of zinc or brass, these spots did not appear; but the difficulty still existed, and a white precipitate covering the plate, showed evidently that it is the volatile nature of the salt which interferes with the process. An attempt to counteract this action of the salt, by adding wax and similar substances to the starch, remained also without any result.

For all laundry purposes, the tungstate of soda only can be recommended. This salt offers only one difficulty, viz., the formation of a bitungstate, of little solubility, which crystallises from the solution. To obtain a constant solution, this inconvenience must be surmounted; and it was found that not only phosphoric acid, in very small proportion, keeps the solution in its original state, but that a small percentage of phosphate of soda has the same effect.

The best way of preparing a solution of minimum strength is as follows:—A concentrated neutral solution of tungstate of soda is diluted with water to 28° Twaddle, and then mixed with 3 per cent. of phosphate of soda. This solution was found to keep and to answer well; it has been introduced into Her Majesty's laundry, where it is constantly being used.

The effects of the soluble salts having been thus compared, a few remarks are necessary respecting the means which may be adopted permanently to fix anti-flammable expedients, so that the substances prepared may be wetted without losing the property of being non-inflammable.

Relying upon the property of alumina as a mordant, we tried the combination of oxide of zinc and alumina, obtained by mixing solutions of oxide of zinc in ammonia and of alumina in caustic soda; but although this precipitate protects the fibre, it does not adhere to it when washed.

The oxychloride of antimony, obtained by precipitation from an acid solution of chloride of antimony by water mixed with only a little ammonia, is a good anti-flammable, and it withstands the action of water, but not that of soap and soda. It was not found that the solution of this and other salts in muriatic acid injured the texture of the fabric, as long as this was dried at an ordinary temperature.

The borate and phosphate of protoxide of tin act effectually, if precipitated in the fibre from concentrated solutions of these salts in muriatic acid by ammonia; they withstand the influence of washing, but give a yellow tinge to the fabrics.

The same remarks apply to arseniate of tin. The stannates of lime and zinc protect the fabric, but do not withstand the action of soap or soda.

The oxides of tin give a favourable result, inasmuch as they really can be permanently fixed; the yellow tinge, however, which they impart to the fabrics will always confine their application to coarse substances, such as canvass, sail-cloth, or ropes.

The canvass thus prepared must be dried and then washed, to remove the excess of precipitate. Salt-water does not remove the tin from the canvass.

A piece about forty yards in length has been prepared by order of the storekeeper-general of the Royal Navy; but it was found to have lost in strength, and increased in weight too much, to allow of its application.

These experiments, however, being the first successful attempts permanently to fix some anti-flammable agents, may have some interest, although they leave but little hope that the result of fixing anti-flammable expedients will ever be obtained without injuring the fabrics.

By determining the comparative value, and ascertaining the difficulties which have prevented, till now, the general use of protecting agents, the authors were led to exclude a number of salts hitherto proposed, and to advocate the adoption of sulphate of ammonia, and of tungstate of soda, in manufactories of light fabrics, and in laundries.

They hope, therefore, that the general introduction of these salts will soon greatly reduce danger and loss of life through fire.

Table II.

Showing the increase in weight of Muslin prepared with various anti-flammable expedients.

Muslin (not starched) prepared with a solution of	Increased in weight about
7 per cent. of sulphate of ammonia - - -	18 per cent.
10 per cent. of tungstate of soda - - -	27 per cent.
12 per cent. of Thouret's compound. - - -	24 per cent.

In the manufacturing process the weight increases at a somewhat higher rate; a piece of starched tarlatan, weighing about 8½ oz., took up about 2 oz. of sulphate of ammonia from a 10 per cent. solution.

Dr. Oppenheim and Mr. Versmann have received a certificate from Messrs. Cochran and Dewar, of the Kirkton Bleach Works, Neilston, who bear witness to the perfect success of the process for rendering muslins non-inflammable, by the application of sulphate of ammonia. They have finished many pieces of the finest muslins by this process, and the texture of the cloth is in no way injured; while neither colour nor the elasticity is materially changed.

The manager of the Queen's laundry expresses entire satisfaction with the action of the solution (namely, of tungstate of soda) for rendering light fabrics, such as curtains, muslin dresses, &c., non-inflammable. After having tested various salts and solutions intended for the purpose, this is the only one found to be neither injurious to the texture or colour, nor in any degree difficult of application in the washing process. The iron passes over the material quite smoothly, as if no solution had been employed. The solution increases the stiffness of the fabric, and its protecting power against fire is perfect. The writer says that many specimens have been submitted to her Majesty, who was highly pleased with them, and has commanded that the solution be used in the laundry for everything liable to danger from fire.

MUSSEL BAND. Thin shelly bands occurring in the coal measures are called by the miners mussel band, or mussel bind.

MUST is the sweet juice of the grape.

MUSTARD. (*Moutarde*, Fr. ; *Senf*, Germ.) The *Sinapis Nigra*, or common black mustard, is a plant which yields the well-known seed used as a condiment to food. Flour of mustard is prepared as follows. The seeds of black and white mustard are first crushed between rollers and then pounded in mortars. The pounded seeds are then sifted. The residue in the sieves is called *dressings*, and what passes through is the *impure flour of mustard*, which by a second sifting yields the pure flour. Common mustard is adulterated with wheat flour, and coloured with turmeric, being rendered hot by pod pepper. Mustard consists of: —

Myronic acid, an inodorous, non-volatile, bitter, non-crystallisable acid.

Myrosine, a substance in many respects analogous to vegetable albumen.

Sinapisine, white, brilliant, micaceous volatile crystals.

Oil of mustard.—Volatile oil of mustard is colourless or pale yellow, it has a penetrating odour and a most acrid burning taste. It is represented by the formula $C^8H^5NS^2$.

Fixed oil of mustard.—This constitutes 28 per cent. of the seeds. It has a faint odour of mustard and a mild oily taste.

M. Lenormand gives the following prescription for preparing mustard for the table. This is usually termed *French mustard.*

With 2 pounds of very fine flour of mustard, mix half an ounce of each of the following fresh plants ; parsley, chervil, celery, and taragon, 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 redhot 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. 97 cwts. of mixed mustard were *imported* in 1858.

MUSTARD OIL. See Oils.

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 sulphide (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 vaporised 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 pestle ; they have a very acrid and bitter taste, and a strong, not disagreeable, smell. Notwithstanding the early knowledge of, and acquaintances with the use of Myrrh, we have no accurate account of the tree which yields it, until the return of Ehrenberg from his travels with Heinfrich during 1820–25, in various parts of Africa and Asia. He brought with him a specimen of the tree, which had been described and figured by Neesvon Esenbeck under the name of *Balsamodendron myrrha.* The plant is first noticed by Alexander Humboldt in 1826.—*Pereira.*

Myrrh is of three qualities : —

The first quality, *Turkey myrrh*, occurs in pieces of irregular forms and of various sizes, consisting of tears, usually covered with a fine powder or dust.

The second quality, *East India myrrh*, is imported from the East Indies in chests. It consists of distinct tears or grains, which are rounded or irregular, and vary in size from that of a pin's head to a pepper corn.

The third quality is also *East India myrrh*, but it occurs in pieces of a dark colour, and whose average size is that of a walnut, Myrrh flows from the incisions of a tree which grows at Gison, on the borders of Arabia Felix. The tree figured by Humboldt is considered by Lindley as identical with the Amyris Kataf of Forskäl. It consists of resin and gum in proportions stated by Pelletier at 31 of the former and 66 of the latter; but by Braconot, at 23 and 77. It is used only in medicine.

Imports of Myrrh:—1857, 202 cwts.; 1858, 364 cwts.

N.

NACARAT is a term derived from the Spanish word *nacar*, which signifies mother of pearl; and is applied to a pale red colour, with an orange cast. The *nacarat* 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.

NACREOUS. (*Nacre*, Fr.) A term applied to shells and minerals which have a pearly or iridescent lustre.

NAILS, MANUFACTURE OF. (*Clou*, 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 the Americans 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, "some men, then unknown, and then in obscurity, began by cutting slices out of old hoops, and, by a common vice griping 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.*

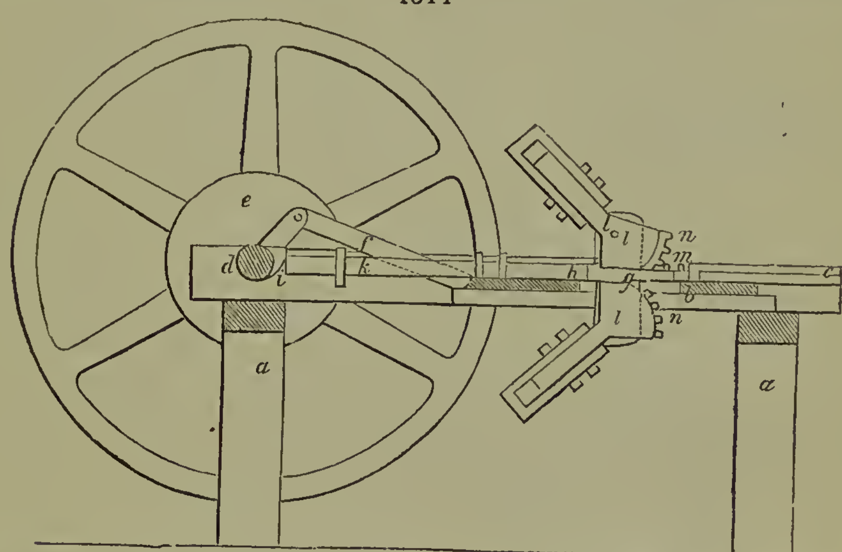
Since the year 1820, numerous patents have been taken out in this country for the manufacture of nails by machinery. A few only of these can be noticed.

The first nail apparatus to which we shall advert, is due to Dr. Church; it was patented by 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. 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 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.* 1314. A strong iron frame-work, of which one side is shown at *a 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.

1314



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 red-hot, 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 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.

Dr. William Church, February, 1832, obtained a patent 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. The machinery consists of laminating rollers, and compressing dies.

The method of forming the rods from which 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, patented an improved apparatus for making square-pointed, and also flat-pointed nails. His invention consisted of 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, as the rolling machinery is. He finishes the points by rollers.

William Southwood Stocker introduced a machine apparently of American parentage, — as it has the same set of features as the old American mechanisms of Perkins, at the Britannia Nail Works, Birmingham, and all the other American machines 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 intended, 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 outwards, 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 red-hot 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 red-hot iron rod, gradually advanced by the hands of the workmen, 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.

NANKIN is a peculiarly coloured cotton cloth, originally manufactured in the above named ancient 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* the 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° Beaumé. 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 a 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 (10½ 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. See Bablah.

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. By the term naphtha, we understand the inflammable fluids produced during the destructive distillation of organic substances. Formerly the term was confined to the fluid hydrocarbons, which issue from the earth in certain parts of the world, and appear to be produced by the action of a moderate heat on coals or bitumens. The term has now, however, become so extended as to include most inflammable fluids (except perhaps turpentine) obtained by distillation from organic matters. We shall study the various naphthas under the following heads : —

Naphtha (Boghead or Bathgate).	Naphtha (Coal).
„ (Bone or Bone Oil).	„ (Native).
„ (Caoutchouc or Caoutchoucine.)	„ (Shale).
	„ (Wood).

For the methods of preparing and purifying naphthas in general, see NAPHTHA, COAL ; also PHOTOGEN. — C. G. W.

NAPHTHA, BOGHEAD or BATHGATE. *Syn.* Photogen, Paraffine Oil. For several years a naphtha has existed in commerce under the above name. It is now prepared on an immense scale in various parts of the Old and New World. It was, we believe, at first procured solely by the distillation, at as low a temperature as possible, of the Torbanehill mineral or Boghead coal, but now it has been ascertained that any cannel coal, or even bituminous shale, if subjected to the same treatment, will yield identical products.

Photogen may be recognised at once by its low specific gravity, the ordinary kinds (boiling between 290° and 480°) having a density of about 0·750; whereas coal naphtha cannot be brought by any number of rectifications below 0·850.

The less volatile portions of the first runnings of photogen, contain a considerable quantity of paraffine, so much so indeed, that the oil is extensively used, under the name of paraffine oil, for lubricating machinery. A mixture of the more and less volatile portions is employed for burning.

Preparation of crude paraffine oil.

The following is an outline of the process employed by Mr. James Young. The best coals for the purpose are Parrot, cannel, and gas coals, and especially the Boghead coal. It is well known that the latter yields a very large quantity of ash or earthy residuum, when burned in an open fire or distilled : this does not, however, interfere in the least with its value as a source of photogen. It is convenient, previous to placing the coals in the still, to break them into fragments of the size of hen's eggs, this operation enabling the heat to penetrate more readily throughout the mass. The apparatus for distillation merely consists of an ordinary gas retort, from the upper side of which a conduction pipe passes to the condensing arrangement. The latter must be moderately capacious, and not kept cooler than 55° Fahr. The reason of this is, that if too small or too cool, the paraffine is liable to accumulate and choke up the exit pipe. When the retort has been closed in the ordinary manner, it is to be heated to a low red, but not higher, until no more volatile products distil over. If the heat rises above the temperature indicated, a considerable loss is incurred, owing to formation of too large a quantity of olefiant and other gases. The retort must be allowed to cool down considerably before the insertion of a fresh charge, otherwise much is lost before the joints are made tight.

Mr. Young states that instead of driving over the whole of the fluid by distillation in the manner described, a portion may be conveyed at once from the still by having an opening in its lower part communicating with a pipe passing to some convenient recipient. By this arrangement, the products from the coal are removed from the still the moment they have assumed the liquid form. It is preferable, however, in almost all cases, to distil the hydrocarbons over in the manner first mentioned.

The product of the operation conducted as above is crude paraffine oil. It will sometimes begin to deposit paraffine when the temperature has only fallen to 40°. During distillation a certain quantity of gas is necessarily produced, but it is essential to economical working that the amount should be as small as possible. To effect this, care must be taken not only to use as low a temperature as is consistent with the distillation of the oil, but also to apply the heat gradually and steadily. See PHOTOGEN.

Purification of the crude paraffine oil for lubricating purposes.

The oil is run into a tank and heated by a steam pipe to about 150° F. This causes the water and mechanically suspended impurities to separate. The fluid should be permitted to repose for about twelve hours before being run off. The impurities and water (owing to their being specifically heavier than the paraffine oil), remain at the bottom of the settling tank.

The crude oil, after separation of the mechanically suspended impurities, is then to be distilled in an iron still attached to a condenser, kept at a temperature of 55°, with the precautions to prevent choking up which were previously described. The distillation is conducted by the naked fire, until no more can be driven over. The dry coke-like mass which remains in the still is to be removed before making a fresh distillation.

To each 100 gallons of this distillate, 10 gallons of commercial oil of vitriol are to be added, and the mixture is to be well mixed for about one hour. The apparatus best adapted for this admixture is described in the article NAPHTHA (COAL). After the thorough incorporation of the oil and acid, the whole is to be allowed to rest for about 12 hours, to enable the acid "sludge" to sink to the bottom of the vessel. The fluid is then to be run off into another vessel (preferably of iron); and, to each 100 gallons, 4 gallons of caustic soda, of the specific gravity 1·300, is to be added. The soda and oil are then to be well incorporated by agitation for an hour, so as to thoroughly neutralise any acid which has not settled out, and also to remove certain impurities which are capable of combining with it.

The oil so purified, is a mixture of various fluid hydrocarbons, to be presently described, holding in solution a considerable quantity of paraffine. The more volatile hydrocarbons may be removed by the following process : —

The purified paraffine oil is to be placed in an iron still, connected with a condensing arrangement. The still is then to have run into it a quantity of water, about equal to half the bulk of the oil, and this distillation is to be continued for 12 hours. It is obvious that a great portion of the water would distil over, if not replaced during the progress of the distillation. It is preferable to perform the distillation by means of direct steam. A volatile clear fluid will distil over with the water. The naphtha so procured is lighter than water, and soon separates from it. It contains little or no paraffine. The oil remaining in the still is, of course, richer in paraffine by the amount of naphtha removed, and the separation of the solid hydrocarbon is facilitated greatly by the process. The naphtha which distils over with the water in the above process, is the fluid, the chemical nature of which is fully described in this article. A very volatile spirit may be extracted from it, by rectifying it in the apparatus recommended for benzole in the article NAPHTHA, COAL.

The further purification of the paraffine oil is managed as follows : — After separation from the water it is run off into a leaden vessel, and 2 gallons of sulphuric acid added for each 100 gallons of oil. The mixture is to be well incorporated for 6 or 8 hours, after which it is allowed to remain quiet for 24 hours, in order that the acid and any combined impurities may settle to the bottom of the tank. The oil is then to be carefully run off into another tank, and to each 100 gallons 28 lbs. of chalk ground with water to a thin paste are to be added. The whole is to be mixed together until every trace of sulphurous acid is removed, and is then kept at about 100° for a week, to permit impurities to settle. The oil thus prepared is fit for lubricating purposes, either *per se* or mixed with an animal or vegetable oil.

Young's process for separating paraffine from paraffine oil.

Mr. James Young extracts paraffine from the oil prepared as above by cooling it to 30° or 40° Fahr. The lower the temperature, the larger the amount which crystallises out. It may be obtained sufficiently pure for lubricating purposes by merely filtering off and squeezing out fluid impurities from the mass by powerful pressure.

The paraffine may be purified further by alternate treatments at about 150° Fahr. with oil of vitriol and caustic soda. The treatments with acid are to be continued until the latter produces no more blackening. The solid hydrocarbon is then to be washed with caustic soda until all acid is removed, and then with boiling water. The treatment with boiling water should be performed several times.

The oil from which the paraffine has been removed by exposure to cold is by no means freed from the whole of the solid; it is, in fact, a saturated solution of paraffine at the temperature to which it was exposed. It is sometimes advantageous, before extraction by cold, to concentrate the paraffine in the paraffine oil, by subjecting the latter to distillation, until one half or two-thirds of the fluid has distilled over; by this means the yield of paraffine is proportionately increased.

The amount of solid matter distilling over with naphthas may be seen by consulting the results obtained by MM. Warren de la Rue and Hugo Müller, in their fractional distillation of Rangoon tar. See NAPHTHA (NATIVE). It is to be observed that solid hydrocarbons differ in the degree to which they pass over with the vapour of fluid hydrocarbons. Thus while pyrène and chrysène only appear among the very last products of the distillation of coal at high temperature, naphthaline will often distil over at very moderate temperatures in presence of volatile fluid hydrocarbons. The author of this article has repeatedly seen considerable quantities distil over in a current of steam at the pressure of the atmosphere, and consequently at 212°. The facility with which solid hydrocarbons pass over in the vapour of volatile fluids, depends not only upon their boiling points, but also to some extent upon special tendencies varying with the nature and state of admixture or combination of the substances operated on.

On the chemical nature of the fluid hydrocarbons constituting Boghead naphtha.

It has been said, in the above condensed account of the process for preparing paraffine oil from coal, that when the crude oil is rectified with water, a clear transparent naphtha is obtained. This fluid, as found in commerce, is by no means of constant quality. By quality, we mean the power of distilling between given limits of temperature. Some kinds are of about the same degree of volatility as commercial benzole, while others distil at nearly the same temperatures as common coal naphtha. The hydrometer is not a safe guide in choosing this naphtha; this arises from the fact that photogens, of very different degrees of volatility, have almost the same densities. The safest plan is to put the fluid into a retort, having a thermometer in the tubulature, and distil the contents almost to dryness. The careful observation of the range of the mercurial column during the operation is the best mode of ascertaining the quality of the fluid.

The more volatile portions which distil over with water, are free from solid bodies, and consist of a mixture of fluids belonging to three series of homologous hydrocarbons, namely,

The benzole series;

The olefiant gas or C^nH^n series; and

The radicals of the alcohols.

As no works on chemistry contain any directions for the proximate separation of complex mixtures of hydrocarbons, the following description of the method adopted by the author of this article for the separation of the substances contained in Boghead naphtha may be useful. It is necessary, in the first place, to determine whether each substance is to be obtained in a state of absolute purity, or whether it is merely desired to obtain the various series distinct from each other. In the process given, it will be supposed that the individual hydrocarbons are required in a state of purity, because it is easy for the operator to leave out any part of the method which may be unnecessary under the particular circumstances of the case. The first step is to obtain constant boiling points, for it must be remembered that if, when any organic fluid is subjected to distillation with a thermometer in the tubulature of the retort or still, the mercury continues to rise as the fluid comes over, it is at once demonstrated that the substance distilling is not homogeneous. In order to obtain the fluids of constant boiling point, it is essential to subject them to a complete series of fractional distillations. This is an operation involving great labour, so much so, that in investigating Boghead naphtha, upwards of one thousand distillations were made before tolerably constant boiling points were secured. In order to perform the operation successfully, two series of bottles are required, one for the series being *distilled*, and the other for the series *distilling*. As many bottles are necessary as there are 10 degree fractions to be obtained. Thus, supposing the fluid, when first distilled, came over between 100° and 200°, and it has been determined to obtain 10 degree fractions, the receiver is to be changed for every 10° that the mercury rises. Thus 10 bottles will be required for the fractions distilling, and the same number for the fractions being distilled into. The operation will be commenced by putting the original fluid (dried carefully with chloride of calcium or sticks of potash) into a retort capable of holding, at least, half as much more fluid as the quantity inserted. Through the tubulature passes a pierced cork, supporting a thermometer, the lower end of which should not dip into the fluid. To the neck of the retort is adapted a good condensing arrangement, so placed that the bottles can be placed beneath the exit pipe. All the bottles having blank paper labels attached, the distillation is to be commenced. The first signs of distillation are to be watched for, but no fluid is to be separately received as an individual fraction until boiling has commenced. As soon as it is found that the mercury indicates 10° more than the temperature at which the distillation commenced, the bottle is to be changed, and so on at every 10°. When the whole fluid is distilled away, a smaller retort is to be taken, capable of well holding each 10° fraction, without fear of anything boiling over. Suppose the first fraction of the first distillation came over between 100° and 110°, it is to be placed in the retort, and the distillation carried on as before. But it will, in almost every instance, be found that the boiling point will have been reduced 30° or 40° by the removal of the fluids of higher boiling point. Under any circumstances, however, the distillate is to be received in bottles, and labelled with the boiling point and the number of the rectification. When all the first 10° fraction has distilled away into the second series of bottles, the next is to be operated on, and so on. By this means only two series of bottles are ever being used at once, viz. the series being distilled, and the series being distilled *into*. Many fluids may be obtained of steady boiling point by 15 or 16 rectifications, involving, in the case of 10 fractions in each series, at least 150 distillations. But most complex organic fluids, such as naphthas, have a much wider range of boiling point than 100°. Boghead naphtha, for example, commences at about 289° F., and rises above 500°. But in the second distillation, the first fraction, instead of distilling at 289°, came over at 250°, the depression of boiling point being nearly 40°. By proceeding in this manner six times, a fraction was obtained boiling at 210°. When a 10° fraction no longer splits up during distillation, that is to say, when it comes over almost between the same points at which it last distilled, it will be proper to commence the separation of the various substances present in each fraction. Before doing this, it is often advisable to make a few preliminary experiments, with the view of ascertaining the nature of the fluids present. The more volatile portions may be tested for benzole by converting them into aniline in the method given in the article BENZOLE. The simplest way of detecting the C^nH^n series (homologous with olefiant gas; see HOMOLOGOUS), will be by ascertaining whether the naphtha is capable of decolourising weak bromine water. Supposing the presence of these to have been demonstrated, the complete separation of the hydrocarbons may be effected as follows:— Four or five ounces of bromine are to be placed in a large flask, capable of being closed with a well fitting stopper. About 8 volumes of water are then added, and the naphtha of the most volatile fraction is to be poured in by very small portions, the contents of the flask being well shaken after each addition.

By this mode of proceeding the dark colour of the bromine will gradually fade and finally disappear. In order to insure a complete reaction it is better at this stage to add a little more bromine, until the colour is permanent after shaking. A little mercury is now to be poured in, and agitated with the fluids in the flask, to remove all excess of bromine. The oily bromine compound is now to be separated, by means of a tap funnel, from the mercury and water, and digested with chloride of calcium until every trace of water is removed. The dry brominated oil is now to be distilled, when the radical and benzole series of hydrocarbons will distil away, leaving the brominated oil, which may then be distilled into a vessel by itself. The next step will be to separate the radicals from the benzole series. For this purpose long-necked assay flasks are necessary. Into one of these vessels, of 3 or 4 ounces capacity, 2 drachms of nitric acid should be poured; 1 drachm of the naphtha is then to be added by very small portions, the flask being kept cool by immersion in cold water. It is essential during the whole time to keep the flask in active motion, in order to bring the hydrocarbon and acid into close contact, and also to cool the contents. If this last precaution be neglected a violent reaction will occur and cause the loss of the greater portion of the fluid. When the whole of the drachm of acid has been added, and it is found that the temperature no longer rises on removing the flask from the cold water, the product is to be poured into a narrow and conical glass, and allowed to repose until the hydrocarbon, unacted on, rises to the surface in the form of a transparent brilliant green fluid. The fluid below is then to be removed by means of a pipette, furnished at the upper end with a hollow elastic ball of vulcanised caoutchouc. By this means suction with the lips becomes unnecessary, and the vapours of hyponitric acid are prevented from irritating the lungs. The indifferent hydrocarbon—that is, the fluid unacted on by the acid—is as yet by no means pure; it obstinately retains traces of the benzole and C^nH^n series. It is, therefore, to be transferred to a flask furnished with a well fitting stopper, and treated with nitric acid (spec. grav. 1·5) a considerable number of times. This second treatment may, without danger of any explosive reaction, be made upon one or two ounces of the partially purified hydrocarbon. When it is found that the separated nitric acid no longer produces milkiness on being thrown into water, it may be assumed that the benzole and C^nH^n class of hydrocarbons are entirely removed. When the treatment with acid has been repeated a sufficient number of times, the fluid is to be placed in a clean flask and well agitated with a solution of caustic potash, which will remove the nitrous vapours which are the cause of the green colour. The purified hydrocarbon is then to be separated by a tap funnel from the water, and dried by digestion with sticks of caustic potash. If it be desired to obtain the radical in a state of absolute purity, it must be distilled three or four times over metallic sodium.

The indifferent hydrocarbons obtained by the above process are colourless mobile fluids, having an odour somewhat resembling the flowers of the white thorn. They are very volatile, even at low temperatures, and have an average density of about 0·716. When the fractions with proper boiling points have been selected, it will be found that they correspond in specific gravity, percentage composition, and vapour density with the radicals of the alcohols, as will appear by the following table, where the experimental results obtained by the author of this article in his examination of Boghead naphtha, are compared with the numbers found by other observers with the radicals obtained by treatment of the hydriodic ethers by sodium, and also by the electrolysis of the fatty acids.

Comparative Table of the Physical Properties of the Alcohol Radicals, as obtained from Boghead Naphtha, with those procured from other sources.

Radicals.	Formulæ.	Boiling Points, Fahr.				
		Frankland.	Kolbe.	Wurtz.	Brazier and Gosslett.	C. G. Williams
Propyle	$C^{12}H^{14}$	-	-	-	-	154·4°
Butyle	$C^{16}H^{18}$	-	226·4°	222·8°	-	246·2
Amyle	$C^{20}H^{22}$	311°	-	316·4	-	318·2
Caproyle	$C^{24}H^{26}$	-	-	395·6	395·6°	395·6

Radicals.	Formulæ.	Densities.				Vapour Densities.				
		Frankland.	Kolbe at 64·4°.	Wurtz, at 32°.	C. G. Williams at 64·4°.	Frankland at 51·8°.	Kolbe.	Wurtz.	C. G. Williams.	Theory.
Propyle	$C^{12}H^{14}$	-	-	-	0·6745	-	-	-	2·96	2·97
Butyle	$C^{16}H^{18}$	-	0 6940	0·7057	0·6945	-	4·053	4·070	3·88	3·94
Amyle	$C^{20}H^{22}$	4·899	-	0·7413	0·7365	0·7704	-	4·956	4·93	4·91
Caproyle	$C^{24}H^{26}$	-	-	0·7574	0·7568	-	-	5·983	5·83	5·87

It has been said that the above hydrocarbons distilled away from the bromine compound in company with others which were removed by treatment with nitric acid. It was subsequently found that the products formed by the action of the acid were nitro-compounds belonging to the benzole series. The bromine compound contains the C^nH^n series of hydrocarbons, the individual members being determined by the boiling point of the fraction selected for experiment. If we select that portion boiling steadily between 160° and 170°, we shall have a bromine compound of the formula $C^{12}H^{12}Br^2$; but if the boiling point of the naphtha lies between 180° and 190°, the bromine compound will be $C^{14}H^{14}Br^2$. It is exceedingly remarkable that if either of these substances be treated alternately with alcoholic potash and sodium, the original hydrocarbon is regenerated. By the mode of operating indicated above it is possible, therefore, to obtain two out of the three series of hydrocarbons in a pure state. The third, namely the benzole series, must be recognised by obtaining products of decomposition.

The acids and bases accompanying the hydrocarbons in Boghead naphtha have not yet been fully investigated; it has, however, been ascertained that certain members of the phenole series of acids and pyridine class of bases are always present. The quantities present in the naphtha of commerce are small in consequence of the purification of the fluid by the agency of oil of vitriol, followed by a treatment with caustic soda.—C. G. W.

NAPHTHA, BONE. *Syn.* Bone Oil; Dippel's Animal Oil. This fluid is procured in large quantities during the operation of distilling bones for the preparation of animal charcoal. The hydrocarbons of bone oil have not as yet been examined, but it has been found that the benzole series are present, accompanied by large quantities of basic oils. The acid portions are also uninvestigated. The bases have been very fully studied by Dr. Anderson, who discovered in bone oil the presence of no less than ten bases, several of them being quite new.

The odour of bone oil is exceedingly offensive and difficult of removal. It does not arise entirely from the presence of the powerfully smelling bases, for even after repeated treatment with concentrated acids it retains its repulsiveness. This is partly owing to the presence of some unknown neutral nitrogenous bodies. When a slip of deal wood is moistened with hydrochloric acid and held over a vessel of crude bone oil, it rapidly acquires a deep crimson tint. This is in consequence of the presence of the extraordinary basic substance pyrrol. The latter, when in a crude state, possesses a most disgusting smell, so much so, that the offensiveness of bone oil was at one time mainly attributed to its presence. It has, however, been recently discovered that pyrrol when perfectly pure has a most fragrant and delightful perfume, somewhat recalling that of chloroform, but still more pleasing.

The basic portion of bone oil may be extracted by shaking it up with moderately strong oil of vitriol. This must be done with precaution, as large quantities of gases are evolved, consisting of carbonic acid, hydrosulphuric and hydrocyanic acids. The fluid when permitted to repose separates into two layers, the upper being the purified oil, and the lower the acid solution of the bases. The latter being separated is to be distilled until about one third has passed over. This distillate will contain the chief portion of the pyrrol. The head of the still is then to be removed and the fluid boiled for some time to remove the last trace. The acid solution, after filtration through charcoal, is to be supersaturated with lime and distilled. The distillate contains the whole of the bases. The apparatus should be so arranged that those bases which are excessively volatile, and consequently come over as gases, may be received in hydrochloric acid. The hydrochloric solution and the oily bases are to be examined separately. The former is to be evaporated carefully to the crystallising point and then allowed to cool. By this means the ammonia may be removed by crystallisation as chloride of ammonium.

When no more sal-ammoniac can be obtained by crystallisation, the mother liquid is to be treated with potash, in an apparatus so arranged that any gaseous products evolved may be collected in hydrochloric acid. The retort must have a thermometer in the tubulature to enable the temperature to be properly regulated. All the bases distilling below 212°, are to be received in hydrochloric acid, and their presence demonstrated by converting them into platinum salts, and fractionally crystallising. The bases distilling above 212°, are to be separated by fractional distillation. An examination of the hydrochloric solution will, according to Dr. Anderson, demonstrate the presence of methylamine, ethylamine, propylamine, butylamine, and amylamine. The following table contains the names and physical properties of the bases which are contained in that portion of the basic oil which distils above 212°. The amylamine, and even the propylamine, can be separated from the basic oils by fractional distillation, instead of the fractional crystallisation of platinum salts, but the latter involves less labour.

Table of the Physical Properties of the Pyridine Series of Bases.

Base.	Formula.	Boiling Point.	Density at 32°.	Vapour Density.	
				Experiment.	Calculation.
Pyridine - -	$C^{10}H^5N$	242°	0·9858	2·916	2·734
Picoline - -	$C^{12}H^7N$	275°	0·9613	3·290	3·214
Lutidine - -	$C^{14}H^7N$	310°	0 9467	3·839	3·699
Collidine - -	$C^{16}H^{11}N$	356°	0·9439	- - -	4·137

Bone oil will not become very valuable as a naphtha for general purposes until some cheap method of removing its odour has been discovered. The *Oleum animale dipellii*, of the older chemists and pharmaceutists was prepared by distilling bones; it was very similar in properties to bone oil.— C. G. W.

NAPHTHA FROM CAOUTCHOUC. *Syn.* Caoutchoucine; Caoutchine. Caoutchouc, by destructive distillation, yields several hydrocarbons, the accounts of which are contradictory. By repeated rectifications they may be separated into fluids of steady boiling points. The late Dr. Gregory succeeded in obtaining a fluid hydrocarbon from caoutchouc which distilled at 96°, but when treated with sulphuric acid, and the fluid separated by means of water, another hydrocarbon was obtained boiling at 428°. It is most probable, however, that the true composition of caoutchoucine has not yet been made out. This will appear by consulting the analyses yet made, many of them indicating too low a hydrogen for the C^nH^n series, and more nearly approximating to n (C^5H^4). The author of this article is engaged in a new examination of these hydrocarbons. It is quite plain, however, that caoutchine is, in every sense of the term, a naphtha. Caoutchine is one of the best solvents known for india-rubber.— C. G. W.

NAPHTHA, COAL. Ordinary coal naphtha is procured by the distillation of coal tar. The latter is placed in large iron stills, holding from 800 to 1500 gallons, and distilled by direct steam. As soon as the specific gravity of the distillate rises to

0·910, the naphtha is pumped into another still, and distilled with direct steam until the distillate again becomes of the density 0·910. It then constitutes what is termed "rough naphtha."

The residue obtained in the first distillation is run off into cisterns or tar ponds to allow of the removal of the water. This residue is called boiled tar. Pitch oil may be obtained from it by distillation with the naked fire, every 1000 gallons will yield about 320 gallons of pitch oil. The residue of pitch in the still is run out while in a melted state. The rough coal naphtha contains a great number of impurities of various kinds; the principal cause of the foul odour being the organic bases described in the article NAPHTHA, BONE. To remove these the naphtha is transferred to large cylindrical vessels lined with lead. These vessels contain a vertical axis passing down them, supporting blades of wood covered with lead, and pierced with holes. The axis or shaft has, at its upper end, a crank to enable it to be rotated. The naphtha having been run into the vessel, sulphuric acid is added, and the shaft with its blades made to revolve. By this means the naphtha and acid are brought into intimate contact. The whole is then allowed to settle, and the vitriol which has absorbed most of the impurities, and acquired, in consequence, a thick tarry consistence, is run off. This acid treacly matter is known in the works as "sludge." The naphtha floating above the sludge is then treated a second time with acid, if the naphtha be required of good quality. During the proeess, the naphtha acquires a sharp smell of sulphurous acid, and retains a certain amount of sulphuric acid in solution. The next process is to treat it with solution of caustic soda to remove these impurities. This may be effected in an apparatus similar to the first. The naphtha, after removal of the caustic liquor, is next run off into a still, and rectified; it then forms the coal naphtha of commerce. The ordinary naphtha of commerce is often very impure, owing to insufficient treatment with oil of vitriol. The author of this article has obtained from one gallon of commercial naphtha, as much as one and a half ounces of the intensely odorous picoline, mixed with certain quantities of other bases of the same series, and also traces of aniline.

In describing eoal naphtha, we shall not confine ourselves to the description of those substances whieh come over in distillation between any given temperature, but shall take a cursory review of the nature and properties of most of the substances produced by the distillation of coal tar. It will be unnecessary here to enter into a minute description of the acids existing in coal tar, inasmuch as they have already been treated of in the article CARBOLIC ACID.

On the basic constituents of coal naphtha.— Coal tar is particularly rich in bases. They are found accompanying all the fluid naphthas and oils, and probably eannot be separated, by distillation alone, from any of the hydroearbons of coal naphtha except benzole. It is highly remarkable that while coal tar yields all the pyridine series of bases found in bone oil, no traces of the alcohol series have yet been discovered. At the time that the author of this article commenced his experiments on the coal naphtha bases, there were only three known to be present, namely, aniline, chinoline, and picoline. The two former were discovered in coal tar by Rungé, who called them kyanol and leukol. Picoline was discovered by Dr. Anderson of Glasgow. The discovery was, at the time, of great value, it being the first instance on record of isomerism among volatile bases. The number of isomeric bases now known is very great, and fresh instances are becoming known every day. The following are the bases known to be present in coal tar, with their formulæ. They will be found mentioned under their names in this work. The physical properties of the pyridine series are given under NAPHTHA, BONE.

Pyridine	$C^{10}H^5N$	Chinoline	$C^{18}H^7N$
Picoline	$C^{12}H^7N$	Lepidine	$C^{20}H^9N$
Lutidine	$C^{14}H^9N$	Cryptidine	$C^{22}H^{11}N$
Collidine	$C^{16}H^{11}N$	Aniline	$C^{12}H^7N$
Pyrrol	C^8H^5N.		

On the hydrocarbons of coal naphtha.— The following are the principal constituents of those coal naphthas the boiling points of which range between 190° and 350°.

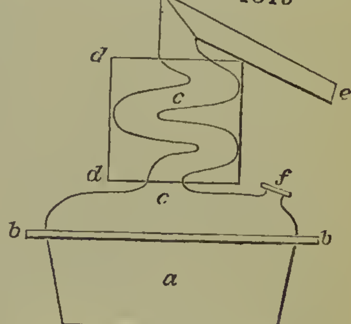
Base.	Formula.	Boiling Point.	Specific Gravity.
Benzole	$C^{12}H^6$	177°	0·850 at 60°
Toluole	$C^{10}H^8$	230°	0·870
Xylole	$C^{10}H^{10}$	259°	
Cumole	$C^{18}H^{12}$	304°	
Cymole	$C^{20}H^{11}$	347°	0·861 „ 57°

The fluid hydrocarbons boiling above this point have not been well studied. Ordinary coal naphtha, in addition to the above hydrocarbons, contains traces of the homologues of olefiant gas, alluded to in the article NAPHTHA, BOGHEAD.

All the above mentioned hydrocarbons may be separated from each other by careful and sufficiently numerous fractional distillations. It is proper before considering them as pure, to shake them up several times with oil of vitriol, and, after well washing first with water, and afterwards with an alkaline solution, to dry them very carefully with chloride of calcium or sticks of potash. It will be observed that in the above table the specific gravities of the hydrocarbons are not in harmony: this arises from the fluids upon which the experiments were made not having all been procured from the same source; for it has been found that the same bodies, as procured from different sources, often present small but appreciable differences in odour, density, boiling point, and other physical properties.

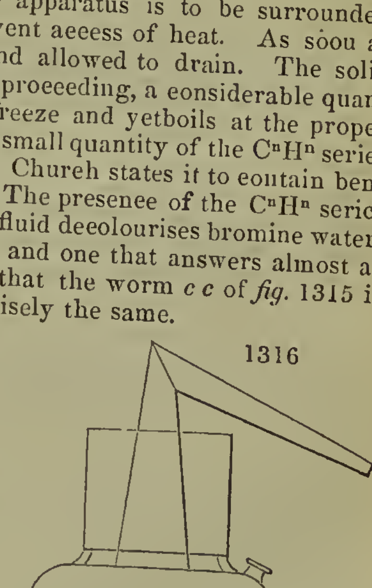
The benzole of coal naphtha may almost entirely be separated by distilling in an apparatus first devised for the purpose by Mr. C. B. Mansfield. The annexed figures from my "Handbook of Chemical Manipulation," illustrate the vessels I am in the habit of employing for the purpose. *Fig.* 1315 consists of a copper or tinned iron still, *a*, holding about two gallons. The flange, *b b*, is merely to support the apparatus in the ring of a gas or charcoal furnace, preferably the former. A wide worm, *c c*, passes through the top of the still into a water-tight cistern, *d d*. The worm ends in a discharge pipe, *e*. The latter is to be attached to a common worm tub containing cold water. The crude benzole, or coal naphtha, is to be placed by means of the opening *f* into the still, and all the joints of the apparatus being closed, and effectual condensation insured, the fire is to be lit. The naphtha soon begins to boil, but nothing comes over, because the water in *d d* effects condensation. In a short time, however, the water in *d d* begins to get warm, and, as soon as 177° is reached, benzole begins to come over, and is perfectly condensed in a second worm, kept cold by means of water. It is plain that as the fluids of higher boiling points begin to come over, the water in *d d* will boil, but distillation then ceases entirely. The reason of this is, that nothing can make the head *c c* hotter than 212°, because of its being surrounded with water. All hydrocarbons that are not volatile at 212° are consequently condensed there, and fall back into *a*. The benzole distilling over is quite pure enough for all ordinary purposes. It may, if required very pure, be rectified a second time in the same apparatus, taking care that the head does not get hotter than 180° or 190°. If the benzole is wanted absolutely free from its accompanying hydrocarbons, it must be purified by freezing. For this purpose the rectified benzole is to be placed in a thin glass or metal vessel, and surrounded with snow or pounded ice mixed with salt. The whole apparatus is to be surrounded with sawdust and covered with woollen cloths to prevent access of heat. As soon as the benzole is frozen, it is to be placed in a funnel and allowed to drain. The solid mass when thawed is pure benzole. By this mode of proceeding, a considerable quantity of fluid is always accumulated which refuses to freeze and yet boils at the proper temperature for benzole. I have found it to contain a small quantity of the C^nH^n series of hydrocarbons (homologous with olefiant gas). Mr. Church states it to contain benzole in a peculiar condition; he calls it parabenzole. The presence of the C^nH^n series may always be proved by the readiness with which the fluid decolourises bromine water.

1315



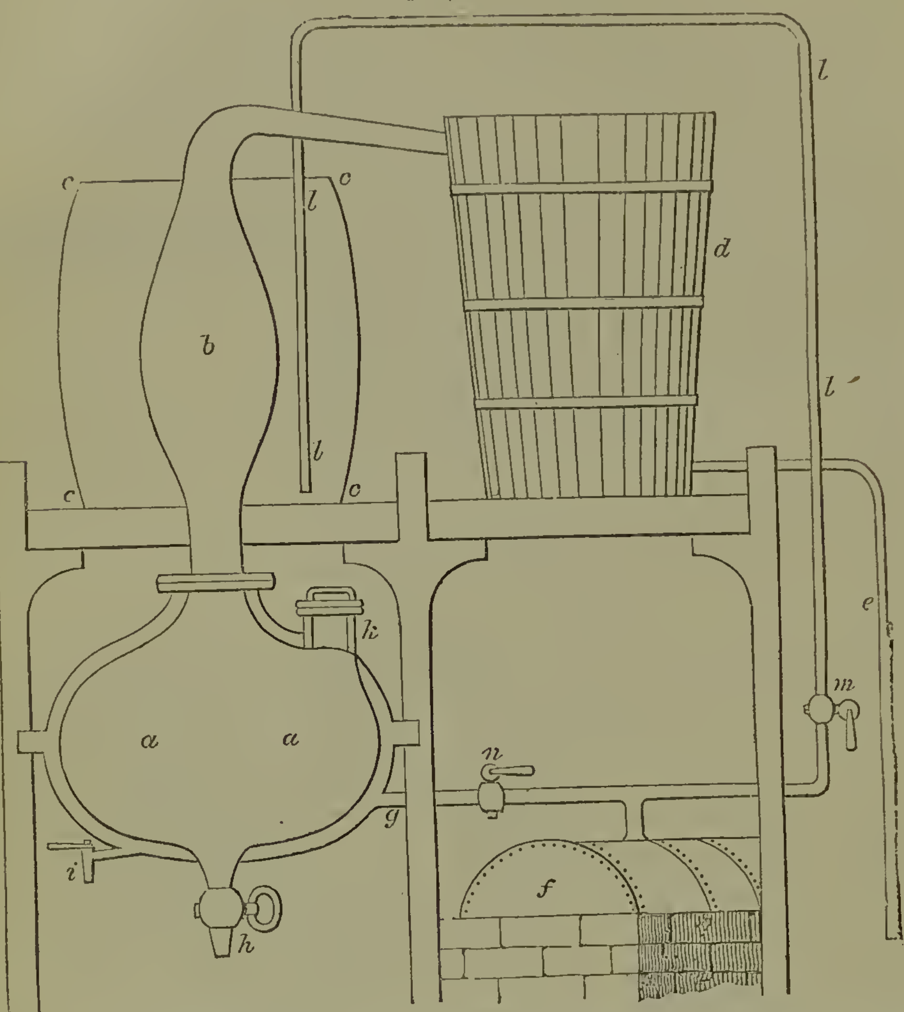
A simpler form of apparatus for rectifying benzole, and one that answers almost as well, is that represented in *fig.* 1316. It will be seen that the worm *c c* of *fig.* 1315 is replaced by a straight tube. The mode of use is precisely the same.

1316



Where the benzole is to be extracted from coal naphtha on the large scale, the following apparatus will be found convenient: — The boiler *a a*, *fig.* 1317, surrounded by a steam jacket, is connected at its upper extremity with a head, *b*, answering to the worm *c* in *fig.* 1315. The head plays into the worm tub *d*; the benzole being conveyed by the exit pipe *e* to the reservoir or close tank in which it is to be stored. The tub *c c c c* contains water to condense the hydrocarbons which are to be removed from the benzole. In order to save time it is convenient at the commencement of the operation to heat the water in *c c c c* to about 170°; this is effected by means of the steam pipe *l l l*, which is connected with the boiler *f*. The steam is admitted to the jacket of the still by means of the pipe *g*. The steam can be regulated or stopped altogether by means of the stop cock *n*. The cock *m* is to regulate the admission of steam to the vessel *c c c c*. The man hole is represented at *k*. A small cock to allow the condensed water in the jacket to be run off, is seen

1317



at *i*. Unless the naphtha is of the best quality the benzole will be difficult to extract by the heat of the jacket alone. It will then be necessary to send direct steam into *a a*. When no more benzole comes over, the remaining naphtha is to be run out of the still by the stopcock *h*. Although the boiler *f* is, for the sake of space, represented in the figure as if placed beneath the support of the condenser or worm tub, it should in practice be removed to a considerable distance for fear of the vapour of the hydrocarbon reaching the stoke-hole and causing an explosion. The condenser *b* may be arranged in the form of a worm like *c* in *fig.* 1315, but the precaution is scarcely necessary if the chamber at *b*, *fig.* 1317, be made sufficiently capacious. The benzole obtained in the above apparatus is, of course, contaminated with toluole; if, however, the rectification be repeated, the water in the chamber *c c c c* not being permitted to become hotter than 180° F., the resulting benzole will be almost pure. One distillation is amply sufficient for the preparation of the commercial article.

A rectifying column somewhat like Coffey's still may also be employed for preparing benzole.

The less volatile naphtha remaining in the still is by no means valueless; it is adapted for almost all the purposes for which ordinary coal naphtha is applicable. By removing the fluid by the tap *h*, and distilling it in an ordinary still, a very good coal naphtha of a density of about 0·870 will be obtained.

The number of processes and patents which have been published relating to coal naphtha is immense. There is, as a general rule, an extreme sameness in them. Each inventor uses the processes of his predecessors with some slight alteration or modification, and patents them as if involving an important discovery. It is true that, in some few instances, these alterations are very valuable, but the general feeling with which one rises from the perusal of patents connected with coal naphtha is, that there is nothing really new in them. All processes for their purification consist, essentially, of treatments with strong oil of vitriol followed by alkalies. It is remarkable to observe the difference in the ideas of inventors and operators with regard to the part played by sulphuric acid in the purification of naphthas. It is by no means uncommon to hear the workmen, and even those who have the direction of naphtha works, attribute the dark colour which naphthas acquire by contact with oil of vitriol, to the latter "precipitating out the tar." The fact is, that a carefully distilled naphtha does not contain any tar. The dark colour is chiefly due to the removal of the hydrocarbons homologous with olefiant gas. All bodies belonging to this series dissolve with a red colour in sulphuric acid, and the fluid on keeping soon begins to evolve sulphurous acid and turn dark, sometimes nearly black. If the naphtha has been insufficiently rectified, it will contain naphthaline, and this will readily unite with the sulphuric acid to form a conjugate acid of dark colour.

It is extremely curious that naphthas which contain large quantities of naphthaline, will often distil without the latter crystallising out. It is volatilised in the vapour of the naphtha and therefore escapes observation. But if a little chlorine be poured into the fluid, or if a little chloride of lime be added, followed by an acid, and the fluid be then distilled, the naphthaline will come over in the solid state, so that it can be removed by mechanical methods. It does not appear to be due to the formation of Laurent's chloride of naphthaline, for the product only contains traces of chlorine.

Benzole has been much used of late to remove greasy and fatty matters from cotton, wool, silk, and mixed fabrics. It is by no means essential that the benzole should be absolutely pure for this purpose. By this it is meant that the presence of naphthas boiling somewhat above 177° does not materially affect the usefulness of the fluid. If, however, the naphtha is to be employed for removing greasy stains from dresses, gloves, or other articles to be worn, the purer and more volatile the hydrocarbon, the more readily and completely the odour will be removed by evaporation. Mr. F. C. Calvert has patented the application of benzole to some purposes of this kind. He first purifies the naphtha by means of sulphuric acid and caustic alkalies in the usual manner, and then rectifies it at a temperature not exceeding 212°.

For this purpose the apparatus described in *fig.* 1317 will be found well suited. The inventor applies the rectified coal naphtha, or nearly pure benzole, to the following purposes: — 1st, for removing spots and stains of grease, *i. e.* fatty or oily matters, tar, paint, wax, or resin, from cotton, woollen, silk, and other fabrics, when, in consequence of its volatility, no mark or permanent odour remains. 2nd, for removing fatty or oily matters from hair, furs, feathers, and wools, and for cleaning gloves and other articles made of leather, hair, fur, and wool. 3rd, for removing the fatty matters which exist naturally in wool. 4th, for removing, from wool, tar, paint, oil, grease, and similar substances used by farmers for marking, salving, and smearing their sheep. 5th, for cleansing or removing the oily or fatty matters which are contained in cotton waste that has been used for cleansing or wiping machinery, or other articles to which oil or grease has been applied. In order to remove the above matters by means of coal naphtha, the articles, if small, are merely rubbed with it. On the large scale the matters to be operated on are placed in suitable vessels, and the naphtha is run in. After contact for some hours the fluid is run off, and the fabrics are passed through squeezers and submitted to strong pressure to remove the greater portion of the benzole or naphtha. The naphthas which run out are distilled off, so that the greasy matters may be preserved and used for lubricating machinery or other purposes.

Furniture paste may also be made from light coal naphtha or benzole by the following process: — One part of wax and one of resin is to be dissolved in two parts of the hydrocarbon, with the aid of heat. When entirely dissolved the whole is allowed to cool and is then fit for use.

It is a vexatious circumstance that no important practical use has yet been found for naphthaline. It is true that it is used for the preparation of lamp black, but the quantity employed for that purpose is but small. The quantity annually produced by the various gas-works is enormous. Its odour and volatility prevent its being applied to lubricating purposes. It often happens that much valuable time is lost by unscientific operators in endeavouring to remove the smell from such substances as naphthaline; they forget that the odour of a body of this class is a part of itself, and cannot be removed without its destruction. It is possible that the compounds of naphthaline may one day be applied to useful purposes. By treating naphthaline with excess of chlorine, and removing fluid substances with ether, a crystalline paste is obtained. This paste, dissolved in boiling benzole and allowed to repose, deposits beautiful rhombohedral crystals, often of large size. They have exactly the form of Iceland spar, and, like that substance, possess the power of double refraction. When nitronaphthaline is treated with acetic acid and iron filings in the same manner as that employed by M. Béchamp for the production of aniline, a base is obtained of the formula $C^{20}H^{9}N$; it is called naphthalamine. It is, therefore, isomeric with cryptidine, but has no other point of resemblance.

The relation which appears to exist between naphthaline and alizarine is also very interesting, and suggestive of the idea that the former substance will not always be regarded as useless.

It is said that naphthaline has been employed with advantage in the treatment of psoriasis. M. Emery states that it succeeded in twelve out of fourteen cases. In the two where it failed the one patient was a woman thirty years of age, who had been afflicted for eight years with psoriasis gyrata; the other patient was a young man who had suffered for several years with lepra vulgaris. In the latter case, two months' treatment having effected no good, pitch ointment was substituted, which effected a cure in two months. The naphthaline was employed in the form of ointment in the strength of ʒss. to ʒi. of lard. The application is sometimes, however, attended with severe inflammation of the skin, which must be relieved with poultices. (*L'Experience*, Oct. 6, 1842.)

The dead oils, as the less volatile parts of coal tar are called, contain several substances, the nature of which is very imperfectly known. Among them may be mentioned pyrène and chrysène. The former has only been examined by Laurent, who gives the formula $C^{30}H^{12}$ for it. They are found in the very last portions that pass in the distillation of coal tar. They are also said to be produced during the distillation of fatty or resinous substances. The portions which distil last are in the form of a reddish or yellowish paste, which rapidly darkens in colour on exposure to light. Ether separates it into two portions, one soluble, containing the pyrène, the other insoluble, containing the chrysène. The pyrène may be obtained by exposing the etherial solution to a very low temperature, which will cause it to crystallise out. The composition of pyrène is, according to Laurent,

	Experiment.	Calculation.	
Carbon	93·18	C^{30}	93·7
Hydrogen	6·11	H^{12}	6·3
	99·29		100·0

The portion insoluble in ether consists of chrysène in a tolerably pure state. I have found that it crystallises on cooling from a solution in Boghead naphtha, in magnificent yellow plates, with a superb lustre resembling crystallised iodide of lead. The following are the results of its analysis. My combustion was made upon chrysène crystallised as above.

	Laurent.		C. G. W.	Calculation.		
Carbon	94·83	94·25	94·63	94·74	C^{12}	72
Hydrogen	5·44	5·30	5·37	5·26	H^{4}	4
	100·27	99·55	100·00	100·00		76

The formula given above merely expresses the ratio of the elements, no compound of chrysène has yet been formed which will enable its atomic weight to be determined with certainty. Laurent's analyses were calculated with old atomic weight of carbon.

The heavier coal oils, when exposed to the action of a powerful freezing mixture, often deposit a mass of crystals only partly soluble in alcohol. The soluble portion consists of napthaline; the other portion which dissolves with difficulty is a curious substance, the nature of which is at present not very well known; it has been called anthracène, or paranaphthaline. It appears, from the analyses which have as yet been made, to be isomeric with naphthaline. It fuses at 356°, and boils at about 580°. The density of its vapour, determined at 848°, was 6·741°, agreeing very well with the formula $C^{30}H^{12}$, which requires 6·643. This formula is one and a half times naphthaline, thus: $C^{20}H^{8} + C^{10}H^{4} = C^{30}H^{12}$.

Metanaphthaline is a peculiar substance which appears to be closely related to the above products. It is formed during the manufacture of resin gas. It is a fatty substance fusing at 158°, and distilling at about 617°; it is at present but little known. A substance which seems to be metanaphthaline has recently been imported in considerable quantity as a lubricating material. It is tinged of a yellow colour, probably from the presence of traces of chrysène.

NAPHTHA, Native. In a great number of places in various parts of the world, a more or less fluid inflammable matter exudes. It is known as Persian naphtha. Petroleum, Rock oil, Rangoon tar, Burmese naphtha, &c. These naphthas have been examined by many chemists, but the experiments have been exceedingly defective, and even the analyses most incorrect, for in all cases where a loss of carbon or hydrogen has been experienced, it has been put down as oxygen. The oil procured from the above sources, when rectified and well dried, contains no oxygen. The constitution of all of them is probably nearly the same, the odour and physical characters closely agreeing in specimens obtained from widely different sources. A thorough investigation of the most plentiful and well marked of all of these naphthas (namely, that from Rangoon) has been undertaken by MM. Warren De la Rue and Hugo Müller, who have been engaged upon it for some years. They find the fluid to consist of two principal series of hydrocarbons, namely, the benzole class and another, unacted upon by acids, and apparently consisting of the radicals of the alcohols. In addition to the fluid hydrocarbons, Burmese naphtha contains a considerable quantity of paraffine.

Burmese naphtha or Rangoon tar is obtained by sinking wells about 60 feet deep in the soil, the fluid gradually oozes in from the soil, and is removed as soon as the quantity accumulated is sufficient. The crude substance is soft, about the consistence of goose grease, with a greenish brown colour, and a peculiar but by no means disagreeable odour. It contains only 4 per cent. of fixed matters. In the distillations, MM. De la Rue and Müller employed superheated steam for the higher, and ordinary steam for the lower temperatures. At a temperature of 212°, eleven per cent. of fluid hydrocarbons distil over; they are entirely free from paraffine. Between 230 degrees and 293° F., ten per cent. more fluid distils, containing, however, a very small quantity of paraffine. Between the last named temperature and 320° F., the distillate is very small in quantity, but from that to the fusing point of lead, 20 per cent. more is obtained. The latter, although containing an appreciable amount of paraffine, remains fluid at 32° F. At this epoch of the distillation, the products begin to solidify on cooling, and 31 per cent. of substance is obtained of sufficient consistency to be submitted to pressure. On raising the heat considerably, 21 per cent. of fluids and paraffine distil over. In the last stage of the operation, 3 per cent. of pitch-like matters are obtained. The residue in the still, consisting of coke containing a little earthy matter, amounts to 4 per cent. We thus have as the products in this very carefully conducted and instructive distillation,

Below 212°	Free from paraffine	11·0
230 to 293°	A little paraffine	10·0
293 to 320°		
320 to fusing point of lead	Containing paraffine, but still fluid at 320°	20·0
At about the fusing point of lead,	Sufficiently solid to be submitted to pressure	31·0
Beyond fusing point of lead	Quantity of paraffine diminishes	21·0
Last distilled	Pitchy matters	3·0
Residue in still	Coke containing a little earthy impurity	4·0
		100·0

All the above distillates are lighter than water. Almost all the paraffine may be extracted from the distillates by exposing them to a freezing mixture. In this manner, no less than between 10 and 11 per cent. of this valuable solid hydrocarbon may be obtained from Burmese naphtha. We may before long expect a full account of the substances contained in Rangoon tar.

Naphtha appearing closely to resemble the above is found at Alfreton, Amiano (Duchy of Parma), Baku (borders of the Caspian), Barbadoes, Clermont (France), Gobian, near Bezières (France), Galicia, Neufchatel (Switzerland), Tegernsee (Bavaria), Trinidad, United States, Val di Noto in Sicily, Wallachia, Zante, St. Zibio (Modena). Naphtha was one of the ingredients said, by some old authors, to enter into the composition of the Greek fire. — C. G. W.

In 1857, our *imports* of Naphtha were 6,558 gallons; in 1858, 3,804 gallons; and in 1857, our *exports* were 164 gallons; and in 1858, 189 gallons.—See Rock Oil.

NAPHTHA, Shale. The true constitution of shale naphtha, or, as it is sometimes called in commerce, "shale oil," has not yet been satisfactorily ascertained. In fact, to do so would involve a very laborious research, or rather series of researches, for the various shales or schists differ much in the quantities and qualities of the naphtha yielded by them. The bituminous shale of Dorsetshire contains much nitrogen and sulphur, arising to a great extent from presence of a large quantity of semi-fossilised animal remains. The crude naphtha, consequently, is intolerably fœtid. By repeated treatments with concentrated sulphuric acid and caustic soda it may, however, be rendered very sweet. It then contains pretty nearly the same constituents as Boghead naphtha. *i. e.* benzole and its homologues, various hydrocarbons of the olefiant gas series, and small quantities of the alcohol radicals or isomeric hydrocarbons. There are also present, previous to purification, carbolic acid and numerous alkaloids; but, strange to say, in the samples I examined there were no traces of aniline to be found. There is little doubt that shales of this kind might be most profitably worked by one or other of the recently patented processes for the preparation of photogen and lubricating oil.

French shale oils have been examined by Laurent and Sainte Evre, but the results are not of any very great value, because care was not taken to separate the various series of hydrocarbons from each other. It is true that Laurent fractionally distilled his oil, and Sainte Evre in addition treated his hydrocarbons with sulphuric acid, anhydrous phosphoric acid, and fused potash. These operations would remove basic and acid bodies, and much, if not all, of the homologues of olefiant gas, but the residue would contain indefinite mixtures of the benzole and radical series.

Laurent's analyses have been quoted by Gerhardt to show that the hydrocarbons approach in composition the formula $n(C^2H^2)$. They are as follows:—

	80° to 95° C.		120° to 121°.	169°.	Theory $n(C^2H^2)$.
Carbon	86·0	85·7	86·2	85·6	85·7
Hydrogen	14·3	14·1	13·6	14·5	14·3
					100·0

The above analyses are calculated according to the old atomic weight of carbon.

M. Sainte Evre, by determining the vapour densities of the fractions, arrived at the following formulæ for the hydrocarbons examined by him:—

Boiling points Cent.	Formulæ.
275° to 230°	$C^{36}H^{34}$
255° to 260°	$C^{28}H^{26}$
215° to 220°	$C^{24}H^{26}$
132° to 135°	$C^{18}H^{16}$

These results are worth very little except as showing where an excellent field exists for investigation.

Laurent, by treating with boiling concentrated nitric acid that part of shale oil which boiled between 80° and 150° Cent., obtained an acid which he called ampelic; it is apparently metameric with salicylic acid. The same, or more probably an homologous substance, is procured by treating in the same manner the oil boiling between 130° and 160°. Picric or, as it is sometimes called, carbazotic acid, is also formed at the same time.

Ampelic acid is a substance about which chemists have felt much curiosity ever since its discovery. It is much to be desired that a new investigation should be made upon it. The following are a few of its properties:—It is white, inodorous, almost insoluble in cold water, and only slightly soluble even when boiling, the solution reddens litmus. It is easily dissolved by alcohol or ether; from solutions in those menstrua it is deposited under the form of a crystalline powder. It fuses somewhere about 260° Cent., *and distils without alteration.* This last property is a valuable one, as it will enable its vapour density, and consequently its atomic weight, to be easily determined with precision. From its solution in sulphuric acid it is precipitated unaltered by water. Gerhardt gives the following as some of the reactions of this interesting body. The solution of its ammonia salt precipitates chloride of calcium white, the precipitate is soluble in hot water, and crystallises on cooling. It is not precipitated by solutions of the chlorides of barium, strontium, manganese, or mercury. Acetate of nickel gives a greenish precipitate, acetate of copper greenish blue. Acetate and nitrate of lead give white precipitates.

The above experiments were made by Laurent in 1837, and, as it is very probable that he never obtained a perfectly pure substance, it is almost certain that valuable and novel results would be obtained on carefully repeating the entire investigation. At the same time, as benzoic acid is $C^{14}H^6O^4$ and ampelic acid according to its discoverer is $C^{14}H^6O^6$, it is more than likely to be a product of oxidation of one of the homologues of benzole.

Intimately connected with the oils of shale are the fluids yielded by the distillation of the numerous bitumens and asphalts found in various parts of the world. Undoubtedly these deposits will one day become of important use in the arts.

The bitumen of Trinidad yields on distillation an intensely fœtid oil, and also a very large quantity of water. It also appears to give a considerable quantity of alkaloids and ammonia. It will, perhaps, scarcely be a profitable speculation at present to bring this bitumen so far for the purpose of distillation, but doubtless there are many ports into which it could be carried at a reasonable price. It is said that some has already found its way into America, for the purpose of having photogen prepared from it.

France is particularly rich in deposits of bitumen, especially in the volcanic districts of Auvergne. Switzerland, Italy, Germany, Russia, Poland, in fact almost every part of Europe contains bitumen of various degrees of consistency and value. Even in our own country there are deposits at Alfreton and other places. The Alfreton bitumen is not unlike that of Rangoon.

Bitumens have been examined by various chemists, more especially by Bousingault and Voelckel. Their results, however, require to be repeated with great care, as hitherto sufficient attention has not been paid to the purification by chemical means of the various hydrocarbons. Fractional distillation, although absolutely necessary, in order to enable bodies to be obtained of different but specific boiling points, does not do away with the necessity for elaborate purifications by means of bromine, nitric, and sulphuric acids, &c.

There is little doubt that a rigorous examination of the oils procurable by distillation of the various European and other bitumens would be rewarded, not only by scientific results of great interest, but also by discoveries of immense commercial importance. It must not be forgotten, in connection with the money value of such researches, that the bitumens yield a very high percentage of distillate, much greater than any of the shales or imperfectly fossilised coals which are wrought on the large scale for the preparation of illuminating or lubricating oils.—C. G. W.

NAPHTHA, Wood. See Pyroxilic Spirit.

NAPHTHALIDINE. See Naphtylamine.

NAPHTHALINE. $C^{12}H^{8}$. A solid crystalline hydrocarbon contained in coal tar. It is especially interesting in consequence of its being the substance so long and perseveringly studied by Laurent. Its combinations and derivatives are immensely numerous, and, in a theoretical point of view, of the greatest importance, the well established theory of substitutions being, to a great extent, founded upon the results obtained by treating naphthaline with nitric acid and the halogens.—C. G. W.

NAPHTYLAMINE. $C^{20}H^{9}N$. An organic base, isomeric with cryptidine, produced from nitronaphthaline by the action of reducing agents, such as sulphide of ammonium, or protacetate of iron.—C. G. W.

NAPLES YELLOW. (*Jaune minéral*, Fr.; *Neapelgelb*, Germ.) This is a fine yellow pigment prepared from antimony. It is said to be prepared by calcining about 12 parts of metallic antimony with 8 parts of red lead and 4 parts of oxide of zinc in a reverberatory furnace. The mixed oxides are to be well rubbed together and fused; after this, the fused mass is to be reduced to a very fine powder. This colour is principally prepared in Italy; but the chrome yellows have almost entirely superseded it. See Yellow Colours.

NARCOTINE. $C^{46}H^{25}NO^{14}$. An alkaloid contained in opium. It may be obtained in large quantities from the coloured and uncrystallisable mother liquors obtained in the preparation of morphine by Gregory's process.—C. G. W.

NATIVE ALLOY. A name sometimes given to Osmium-Iridium, which see.

NATIVE AMALGAM. This occurs in beds containing mercury and cinnabar. It is found at Almaden in Spain, at Szlana in Hungary, at Allemont in France, and some other places. According to the analysis of Klaproth and Meyer, it consists of,

Silver - - - - - -	36·00	25·00
Mercury - - - - -	64·00	73·30

NATROLITE, from the Latin *Natron*, soda. This mineral occurs reniform, botryoidal, and massive; it has a splintery fracture, is, on the edges, translucent, and of a pearly lustre. It consists of soda, alumina, silex, and water; it is found in Scotland, Switzerland, Saxony, and Nova Scotia.

Natrolite receives a high polish, and it has, therefore, been used for rings and other ornaments.

NATRON is the name of the native sesquicarbonate of soda, which occurs as a deposit on the sides of several lakes to the west of the Delta of Egypt; also as thin crusts on the surface of the earth, rarely an inch in thickness, at the bottom of a rocky mountain, in the province of Sukena, near Tripoli, and two days' journey from Fezzan, and is called by the Africans *trona*. The walls of Cassar (Qasrr), a fort now in ruins, are said to have been built of it. At the bottom of a lake at Lagunillas, near Merida, in Venezuela, is found a substance called by the Indians *urao*, which is tolerably pure sesquicarbonate of soda. It is collected every two years by the natives, who, aided by a pole, plunge into the lake, separate the bed of earth which covers the mineral, break the urao, and rise with it to the surface of the water; it is then removed to the magazine, and dried in the sun. Natron is also found near Smyrna, in Tartary, Siberia, Hungary, Hindostan, and Mexico; in the last country there are several natron lakes, a little to the north of Zacatecas, as well as in many other provinces.

These deposits are never pure sesquicarbonate of soda, but contain generally some sulphate of soda, chloride of sodium, and earthy matters.

The following are the analyses of some of them: —

	Boussingault. (Urao.)	Klaproth. (Trona.)	Beudant. Walls of Cassar (Trona).	
Carbonate of soda - -	80·22	75·0		66·20
Water - - - - -	18·80	22·5		20·55
Foreign matter - -	0·98	($NaSO^4$) 2·5	($NaSO^4$)	1·96
	100·00	100·0	($NaCl$)	3·95
			(earthy matter)	7·33
				99·99

According to Phillips and H. Rose, a crystallised sesquicarbonate of soda is deposited by boiling down and cooling a watery solution of the bicarbonate. By heat, as well as by long boiling of its watery solution, the sesquicarbonate evolves one-third of its carbonic acid, and is converted into the monocarbonate.—H. K. B.

NATURE-PRINTING. (*Naturselbstdruck*, Germ.) The following description of this very beautiful process is an abstract of a lecture delivered by Mr. Henry Bradbury at the Royal Institution: —

Nature-printing is the name given to a technical process for obtaining printed reproductions of plants and other objects upon paper, in a manner so truthful, that only a close inspection reveals the fact of their being copies; and so distinctly sensible to even touch are the impressions, that it is difficult to persuade those unacquainted with the manipulation that they are an emanation of the printing-press.

The distinguishing feature of the process consists, firstly, in impressing natural objects — such as plants, mosses, seaweeds and feathers, into plates of metal, causing as it were the objects to engrave themselves by pressure; secondly, in being able to take such casts or copies of the impressed plates, as can be printed from at the ordinary copperplate-press.

This secures, in the case of a plant, on the one hand, a perfect representation of its characteristic outline, of some of the other external marks by which it is known, and even in some measure of its structure, as in the venation of ferns, and the ribs of the leaves of flowering plants; and on the other, affords the means of multiplying copies in a quick and easy manner, at a trifling expense compared with the result — and to an unlimited extent.

The great defect of all pictorial representations of botanical figures has consisted in the inability of art to represent faithfully those minute peculiarities by which natural objects are often best distinguished. Nature-printing has therefore come to the aid of this branch of science in particular, whilst its future development promises facilities for copying other objects of nature, the reproduction of which is not within the province of the human hand to execute; and even if it were possible, it would involve an amount of labour scarcely commensurate with the result.

Possessing the advantages of rapid and economic production, the means of unlimited multiplication, and, above all, unsurpassable resemblance to the original, Nature-printing is calculated to assist much in facilitating not only the *first-sight* recognition of many objects in natural history, but in supplying the detailed evidences of identification — which must prove of essential value to botanical science in particular.

Experiments to print direct from nature were made as far back as about two hundred and fifty years; it is certain therefore that the present success of the art is mainly attributable to the general advance of science, and the perfection to which it has been brought in particular instances.

On account of the great expense attending the production of woodcuts of plants in early times, many naturalists suggested the possibility of making direct use of Nature herself as a copyist. In the *Book of Art*, of Alexis Pedemontanus (printed in the year 1572), and translated into German by Wecker, may be found the *first* recorded hint as to taking impressions of plants.

At a later period — in the *Journal des Voyages*, by M. de Moncoys, in 1650, it is mentioned that one Welkenstein, a Dane, gave instruction in making impressions of plants.

The process adopted to produce such results at this period consisted in lying out flat and drying the plants. By holding them over the smoke of a candle, or an oil lamp, they became blackened in an equal manner all over; and by being placed between two soft leaves of paper, and being rubbed down with a smoothing bone, the soot was imparted to the paper, and the impression of the veins and fibres was so transferred. But though the plants were dried in every case, it was by no means absolutely necessary; as the author has proved by the simple experiment of applying lamp-black or printer's ink to a fresh leaf, and producing a successful impression.

Linnæus, in his *Philosophia Botanica*, relates that in America, in 1707, impressions of plants were made by Hessel; and later (1728—1757), Professor Kniphof, at Erfurt (who refers to the experiments of Hessel), in conjunction with the bookseller Fünke, established a printing-office for the purpose. He produced a work entitled *Herbarium Vivum*. The range and extent of his work, twelve folio volumes, containing 1200 plates, corroborates the curious fact of a printing-office being required. These impressions were obtained by the substitution of printer's ink for lamp-black, and flat pressure for the smoothing-bone; but a new feature at this time was introduced—that of colouring the impressions by hand according to nature—a proceeding, which though certainly contributing to the beauty and fidelity of the effect, yet had the disadvantage of frequently rendering indistinct, and even of sometimes totally obliterating, the tender structure and finer veins and fibres. Many persons at the time objected to the indistinctness of such representations and the absence of parts of the fructification: but it was the decided opinion of Linnæus, that to obtain a representation of the difference of species was sufficient.

In 1748, Seligmann, an engraver at Nuremberg, published in folio plates figures of several leaves he had reduced to skeletons. As he thought it impossible to make drawings sufficiently correct, he took impressions from the leaves in red ink, but no mention is made of the means he adopted. Of the greater part he gave two figures, one of the upper and another of the lower side.

In the year 1763 the process is again referred to in the *Gazette Salutaire*, in a short article upon a *Recette pour copier toutes sortes de plantes sur papier*.

About twenty-five or thirty years later, Hoppe edited his *Ectypa Plantarum Ratisbonensium*, and also his *Ectypa Plantarum Selectarum*, the illustrations in which were produced in a manner similar to that employed by Kniphof. These impressions were found also to be durable, but still were defective.

In the year 1809 mention is made in Pritzell's "Thesaurus" of a *New Method of taking Natural Impressions of Plants;* and lastly, in reference to the early history of the subject, the attention of scientific men was called to an article, in a work published by Grazer, in 1814, on a *New Impression of Plants*.

Twenty years afterwards, the subject had undergone remarkable change, not only in the results produced, but also in the mode of operation to be pursued, which consisted in fixing an impression of the prepared plant in a plate of metal by pressure. It also appears, on the authority of Professor Thiele, that Peter Kyhl, a Danish goldsmith and engraver, established at Copenhagen, applied himself for a length of time to the ornamentation of articles in silver ware, and the means he adopted were, taking copies of flat objects of nature and art in plates of metal by means of two steel rollers. Here may be marked the first real steps of the process, from a simple contrivance to an art. The subsequent development which science has given to these means, and the amplifications which experience has added, have realised what can now be produced; but it should not be assumed that adaptation and amplification are invention.

Various productions in silver, of Kyhl's process were exposed in the Exhibition of Industry held at Charlottenburg, in May, 1833. In a manuscript, written by this Danish goldsmith, entitled *The Description (with forty-six plates) of the Method to copy Flat Objects of Nature and Art*, dated 1st May, 1833, is suggested the idea of applying this invention to the advancement of science in general. The plates accompanying this description represented printed copies of leaves, of linen and woven stuffs, of laces, of feathers of birds, scales of fishes, and even of serpent-skins.

It would appear that Peter Kyhl was no novice at the process. He distinctly points out what he conceives to be its value, by the subjects that he tried to copy, and he enters into detail as to the precautions to be observed in the operation of impressing metal plates so as to insure successful impressions. His manuscript explains that he had experimented with plates of copper, zinc, tin, and lead. Still there existed obstacles which prevented him from making any application of his invention. In the case of zinc, tin, and copper plates, the plant, from the extreme hardness of the metals, was too much distorted and crushed; while in lead, though the impression was as perfect as could be, there were no means of printing many copies; as it was not possible, after the application of printer's ink, to retain the polished surface that had been imparted to the leaden plate, or to cleanse it so thoroughly as to allow the printer to take impressions free from dirty stains. This was a serious obstacle, which was not compensated for even by the peculiarly rich surface of the parts that were impressed, attributable to the lead being more granular than copper, the effect of which is so favourable to adding density or body of colour, without obliterating the veins and fibres. Peter Kyhl died in the same year that he made known his invention. At his death, his manuscripts and drawings were deposited in the archives of the Imperial Academy of Copenhagen.

To proceed to more modern efforts. Dr. Branson, of Sheffield, in 1847, commenced a series of experiments, an interesting paper upon which was read before the Society of Arts in 1851; and therein for the first time, was suggested the application of that second and most important element in Nature-printing, which is now its essential feature — the Electrotype.

It then occurred to Dr. Branson that an Electrotype copy would obviate the difficulty. He afterwards stated that he abandoned the process of Electrotyping in consequence of his finding it tedious, troublesome, and costly to produce large plates. Having occasion, however, to get an article cast in brass, he was astonished at the beautiful manner in which the form of the model was reproduced in the metal. He determined, therefore, to have a cast taken in brass from a gutta-percha mould of ferns, and was much gratified to see the impression rendered almost as minutely as by the Electrotype process; the mode of operation is to place a frond of fern, algæ, or similar flat vegetable form, on a thick piece of glass or polished marble; by softening a piece of gutta-percha of proper size, and placing it on the leaf and pressing it carefully down, it will receive a sharp and accurate impression from the plant. The gutta-percha, allowed to harden by cooling, is then handed to a brass-caster, who reproduces it in metal from its moulding-base.

In 1851, Professor Leydolt, of the Imperial Polytechnic Institute at Vienna, availing himself of the resources of the Imperial Printing-Office, carried into execution a new method he had conceived of representing agates and other quartzose minerals in a manner true to nature. Professor Leydolt had occupied himself for a considerable period in examining the origin and composition of these interesting objects in geology. In the course of his experiments and investigations he had occasion to expose them to the action of fluoric acid, when he found in the case of an agate, that many of the concentric rings were totally unchanged, while others, to a great extent decomposed by the acid, appeared as hollows between the unaltered bands. It then occurred to Professor Leydolt that the surfaces of bodies thus corroded might be printed from, and copies multiplied with the greatest facility.

The simplest mode for obtaining printed copies is to take an impression direct from the stone itself. The surface after having been treated with fluoric acid, is washed with dilute hydrochloric acid and dried; then carefully blackened with printer's ink. By placing a leaf of paper upon it, and by pressing it down upon every portion of the etched or corroded surface with a burnisher, an impression is obtained, representing the crystallised rhomboidal quartz, *black*, and the weaker parts that have been decomposed by the action of the acid, *white*. It requires but a small quantity of ink, and particular care must be exercised in the rubbing down of the impression. This mode is good as far as it goes — but it is slow and uncertain — and incurs a certain amount of risk, owing to the brittle nature of the object; and the effect produced is not altogether correct, since it represents those portions black that should be white, and those white that should be black.

The stone not being sufficiently strong to be subjected to the action of a printing-press, an exact *facsimile* cast, therefore, of it must be obtained, and in such a form as can be printed from. To effect this, the surface of any such stone (previously treated with fluoric acid), must be extended by embedding it in any plastic composition that will yield a flat and polished surface, so that the composition surrounding the corroded stone will be level with its surface; all that is necessary now is to prepare the whole surface for the electrotype apparatus, by which a perfect *facsimile* is produced, representing the agate impressed, as it were, into a polished plate of copper. This forms the printing-plate. The ink in this case, as opposed to the mode before referred to, is not applied upon the surface, but in the depressions caused by the action of the acid on the weaker parts; the paper is forced into these depressions in the operation of printing, which results in producing an impression in relief.

Mr. R. F. Sturges, of Birmingham, states that in August, 1851, he was engaged in making certain experiments with steel-rollers and metal plates for ornamenting metallic surfaces, for which he obtained a patent sealed in January, 1852. He produced plates in lead, tin, brass, and steel from various fabrics, such as wire lace, thread lace, perforated paper, and even from steel engravings, particularly a medallion of the Queen, from which impressions were printed, and which were distributed among his friends — but that which he did, led to no such result as we are at present considering, and nothing more was heard of the subject until the publication of Nature-printing in its present state. He, however, also considers himself the undoubted *inventor* of Nature-printing, notwithstanding what had been done by the experiment of Kyhl in 1833.

Mr. Aitken too, about this period was occupied in making experiments for the ornamentation of Britannia metal, and also claims the invention, having introduced the use of natural objects, and, as he says, expressly for printing purposes. But Sturges and Aitken only followed Kyhl in their operations, as the one experimented with steel rollers for the purpose of ornamenting metallic surfaces, while the other applied the same to printing purposes, both of which experiments were carried out by Kyhl.

In the Imperial Printing-Office at Vienna, the first application of taking impressions of lace on plates of metal, by means of rollers, took place in the month of May, 1852: according to Councillor Auer's statement in his pamphlet, it originated in the Minister of the Interior, Ritter von Baumgartner, having received specimens from London, which so much attracted the attention of the Chief Director, that he determined to produce others like them. This led to the use of gutta-percha after the manner that Dr. Branson had used it; but finding this material did not possess altogether the necessary properties, the experience of Andrew Worring induced him to substitute lead, which was attended with remarkable success. This was, however, only following in the steps of Kyhl. Professor Haidinger, on seeing specimens of these laces, and learning the means by which they had been obtained, proposed the application of the process to plants.

The substitution of lead for gutta-percha was a great step in the process, but would have been insufficient had not the requisite means already existed for producing faithful copies of those delicate fibrous details that were furnished in the examples of the impressions of botanical and other figures in metal. These means consisted mainly in the great perfection to which the precipitation of metals upon moulds or matrices by electro-galvanic agency has been brought, the application of which—more generally known by the name of the Electrotype process — was suggested and executed by Dr. Branson in 1851; still he met with no signal success, which may be attributed to his experiments having been conducted on a limited scale.

The *first* practical application of Nature-printing for illustrating a botanical work, and which has been attended with considerable success, is to be found in Chevalier Von Heufler's work on the mosses collected from the valley of Arpasch, in Transylvania; the *second* (*first in this country*), is a work on the "Ferns of Great Britain and Ireland," by Thomas Moore, in the course of publication, under the editorship of Dr. Lindley. Ferns, by their peculiar structure and general flatness, are especially adapted to develop the capabilities of the process, and there is no race of plants where minute accuracy in delineation is of more vital importance than in that of the ferns; in the distinction of which, the form of indentations, general outline, the exact manner in which repeated subdivision is effected, and especially the distribution of veins scarcely visible to the naked eye, play the most important part. To express such facts with the necessary accuracy, the art of photography would have been insufficient, until Nature-printing was brought to its present state of perfection.

The beautiful productions which have been given to the public by Mr. Henry Bradbury sufficiently prove the applicability of the processes which we have described. The colouring of the plates has been greatly improved by practice, and by the deposition of nickel on the surface of the electrotype plate the printer has been enabled to print off thousands of impressions without any evidence of deterioration.

NEALING. See ANNEALING.

NEB-NEB is the East Indian name of BABLAH, which see.

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.

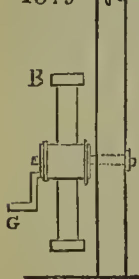
The best steel, reduced by a wire-drawing machine to the suitable diameter, is the material of which needles are formed. It is brought in bundles to the needle factory, and carefully examined. For this purpose, the ends of a few wires in each bundle are cut off, ignited, and hardened by plunging them 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 put 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.

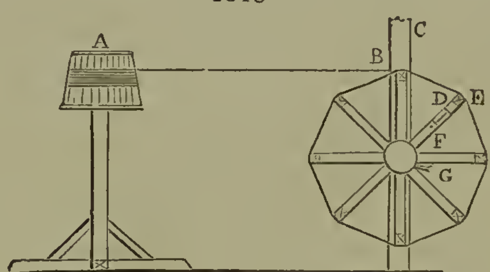
The first operation, properly speaking, of the needle factory, is unwinding the bundles of wires. With this view the operative places the coil upon a somewhat conical reel, *fig.* 1318, whereon he may fix it at a height proportioned to its diameter. The wire is wound off upon a wheel B, formed of eight 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 D, consists of two parts; of an upper part, which bears the cross bar E, to which the wire is applied; and of an under part, connected with the nave. The part E slides in a slot in the fixed part F, 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.* 1319 shows the wheel in profile. It is driven by the winch-handle G.

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.* 1320, or by means of the mechanical shears, represented in *fig.* 1321. 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 B of a bent lever B G C, and is made fast to it by a bolt. An iron rod D F, 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 E, forces it to open and shut alternately. The operative placed upon the floor under F 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.

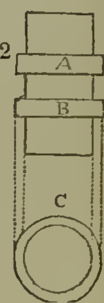
1319



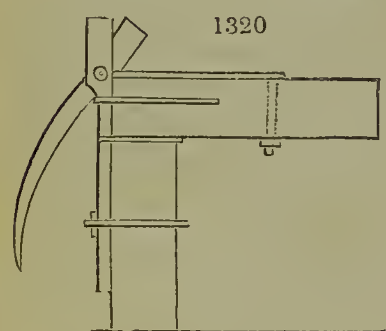
1318



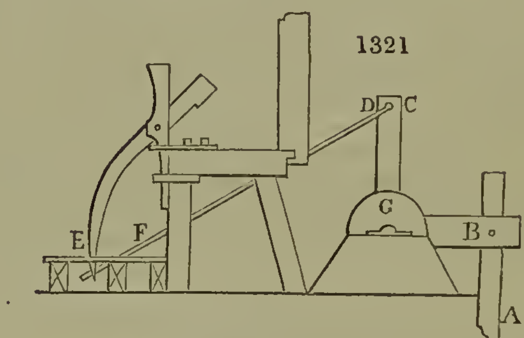
1322



1320



1321

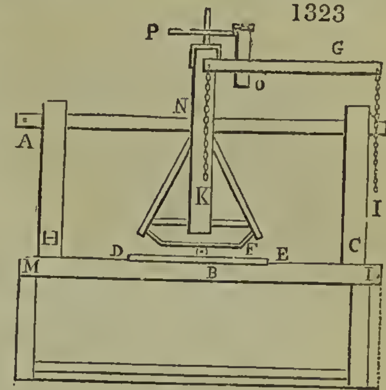


These bundles are afterwards cut with the same shears into the desired needle lengths, these being regulated by the diameter. For this purpose the wires are put into a semi-cylinder of the proper length, with their ends at the bottom of it, and are all cut across by this gauge. The wires, thus cut, are deposited into a box placed alongside of the workman.

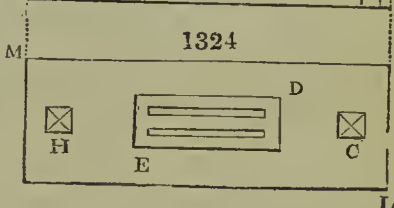
Two successive incisions are required to cut 100 wires, the third is lost; hence the shears, striking 21 blows in a minute, cut in 10 hours fully 400,000 ends of steel wire, which produce more than 800,000 needles. The wires thus cut are more or less bent, and require to be straightened. This operation is executed with great promptitude, by means of an appropriate instrument. In two strong iron rings A B, *fig.* 1322, 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 M, *fig.* 1323, covered with a cast-iron plate D E, in which there are two grooves of sufficient depth for receiving the two ring bundles of wire, or two openings like the rule F, *fig.* 1323, upon which is placed the open iron rule F, shown in front in *fig.* 1325 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.* 1323, 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 E is inserted solidly into it. Above the table,—seen in *fig.* 1324 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 N, at the point N, 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 N. At the bottom of this piece is fixed, as shown in the figure, the open rule F, seen upon a larger scale in *fig.* 1325.

1323



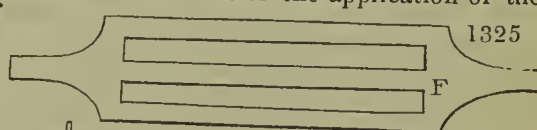
1324



When the workman wishes to introduce the bundle B, he raises, by means of two chains I, K, *fig.* 1323, and the lever G 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 groove E D, *fig.* 1323, he allows the swing piece to fall back, so that the same rings enter the open clefts of the rule F; 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.* 1326, 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 is 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 is one of the most effective.

1325



1328

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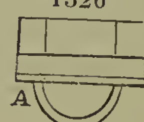
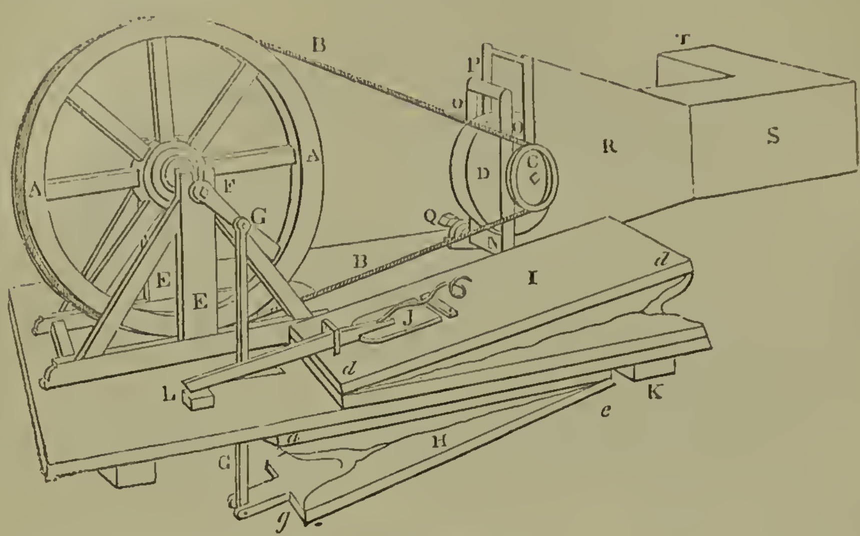
1326



A A, *fig.* 1329, is the fly-wheel of an ordinary lathe, round which the endless cord B B passes, and embraces the pulley C, mounted upon the axle of the grindstone D. The fly-wheel is supported by a strong frame E E, 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 F, which by means of an intermediate crank G G, sets in action a double bellows H I, 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 a*, being fast and attached to the floor, and the other *e 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 G. 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 N O 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 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 P.

The wind which escapes through the slits of these pipes blows upon the grindstone, and carries off its dust into a conduit R, *fig.* 1329, which may be extended to S, beyond

1329



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 J, 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.* 1327, 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.* 1320, 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 also cut 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 flatted 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 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.

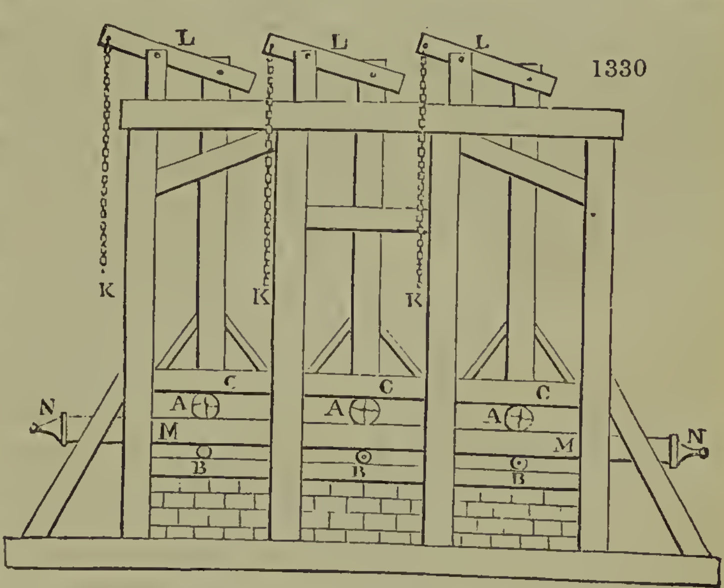
The next operative makes the groove at the eye, and rounds the head. He fixes the needle in pincers, *fig.* 1328, so that the eye corresponds to their flat side: he then rests the head of the needle in an angular groove, cut in a piece of hard wood fixed in a vice, with the eye in an upright position. 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 dexterous 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.

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 the layers, and their mixture is besmeared with rape-seed oil. *Fig.* 1334 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 siliceous matter, or emery, enclosed in the bag. *Fig.* 1330 represents an improved table for polishing the needles by attrition-bags. The lower table, M M, is movable, whereas in the old construction 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 M M may be of any length that is required, and from 24 to 27 inches broad; resting upon the wooden rollers, B, B, B,



1330

placed at suitable distances, it receives a horizontal motion, either by hand or other convenient power; the packet 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 K, K, K, 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 M, 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.

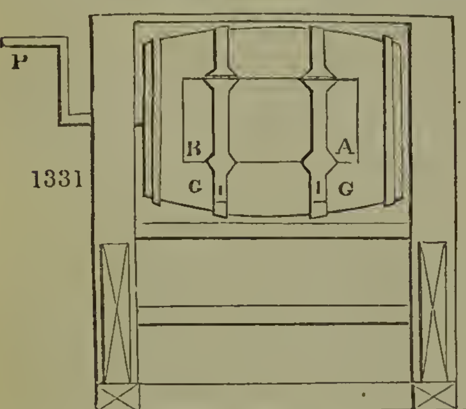
Scouring by the cask.—After being worked during 18 or 20 hours under the tables, the needles are taken out of the packets, and put into wooden bowls, where they are mixed with sawdust to absorb the black grease upon their surfaces. They are next introduced into a cask, *fig.* 1331, and a workman seizing the winch P, turns it round a little; he now puts in some more sawdust at the door, A, B, which is then shut by the clasps G, G, and continues the rotation till the needles are 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.

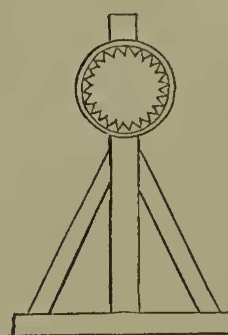
The needles are in the next place arranged in order, by being shaken, as above described, in a small somewhat concave iron tray. After being thus laid parallel to each other, they are shaken up against the end of the tray, and accumulated in a nearly upright position, so that they can be seized in a 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

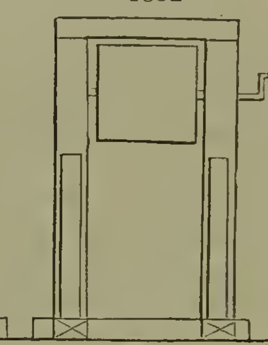
1331



1333



1332

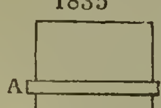


ten times in succession, in manufacturing the best articles; the only variation being in the first process. Originally the bundles of needles are formed with alternate layers of siliceous schistus and needles; but after the seventh time, bran freed from flour by sifting is substituted for the schistus. 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 everything 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.* 1332, and in section in *fig.* 1333. 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.

1336

1334

1835



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.* 1335, 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.* 1336, he lays hold 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 sorter with his finger and thumb.

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 *bluer* receives these packets, and taking 25 of the 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, 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 *bluer*.

It is easy to distinguish good English needles from spurious imitations; because the former have their axes coincident with their points, which is readily observed by turning them round between the finger and thumb.

The construction of a needle requires numerous operations; but they are rapidly and uninterruptedly successive, so that 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.

NEPHRITE. See JADE.

NERO ANTICO. The name given by the Italians to the black marble used by the Egyptian and other ancient statuaries.

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. See PERFUMERY.

NET (*Filet*, *reseau*, 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.

NETTLE TREE. The *Celtis Australis*. The wood of the nettle tree is nearly as compact as box, and takes a very high polish; it is sometimes used in the manufacture of flutes.

NEUTRALISATION 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 compound.

NEUTRAL TINT. A factitious grey pigment, composed of blue, red, and yellow, in various proportions, used by water-colour painters.

NEW RED SANDSTONE. See SANDSTONE.

NICARAGUA WOOD. The tree yielding this wood has not been ascertained; it is supposed to be a species of *Hæmatoxylon*. This wood, and a variety called Peach wood, are sent to this country for the use of the dyers. They are similar in colour to Brazil wood; but they are not sufficiently sound for any use in manufacture.

NICKEL. The ores of Nickel, found in these islands, are the following:—

Annabergite. Arseniate of nickel, found at Huel Chance and Pengelly mines in Cornwall.

Emerald nickel. Said to be found by Dr. Heddle on chromate of iron from Swinaness, in Unst, one of the Shetland Islands.

Millerite. Sulphide of nickel. This mineral has been found with the Septaria, at Ebbw Vale, in Monmouthshire, at Combe Martin, and at Huel Chance and Pengelly, in Cornwall.

Eisen-nickelkies. Sulphide of iron and nickel. On the property of the Duke of Argyll, near Inverary, this ore has been found in considerable quantities. Greg and

Lettsom give the following analysis of "a specimen of the rough ore taken and reduced to powder:"—

Iron	43·76
Nickel	14·22
Sulphur	34·46
Silica	5·90
Lime	1·45
	99·79

Kupfernickel. Copper nickel. Two or three mines in Cornwall have produced this ore in some quantities. It has been worked at Huel Chance and at Pengelly. It was found at the Fowey Consols mine.

	In 1856. Tons.	1857. Tons.	1858. Tons.
St. Austell Consols produced	$11\frac{1}{2}$	1	$1\frac{1}{2}$
Fowey Consols			3

Rammelsberg has given us the following analysis of a foreign variety, which corresponds very nearly with some of our English products:—

Arsenic	48·80
Nickel	39·94
Cobalt	0·16
Antimony	8·00
Silica	2·00

For the less important and foreign varieties the reader is referred to *Dana*, or *Brooke and Miller's Mineralogy.*

Nickel is usually associated with cobalt ores, and much chemical ingenuity has been employed to effect the perfect separation of these metals,—both of which are now very valuable in the arts. Extensive nickel refineries, in which the separation is skilfully carried out, but in all with some considerable secresy, now exist in this country; but the following remarks by Dr. Ure, with but slight alteration, are still in the main applicable:—The art of working the ores of nickel and cobalt 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 almost entirely dependent upon Norway, Northern Germany, and the Netherlands; from whence we import large quantities annually. The foreign ores are 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, and has not in any one instance given a satisfactory result. In the German ore the quantity of metallic ingredients is not only larger than in the Cornish, but 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 oxidising furnace, in contact with sand or ground flint, affords at once an impure silicate of cobalt and arsenide 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 impediment seems actually to have defeated our smelters. 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 matrix of the Cornwall ore, and which is devoid of action upon the arsenide of cobalt and nickel. The common fixed alkalies, 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 arsenides, 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. 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.—*Ure.*

Since the manufacture of German silver, or *Argentine plate*, 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 generally 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 sulphide of nickel free from arsenic; while the arsenic associated with the sulphur, and combined with the resulting sulphide of potassium, remains dissolved. Should any arsenic still be found in the sulphide, as may happen if the first roasting heat was too great, the above process must be repeated. The sulphide 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 kupfernickel, 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.

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 $\frac{1}{50}$ of an inch, and rolled into plates $\frac{1}{500}$ 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. Its melting point is nearly as high as that of manganese. It is not oxidised by contact of air, but may be burned in oxygen gas.

There is one oxide and a sesquioxide of nickel. The oxide is of an ash-grey colour, and is obtained by precipitation with an alkali from the solution of the muriate or nitrate. The sesquioxide is black, and may be procured by exposing the nitrate to a heat under redness. The hydrated oxide has a dirty pale green colour.

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). 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 hydrochloric 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, 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
	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, 0·739 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, 0·188 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
	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.

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.

From nickel, manganese may be best separated in the same manner as cobalt. 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 sulphides precipitated by hydrosulphate of ammonia are not dissolved by very dilute hydrochloric acid. 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 sulphides of nickel and cobalt remain undissolved; they are washed with water containing a little sulphuretted hydrogen and a trace of hydrochloric acid. The sulphide of manganese is dissolved with facility, but although the fluid filtered from the sulphides of nickel and cobalt gives only a rather dirty flesh-coloured precipitate on the addition of ammonia and hydrosulphate of ammonia, still the sulphide of manganese contains small portions of sulphide of cobalt or nickel; and when therefore it is treated anew with very dilute hydrochloric acid, minute quantities of the black sulphides 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 sulphide 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 sulphide of iron, like sulphide of manganese, is easily soluble in very dilute hydrochloric acid; but in this case the resolution of the sulphide 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.

For the details of processes which have been found useful in the separation of nickel from other bodies, the reader is referred to *Ure's Dictionary of Chemistry*.

Various alloys of nickel have been formed under different names; the following are a few of them:—

Argentane, or *German Silver*, consists of 8 parts of copper, 2 parts of nickel, and 3 parts of zinc. This composition has often a yellow tinge, and it is consequently employed for inferior articles only. Another form gives copper 50·000, zinc 25·0, and nickel 25·0.

White Argentane, or Argentine Plate, is, usually, copper 8 parts, nickel 3 parts, zinc 3 parts. This is a very fine alloy and passes under different names, according to the caprice of the manufacturer. A manufacturer's receipt which we have seen is copper 60·0, zinc 17·0, nickel 23·5.

Electrum, copper 8 parts, nickel 4 parts, and zinc 3 parts. This composition has many advantages, especially in its fine colour and its resistance of oxidation.

Copper 8 parts, nickel 6 parts, and zinc 3 parts, is a very hard and fine compound metal; but from its hardness there is some difficulty in working it.

Tutenague of China—*Pachfong* of the East Indies—is, copper 8 parts, nickel 3 parts, and zinc 3 parts and half.

A solder for German silver is prepared by fusing together 4 parts of the ordinary argentine, and 5 parts of zinc.

Nickel may, it appears, be alloyed with iron. Stromeyer describes a native compound of this kind; and Berthier states that by heating the arsenide of nickel with iron in any proportions, double arsenides are obtained, which are hard and brittle, with a cast-iron colour.

Our *Imports* in 1857 and 1858 were as follows:—

Nickel Ore:—	1857.	1858.
	Computed real value.	
	£	£
Sweden	220	543
Norway	476	4003
Hamburg	-	775
Hanover	225	
Hanse Towns	466	
Spain	452	
Sardinia	360	130
United States		155
Other parts	12	22
	£2211	£5628

Nickel:—

		1857.	1858.
		Computed real value.	
		£	£
Metallic, and Oxide of, and Arseniate of Nickel.	Belgium	-	205
	Sweden	430	
	Hamburg	-	610
	Hanover	200	
	Hanse Towns	1390	
	Holland	620	588
	Other parts	12	43
		£2730	£1449

NICOTIANA TABACUM. The tobacco plant, so called in honour of John Nicot, of Nismes, ambassador from the King of France to Portugal, who procured the first seeds from a Dutchman, who obtained them from Florida. See TOBACCO.

NICOTIANINE. This is a concrete volatile oil, obtained by distilling tobacco leaves with water; a turbid liquid comes over, and after standing some time, this oil forms on the surface; only a very small quantity is produced, six pounds of the leaves yield only eleven grains.

This oil is solid, has the odour of tobacco, and a bitter taste. It is volatile, insoluble in water and the dilute acids, and in alcohol and ether, but soluble in caustic potash. It has a resemblance to camphor, and was called by Gmelin, "Tobacco Camphor." According to M. Barral, nicotianine should yield some nicotine by distillation with potash.

The formula for it is probably $C^{46}H^{32}N^2O^6$.

May it not be an oil, deriving its smell, taste, &c., from a small quantity of nicotine which is mixed with it?—H. K. B.

NICOTINE. This alkaloid is the active principle of the tobacco plant; it was first obtained, in an impure state, by Vauquelin in 1809. It is contained in the different species of tobacco, probably in the state of malate or citrate. It was obtained pure by Possel and Reimann from the leaves of the *Nicotiana Tabacum*, *Macrophylla rustica*, and *Macrophylla glutinosa*. Nicotine and its salts have been examined and analysed by MM. Ortigasa, Barral, Melsens, and Schlœsing.

The following is the process employed by M. Schlœsing for extracting the nicotine from the tobacco. The tobacco leaves are exhausted by boiling water, the extract is then evaporated till solid, or to a syrupy consistence, and shaken with twice its volume of alcohol. Two layers are formed, the under layer is black and almost solid, and contains some malate of lime, the upper layer containing all the nicotine. This latter is concentrated by distillation, and again treated with alcohol to precipitate certain substances. This solution is concentrated, and treated with a concentrated solution of potash; it is allowed to cool, and is then agitated with ether, which dissolves all the nicotine. To the ethereal solution is added powdered oxalic acid, when oxalate of nicotine is precipitated as a syrupy mass. This is washed with ether, treated with potash, taken up with water, and distilled in a salt bath, when the nicotine comes over, and may be rendered pure and colourless by redistilling in a current of hydrogen.

The following are the quantities contained in the various American and French tobaccos, according to M. Schlœsing:

100 parts of tobacco dried at 212°—

	Nicotine.
Virginia	6·87
Kentucky	6·09
Maryland	2·29
Havannah (cigares primera), less than	2·00
Lot	7·96
Lot-et-Garonne	7·34
Nord	6·58
Ille-et-Vilaine	6·29
Pas-de-Calais	4·94
Alsace	3·21

M. Melsens has observed the presence of nicotine in the condensed products of of tobacco smoke. The oil which is formed in pipes after smoking tobacco in them, and which gives the colour to the pipe contains nicotine. The question may then perhaps be asked, "if tobacco smoke contains such a deadly poison, why are there not more ill effects from smoking." It may perhaps be answered in this way; tobacco when smoked only yields about $\frac{1}{150}$th or less of its weight of nicotine, and then very little of that is condensed in the mouth. And again the system may become accustomed to it, as is the case with opium eaters, and *then* it requires much more to take an effect; it can scarcely be doubted though, that the continual habit of smoking large quantities of tobacco is injurious.

Nicotine when pure is a colourless, transparent, oily liquid possessing an acrid odour and an acrid burning taste. Its density is 1·024, and that of its vapour 5·607. It restores the blue colour of reddened litmus, and renders turmeric brown. It becomes yellowish by age, and when exposed to the air becomes brown and thick, absorbing oxygen. It is very soluble in water, alcohol, and the oils (fixed and volatile); also in ether, which has the power of extracting it completely from its aqueous solution.

It is very hygrometrical; exposed to a moist atmosphere, it rapidly absorbs water, but loses it again in an atmosphere dried by potash. When thus hydrated it becomes a solid crystalline mass if exposed to the cold of a mixture of ice and salt. When anhydrous it does not become solid at 14° F. It boils at 482° F., and is at the same time slightly decomposed; but notwithstanding its high boiling point, it may be easily distilled with the vapour of water without decomposition.

The vapour of nicotine is so irritating, that we should experience a difficulty of breathing in a room where a drop of that alkaloid had been volatilised. Its vapour burns with a white smoky flame, depositing charcoal, like an essential oil. Nicotine turns the plane of polarisation strongly to the left. From the volume of its vapour, and from the quantity of sulphuric acid required to form with it a neutral salt, the formula of nicotine would appear to be $C^{20}H^{14}N^2$; but from some of its combinations it would appear to be half of this, viz. $C^{10}H^7N$, and is so written by some chemists.

By the aid of heat nicotine dissolves sulphur, but not phosphorus. Nicotine unites with acids, forming salts, which are very deliquescent, difficultly crystallisable, insoluble in ether, except the acetate, and when pure possess no smell, but an acrid tobacco taste. The double salts which nicotine forms crystallise much more easily.

The aqueous solution of nicotine is colourless, transparent, and strongly alkaline; it forms a white precipitate in a solution of corrosive sublimate, also in a solution of acetate of lead, and with both chlorides of tin. The precipitate which it forms with solutions of the salts of zinc is soluble in an excess of nicotine. Salts of copper give with it, at first, blue precipitates, but these dissolve in excess of nicotine, forming a deep blue solution, as they do when supersaturated with ammonia. Bichloride of platinum yields with it a yellow granular precipitate. A solution of permanganate of potash is immediately decolorised by a solution of nicotine.

Pure concentrated sulphuric acid turns nicotine red, in the cold, and by the application of heat the liquid becomes thick and darker, and when boiled with it, becomes black, and gives off sulphurous acid.

With cold hydrochloric acid it gives off white fumes, just as ammonia does; when heated, the mixture becomes more or less violet-coloured.

Nitric acid communicates to it, by a gentle heat, an orange yellow colour, with disengagement of red vapours which become deeper as the temperature is raised, until after prolonged ebullition nothing but a black mass remains. Chlorine acts very strongly on it, disengaging hydrochloric acid, and yielding a blood red liquid.

Iodine water precipitates it of a brown colour.

Nicotine is a most powerful poison, one drop put on the tongue of a large dog being sufficient to kill it in two or three minutes.

The quantity of nicotine contained in any sample of tobacco, may be determined as follows; about 150 grains of the tobacco is exhausted, in a continuous distillation apparatus, by means of ammoniated ether; after driving off the ether and ammonia by heat, the quantity of nicotine may be determined by a standard solution of sulphuric acid; 500 pts. of sulphuric acid (anhydrous SO^3), neutralising 2025 pts. of nicotine (*Schlœsing*). — H. K. B.

NITRATE OF AMMONIA. See AMMONIA NITRATE.

NITRATES OF LEAD, POTASH, SILVER, SODA, STRONTIA. The salts of nitric acid, which are employed in the arts, are described under the heads of the metallic or earthy constituent.

NITRE. The common and technical name for Nitrate of Potash. See POTASH, NITRATE. Our *imports* and *exports* in 1857, were:—

Nitre, Cubic:— *Imports.*

	Cwts.	£
Hanse Towns	24,775	24,763
France	7,971	8,701
United States	25,408	24,467
Peru	293,517	295,245
Other parts	2,832	2,659
	354,503	£355,836

Exports.

Nitre, Cubic : —

	Cwts.	£
Russia — Northern Ports	924	924
Sweden	316	316
Belgium	478	478
Portugal	769	769
Spain	402	402
British West Indies	6,691	6,691
Other countries	790	790
	10,370	£10,370

NITRIC ACID, *Aquafortis* (*Acide nitrique*, Fr. ; *Salpetersaüre*, 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. The formula of the hydrated acid is HO,NO^5, its equivalent being 54.

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 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 are described under HYDROCHLORIC 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.

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 redistillation 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.

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 oxidises it rapidly, and evolves fumes of nitrous gas with explosive violence. In two papers upon nitric acid published by Dr. Ure in the fourth and sixth volumes of the Journal of Science (1818 and 1819), he 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 equilibrum 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.

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	1·2827	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	51·068	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	66·155	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

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.

It has been proposed to decompose nitrate of soda by the action of boracic acid, so as to produce biborate 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 crystallised 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 1 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 crystallised.

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. 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. Chlorine issues from a glass gasometer, it passes over chloride of lime, and then over pumice-stone moistened with sulphuric acid; it then passes through the nitrate of silver. 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.

NITRO-BENZOL (Azobenzol). $C^{12}H^5(NO^4)$. It is important in the arts, both as a source of analine for the manufacture of dye-colours, and on account of its use for flavouring as a substitute for oil of bitter almonds, which it closely resembles in flavour when pure, and over which it has the advantage of not being poisonous.

It is prepared from benzol (which see), by adding it drop by drop to hot fuming nitric acid; the nitrobenzol separates on dilution with water in the form of a yellowish oil, which may be purified by washing with water alone, or a solution of carbonate of soda. It has a density of 1·209, at 60° F. (15·5 C.), and just above the freezing point of water is converted into a crystalline solid.

It is nearly insoluble in water, but alcohol and ether dissolve it in all proportions. Its conversion into analine under the influence of reducing agents has been before mentioned. See ANALINE.

Nitrobenzol may be viewed as having been derived from benzol, $C^{12}H^6$, by the substitution of one equivalent of hydrogen by the tetroxide of nitrogen, thus:—

$$C^{12}\left\{\begin{matrix}H^5\\NO^4\end{matrix}\right.$$

H. M. W.

NITROGEN. *Symbol* N; *equivalent*, 14; *combining measure, two volumes; specific gravity*, 0·9713; *Syn.* Azote. (*Nitrogène ou Azote*, Fr.; *Stickstoff, Salpeterstoff*, Germ.) This gas, which serves so important a purpose in diluting the atmospheric oxygen to the point necessary for healthy respiration, has been known in a more or less impure state since 1772, when Dr. Rutherford showed that the vitiated air from the lungs contained a principle incapable of supporting life, but differing from carbonic acid. *Preparation.* — Nitrogen is usually prepared from atmospheric air by removing its oxygen. This may be done in a variety of ways. 1. By burning some substance in a confined portion of air, and removing the oxide by a solvent. Thus alcohol burnt in air yields nitrogen, water, aud carbonic acid. The water condenses, and the carbonic acid may be absorbed by agitation with lime water. The oxygen may also be taken away by the combustion of phosphorus. The phosphoric acid produced, being soluble in water, is easily removed. 2. The most elegant mode of obtaining the nitrogen, and one which, properly performed, is susceptible of the highest quantitative accuracy, is to pass air over red-hot copper, which absorbs the oxygen forming oxide of copper, pure nitrogen remaining. 3. The oxygen of atmospheric air may also be removed by certain solvents. A solution of pyrogallate of potash, or, rather, a solution of pyrogallic acid in an excess of potash, takes the oxygen from air with great rapidity and great precision. Upon this fact Liebig has founded his process for estimating the percentage of oxygen in certain gaseous mixtures. A very pure nitrogen may be obtained, according to Corenwinder, by heating a solution of nitrite of potash with chloride of ammonium. Nitrogen may be obtained from ammonia by the action of chlorine which combines with the hydrogen. Flesh gently heated with diluted nitric acid yields the gas contaminated with its binoxide. The latter may conveniently be got rid of by passing the gases liberated through two Liebig's potash bulbs filled with a moderately concentrated solution of protosulphate of iron. *Properties.*—Nitrogen has, more especially until lately, been regarded as one of the most inert of the elements, as a body with but slight tendency to enter into combination, and, when combined, being easily removed by even the least energetic reaction. This opinion has been founded on too limited a study of its properties. It is true that with some elements it unites but feebly, and such combinations are, in a few cases, decomposed by the slightest causes; and, in the case of the so-called iodide and chloride, by mere friction or percussion. But the energies of nitrogen are not to be estimated from these compounds alone. There are bodies with which it exhibits an intense desire for union, among these may be mentioned carbon, titanium, and boron. Hydrogen and certain organic groups also unite readily with nitrogen, forming stable and highly characteristic classes of compounds.

Compounds of nitrogen with oxygen.—The following table contains the composition and principal physical properties of the oxides of nitrogen:—

Table of the Composition and Physical Properties of the Oxides of Nitrogen.

Name.	Formula.	Specific gravity of gas.	Combining vol.	Atomic weight.	Weight of 100 c. inches of gas or vapour.
Protoxide of nitrogen, *syn.* nitrous oxide or laughing gas - - - -	NO.	1·527	Two volumes.	22·	46·3 grains
Binoxide of nitrogen, *syn.* nitric oxide - - -	NO^2.	1·039	Four volumes.	30·	32·2 "
Nitrous acid, *syn.* hyponitrous acid - - -	NO^3.	2·630	Two volumes.	38·	81·5 "
Peroxide of nitrogen, *syn.* hyponitric acid - -	NO^4.	1·720	Four volumes.	46·	53·3 "
Nitric acid - - -	NO^5HO or NO^6H			63·	

In the above table the densities of the vapours of nitrous and nitric acids are given as obtained by calculation on the hypothesis that they could exist at 60° and 30 inches without condensation. That is to say, as the numbers would come out in a determination of the vapour density by the method by M. Dumas.

Determination of the purity of nitrogen gas.—The simplest and most accurate process is that of M. Bunsen. The first thing is to determine whether a combustible gas containing oxygen be present. For this purpose it is merely necessary to pass an electric spark through the gas contained in a eudiometer. If the bulk remains unaltered the absence of any considerable amount of combustible gas mixed with oxygen is proved. But they may be present in such small quantity, as compared with the noncombustible gas, that no explosion can ensue on passing the spark. It is then necessary to add some battery gas in order to render the mixture inflammable. [By "battery gas" is understood the gas obtained by the electrolysis of water.] For the purpose of the experiment we may add to every 100 volumes of the gas under examination 40 volumes of battery gas. If the volume after explosion be unaltered the total absence of oxygen and combustible gases is demonstrated. It is still possible that the nitrogen may be contaminated with oxygen, although inflammable gases are absent. To determine this fact we must add both hydrogen and battery gas in such proportions that the volume of the original gas plus hydrogen is to that of the battery gas as 100 : 40. If no oxygen be present the volume after explosion will be that of the original gas and the hydrogen. The reason being that if oxygen had been present some of the hydrogen would have disappeared in order to form water. The nitrogen gas may still be contaminated by a trace of a combustible gas. To determine this point as much common air is to be added to the last mixture containing hydrogen, as will form a detonating mixture with that hydrogen. This detonating mixture so produced should form from 26 to 64 per cent. of the incombustible gases.

If, on making the explosion, it is found that two thirds of the condensation is equal to the volume of the hydrogen added, it will show that no combustible gas was present, and that, therefore, the original gas consisted of pure nitrogen.

Special affinities of nitrogen.—In the same manner that ordinary metallic substances absorb oxygen with avidity from the atmosphere, especially at more or less elevated temperatures, so other elementary bodies combine with nitrogen to form the nitrides. Messrs. Wöhler and Sainte-Clair Deville have carefully investigated this subject and with great success. When a mixture of titanic acid and charcoal is heated in a charcoal tray (contained in a charcoal tube) to a temperature sufficient to fuse platinum, and a current of dry nitrogen is sent over the mixture, the gas is absorbed with such rapidity that, no matter how rapid the current, none escapes from the tube.

Boron also possesses great tendency to combine with nitrogen at high temperatures. Amorphous boron heated in a current of ammonia becomes incandescent, the nitrogen is absorbed and the hydrogen escapes, and may be inflamed at the exit of the apparatus. A mixture of boracic acid and charcoal, if ignited in a current of nitrogen, yields the white infusible nitruret of boron, first described by Mr. Balmain under the name of Æthogen, but subsequently more accurately investigated by M. Wöhler.

Silicon also combines with nitrogen under favourable circumstances. These facts, coupled with the old experiment made by the French chemists on the nitruret of potassium and the action of ammonia at a red heat upon iron, show that nitrogen is far from being the inert substance generally supposed.—C. G. W.

NITROGEN, DEUTOXIDE OF; *Nitrous gas, Nitric oxide* (*Deutoxide d'azote*, Fr.; *Stickstoffoxyd*, Germ.), NO^2, 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 that $\frac{1}{20}$ 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 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, PROTOXIDE OF, *Nitrous Oxide* (*Protoxide d'Azale*, Fr.; *Stickstoffoxydul*, Germ.), is a gas which displays remarkable powers on the system when inhaled, causing in many persons unrestrainable feelings of exhilaration, whence it has been called the laughing or intoxicating gas; but the effects often vary. When pure this gas does not seem to be injurious; but the bad effects which sometimes follow its use are most probably due to the use of the gas when not quite pure.

It was first discovered by Dr. Priestley in 1776, and was afterwards studied by Sir H. Davy, who called it nitrous oxide; it was Davy also who first observed its stimulating effects when taken into the lungs.

It is prepared by heating solid nitrate of ammonia in a flask, provided with a bent tube to carry away the gas; care must be taken, in applying the heat, to avoid the tumultuous disengagement of the gas: the nitrate melts and enters into gentle ebullition, and the gas is steadily evolved. If too much heat be applied the flask becomes filled with white fumes, which have an irritating odour, and the gas which comes over is little else than nitrogen. Protoxide of nitrogen should always be collected over warm water, as cold water dissolves nearly its own volume of this gas. The following equation expresses the decomposition of the nitrate of ammonia:—

$$NH^4NO^6 = 2NO + 4HO,$$

the only products being water and protoxide of nitrogen. Protoxide of nitrogen, at ordinary temperatures, is a colourless, transparent, and almost inodorous gas, of distinctly sweet taste, Its specific gravity is 1·525; 100 cubic inches weigh 47·29 grains; it is therefore much heavier than atmospheric air. It supports the combustion of a taper or a piece of phosphorus with almost as much energy as pure oxygen; it is easily distinguished, however, from that gas by its solubility in cold water, and by not forming red fumes when mixed with binoxide of nitrogen. It has been liquefied, although with difficulty; it requiring at 45° F. a pressure of 50 atmospheres; the liquid when exposed under the bell-glass of an air-pump is rapidly converted into a snow-like solid.

When mixed with an equal volume of hydrogen, and fired by the electric spark in the eudiometer, it explodes with violence, and liberates its own measure of nitrogen; every two volumes of the gas contain therefore two volumes of nitrogen and one volume of oxygen condensed into two volumes. By weight it contains 14 parts of nitrogen to 8 of oxygen, its equivalent being therefore 22, and its symbol NO. —H. K. B.

NITRO-GLUCOSE. When we act on finely powdered cane sugar with nitro-sulphuric acid, a pasty mass is first formed; if this be stirred for a few minutes lumps separate from the liquid. When these lumps are kneaded in water, until every trace of acidity is removed, they acquire a white and silky lustre; these are the above-named substance.

NITRO-MURIATIC ACID; *Aqua regia* (*Acide nitro-muriatique*, Fr.; *Salpetersalzsäure, Königswasser*, Germ.); is the compound menstruum invented by the alchemists for dissolving gold. If strong nitric acid, orange-coloured by saturation with nitrous or hyponitric acid, be mixed with the strongest liquid hydrochloric 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 platinum. But if colourless concentrated nitric acid and ordinary hydrochloric acid be mixed together, the mixture immediately becomes yellow, and acquires the power of dissolving these two noble metals. Mr. E. Davy seems first to have obtained a gaseous compound of chlorine and binoxide of nitrogen in 1830, and a combination of these two constituents was distilled from *aqua regia*, and liquefied by M. Baudrimont in 1843. But it was not until M. Gay-Lussac investigated the subject (*Annales de Chimie*, 3me, sér. xxiii. 203; or *Chemical Gazette*, 1848, p. 269) that the true nature of the mutual action of nitric and hydrochloric acids was fully explained. When these two acids are mixed in a concentrated state, a reaction soon commences, the liquid becomes red, and effervescence takes place, from the escape of chlorine and a chloronitric vapour. On passing this gaseous mixture through a U tube, the bent part of which is immersed in a freezing mixture of ice and salt, the chloro-nitric compound is condensed as a dark-coloured liquid, and is thus separated from the chlorine which accompanied it.

Chloro-nitric acid, NO^2Cl^2, may be represented as a peroxide of nitrogen, in which two equivalents of oxygen are replaced by two equivalents of chlorine. This chloro-nitric acid does not take any part in the dissolving of gold and platinum, which is effected by the chlorine alone. Chloro-nitric acid may also be formed by mixing the two gases, binoxide of nitrogen and chlorine, in equal volumes, which assume a brilliant orange colour, and suffer a condensation of exactly one-third of their original volume. Another compound of chlorine and binoxide of nitrogen always appears simultaneously with this in variable proportions. Its composition is NO^2Cl, and may be represented as nitrous acid (NO^3), in which one equivalent of oxygen has been replaced by one of chlorine. It is a vapourous liquid, possessing similar properties to the other, but having a much greater vapour density.

The theoretical vapour density of the chloro-nitric acid is 1·74, and that of the chloro-nitrous acid 2·259.

The vapours of both these compounds are decomposed, when conducted into water, into hydrochloric acid and hyponitric acid or nitrous acid. They are also decomposed by mercury; the chlorine combining with the metal, leaving pure binoxide of nitrogen.

Various proportions of nitric and hydrochloric acids are used in making aqua regia; sometimes two or three parts, and sometimes six parts of hydrochloric acid to one part of nitric acid; and occasionally chloride of ammonium, instead of hydrochloric 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 hydrochloric acid.—H. K. B.

NITROUS ACID (NO^3; equivalent, 38), is obtained by mixing four measures of binoxide of nitrogen with one measure of oxygen; they unite and form an orange-red vapour, which when exposed to a temperature of 0° Fahr. condenses to a thin mobile green liquid. It is decomposed by water, and is converted into nitric acid and binoxide of nitrogen.

$$3NO^3 + HO = HNO^6 + 2NO^2.$$

On this account it cannot be made to unite directly with metallic oxides; the salts of this acid are therefore obtained by an indirect process. Nitrate of Potash, when exposed to a high temperature, is decomposed, losing oxygen and becoming nitrate of potash; some caustic potash is also formed at the same time. To obtain it pure, this is dissolved in water, and while boiling we had nitrate of silver, when we obtain first of all a dark precipitate of oxide of silver, caused by the caustic potash; which is separated by a filter, and on cooling the liquid the nitrate of silver crystallises in white needles, which may be purified by recrystallisation. From this salt the pure nitrites may be obtained; for instance, by adding to a solution of nitrite of silver chloride of potassium we obtain the potash salt

$$AgNO^4 + KCl = AgCl + KNO^4.$$

Hyponitric Acid (NO^4, equivalent 46) is best procured by distilling, in a coated glass retort, perfectly dry nitrate of lead. Hyponitric acid and oxygen pass over into a receiver, surrounded with a freezing mixture; the former condenses into a liquid, while the oxygen passes off by the safety tube, and only oxide of lead remains in the retort. This hyponitric acid or *peroxide of nitrogen* is a liquid, colourless at — 4° Fahr., but is at higher temperatures yellow and orange. It boils at 82° Fahr., gives off a dark red vapour, which becomes almost black when further heated. A beautiful lead-salt of this acid has been discovered by M. Péligot. It is formed by digesting a dilute solution of nitrate of lead with finely divided metallic lead at a temperature between 150° and 170° Fahr. See *Ure's Chemical Dictionary.* —H. K. B.

NOBLE METALS. This was a division formerly adopted; it included those metals which can be separated from oxygen by heat alone; these are mercury, silver, gold, platinum, palladium, rhodium, iridium, and osmium.

NOILS is the term used in the worsted trade for the short wool taken from the long staple by the process of combing, and is used to give apparent solidity or thickness in the handling of cloth.

NON-INFLAMMABLE FABRICS. See Muslin, *non-inflammable.*

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,* of Thunberg, *M. Officinalis* of Linnæus, a very beautiful tree of the family of the *Laurineæ* of Jussieu.

The nutmeg grows in the Molucca Islands; it is cultivated in Java, Singapore, Sumatra and many islands of the Indian Ocean, and also in some parts of the West Indies. The Dutch it is said endeavoured to confine the growth of the nutmeg to three of the Banda Isles; but their attempts were frustrated by a pigeon, called the nutmeg bird, which, extracting the nutmeg from its pulpy pericarp, digests the mace, but voids the nutmeg in its shell, which falling in a suitable situation readily germinates. Young plants thus obtained are used for transplanting into nutmeg parts. In the Banda Isles there are three harvests annually; the ripe fruit is gathered by means of a barb attached to a long stick, the mace separated from the nut, and both separately cured.

Mace is prepared for the market by drying it for some days in the sun; some flatten it by the hands in single layers, others cut off the heels, and dry the mace in double blades.

Nutmegs require more care in curing, on account of their liability to the effects of an insect (the nutmeg insect). They are well and carefully dried in their shells, by being placed on hurdles, or gratings, and smoke dried for about two months by a slow wood fire, at a heat not exceeding 140° Fahr.

Dr. Pereira informs us that, "In the London market, the following are the sorts of round nutmegs distinguished by the dealers:

"1. *Penang nutmegs.* These are unlimed or brown nutmegs. They are sometimes limed here for exportation, as on the continent the limed sort is preferred. According to Newbold the average amount annually raised at Penang is 400 piculs (of 133½ lbs. each).

"2. *Dutch* or *Batavian nutmegs.* These are limed nutmegs. In London they scarcely fetch so high a price as the Penang sort.

"3. *Singapore nutmegs.* These are a rougher, unlimed, narrow sort, of somewhat less value than the Dutch kind. According to Mr. Oxley, 4,085,361 nutmegs were produced in Singapore in 1848, or about 252 piculs (of 133½ lbs. each), but the greater number of trees had not come into full bearing; and it was estimated that the amount would in 1849 be 500 piculs."

The *long* or *wild nutmeg* is also met with in commeree.

Mace of two kinds is found in the market, the *true* and *false.*

Of the the true maces, there are the following varieties:—

1. Penang maee. This fetches the highest price. It is flaky and spread. The annual quantity produced in Penang is about 130 piculs (133½ lbs. each).

2. The Dutch or Batavian mace.

3. The Singapore mace.

The wild or false mace is devoid of aromatic flavour.

The uses of nutmegs and mace in dietetics are well known; an essential oil of nutmegs (*Oleum myristicæ*), is obtained by submitting water and nutmegs to distillation.

In 1857 and 1858 our importations of nutmegs and maee were as follows:—

Imports of Nutmegs.

	1857. lbs.	1858. lbs.
Holland	10,165	28,341
Java	18,739	22,055
United States	18,826	
British East Indies	394,984	372,077
British West Indies	6,147	4,085
Other parts	6,111	227
	462,972	421,785

Of these, in 1857, 101,061 lbs., and in 1858, 232,834 lbs., were entered for home consumption.

Imports of Mace.

	1857. lbs.	1858. lbs.
Holland	950	2,233
Sumatra	1,286	
Java	5,789	7,341
Philippine Islands	1,338	
British East Indies	105,099	83,341
British West Indies	949	443
Other parts	832	691
	116,283	93,924

Of this quantity, in 1857, 24,176 lbs. and in 1858, 29,549 lbs. were entered for home consumption.

NUTMEG, BUTTER OF. See OILS.

NUT-GALLS. See GALL-NUTS.

NUT OIL. An oil professedly obtained from waluuts, which is thought to be superior to the best linseed oil for delicate pigments; when deprived of its mucilage it is pale, transparent, and limpid. See OIL.

NUTRITION, or the process for promoting the growth of living beings, occupies a most important position in the study of physiology, and in the important practical question of health. In some of the more succulent plants we observe that they increase in volume after detachment from their parent soil, by the absorption of the nutriment which they find in the atmosphere, viz. oxygen, vapour of water, carbonic acid, and ammonia. But all these are gaseous bodies or vapours, while the plant itself is a solid. Hence we infer that such a plant is capable of reducing gases to a solid form, and of thus increasing in bulk and weight. It appears that all plants are similarly endowed, and that they mainly subsist by feeding on the gases which surround them, by converting these elastie fluids, assisted by the elements of the soil, by means of the organs with which they are supplied, into the solid forms of the vegetable kingdom, so endless in figure, but yet so lovely that the greatest familiarity only renders them objects of superior admiration. When we turn to the animal world we find that the individuals of which it is eomposed are ineapable of eondensing gases. The least educated person knows that animals cannot subsist on air, but that they require to imbibe solid matter, which, by research, it has been found must be similar to that of which they themselves consist. Hence an animal may be defined to be, a being which subsists by appropriating to itself food similar to the matter of which its own body is composed. A reason is thus found for its locomotion; while a plant finding its nourishment in the air in which it is immersed has its food brought to it by the usual laws of inanimate nature. In some of the lower parts of the animal scale it has been found that matter exists (cellulose) identical with that supposed to be peculiar to vegetables, and hence it may be probable, that, as nature is simple in her works, the animated world consists of a chain, formed of a series of beings, passing down in regular gradation, from comparatively the most perfect to the most imperfect state; the lowest plant being closely allied to the lowest form of animal. If this be so, it will at once be obvious, that to say where plants begin and animals end, cannot be a problem of easy solution. But even in the higher classes of animals substances usually considered characteristic of vegetable life have been recently believed to have been detected. But the occurrence of such materials in the animal structure upon a limited scale, might be possibly accounted for by processes of reduction, so peculiarly the distinguishing feature of the chemistry of animals, rather than by constructive means, such as denote the result of vegetable activity.

The determination of the proper food for animals is a great experiment, and must be guided by the light of science. In reference to the human race, we must carefully study the habits and the results of the instinct of the inferior animals subsisting on similar aliment. For it is evident that there are certain laws which naturally regulate the lower beings in the choice of their food. It would be a phenomenon to hear of the suicide or accidental death, from choice of food, of a domesticated animal, still more so, of that of a creature which is free to roam amid the wild scenes of nature. We can recall but an isolated case of the failure of animal instinct with regard to the selection of food. It was in the instance of a pony which swallowed a quarter of an ounce of dried and powdered monkshood (*Aconitum napellus*). The animal suffered considerably, as if under an attack of glanders, for a few hours. But these occurrences are so rare, that it might almost be affirmed, that man is the only created being which disobeys the laws of nature. It is merely when domesticated, and under circumstances analogous to those in which man himself is placed, that we find the inferior creation imitating, by such experiments, the example of their more godlike superiors.

The consideration of the subject of nutrition comprehends the nature of nutriment or food, and of its change into blood, and into the solids and fluids of the animal structure. Food is required in proportion to the wear and tear of the body. The waste which the animal system thus undergoes varies with the age and the labour to which the animal is subjected. Hippocrates knew that children are more affected by abstinence than young persons; these more than the middle-aged, and the latter more than old men. In conformity with this observation, Dante has framed the stirring incidents in the story of Count Ugolino, a nobleman of Pisa, who was confined, with his four sons, in the dungeon of a tower, the key of which being cast into the river Arno, they were, in this horrible situation, starved to death. On the fourth morning, the youngest child "sunk in death," while the others followed "one by one." From the history of the slave traffic we learn that many of the poor Africans, torn from their country and friends, often prefer death in various forms to a life of bondage. Some of them have been known to starve themselves to death; and in two cases, in which the details are graphically supplied, the pains of the sufferer were terminated "in eight or ten days," while in the other case the mortal scene was closed on the ninth day. (*Dr. Trotter*, *Mr. Wilson*, 1790, *Parliam. Com.*) An interesting incident has been recorded of a North American Indian, the last of his tribe, which had been thus almost extinguished by small-pox. He resolved to die; and, abstaining from all nutriment, perished on the ninth day. (*Catlin.*) In order to study the nature of the process of nutrition, we are obliged to take advantage of all the avenues to knowledge which present themselves, in viewing the animal system. One of the readiest means seems to be, to ascertain how, without the use of food, the built-up animal loses weight, languishes, and dies, under the conditions of inanition; and for this purpose we have too frequent opportunities among the children of the poor in ill-ventilated, lowly dwellings; or we may experiment upon an inferior animal, ascertain daily its loss of weight by absence of nutriment, and after the lapse of a sufficient period, feed it with aliment carefully analysed. The gradual change in the weight occasioned by the passage of the food from the stomach into the circulation, is then to be watched, and the further influence on the system by its disappearance in the form of excretions, and of expiration by the lungs and skin. Death is occasioned in the instances related, by starvation, as it is termed in common language. In other words, the oxygen which a human being is compelled to introduce into his lungs daily, to the extent of $32\frac{1}{2}$ ounces, combines with the carbon and hydrogen of the solid tissues of the body, to be expired in the form of carbonic acid. The amount of carbon actually consumed has been found to be $13\frac{9}{10}$ ounces. The consumption of the carbon and hydrogen in each animal must depend on the oxygen introduced by respiration. Hence the child, as in the tragedy of Dante, whose respiratory organs are in great activity, requires a more frequent supply of food, and in greater abundance than an adult. A bird deprived of food, dies on the third day; — while, a serpent — which, when confined in a bell jar of air, consumes in an hour so little oxygen that the carbonic acid formed is inappreciable — can live without food for three months or longer. (*Liebig.*) It has been found that turtle-doves, when kept without solid food for seven days, lost 4·12 per cent. of their weight, and 2·696 per cent. of carbon by respiration, having exhaled daily 3·722 per cent. when fed on millet; the excrements weighed ·21 per cent. of the weight of the body. (*Boussingault, Ann. Chim.* 3 sér. 11, 433.) Other researches have shown that mammalia lose daily in starvation 4· per cent., birds, 4·4 per cent.; thus affording a mean of 4·2 per cent. of their weight. (*Chossat.*) A cat, weighing about 90 ounces (2572 grammes), died on the eighteenth day of starvation, losing daily 2·87 per cent. of its weight; the total loss being 51·7 per cent. of its weight. (*Bidder and Schmidt.*) The deductions which have been made from this experiment are that the cat lost 1264·8 grammes of its weight, which consisted of 200·43 grammes of muscle, 132·75 grammes of fat, and 927·62 grammes of water. In another experiment, a cat weighing 3047·8 grammes had injected into its stomach daily 150 grammes of water. The trial was continued for a week, during which the animal lost 438 grammes, or 62·57 grammes daily, a less diminution of weight than when no water was supplied; and hence we can understand, in some measure, the facts which have been detailed of protracted cases of starvation under the influence of water. Of the different parts of the body which relatively sustain diminution of weight in these instances, it appears that the blood undergoes the greatest loss, or about 93·7 per cent. of its weight during the 18 days, the pancreas 85·4 per cent., the fatty tissue 80·7 per cent., muscles and tendons 66·9 per cent., brain and spinal cord 37·6, bones 14·3 per cent., kidneys only 6·2 per cent. of each of their original weights. Hence the loss of weight in starvation is chiefly experienced in the muscles, the blood, and the fat. Half of the loss may be referred to the muscular tissue, a quarter to the fat, and the remaining quarter to all the other organs. It seems to be principally the products of decomposition of the muscles, and of the fat, which are represented in the excretions. With reference to the form in which these portions of the animal frame disappear from the system in the excretions and exhalations, it appears that the daily loss of muscle undergone by an animal was ·611 per cent. of its weight, while the fat was ·422 per cent. These yielded 2·16 per cent. carbonic acid, 1·6 per cent. of aqueous vapour through the skin, ·20 per cent. of urea in the urine, ·008 per cent. sulphuric acid, ·001 per cent of phosphoric acid, ·029 per cent. inorganic constituents of the urine, ·080 per cent. dry fæces (including ·02 per cent. of bilious matter), and 2·24 per cent. of fluid water removed with the urine and fæces. (*Op. cit.*) Such is the elucidation, so far as it has been carried by experiment, of the results of starvation, and of the nature of the products which, by the influence of the atmosphere, are thrown off from the animal system. The next object of interest which has attracted attention, has been the increase of an animal in weight and bulk. An experiment on a cat, weighing 2177 grammes, has shown that the animal in eight days consumed 1886·7 grammes of flesh, 27·4 grammes fat, and increased in weight by 337 grammes. During the experiment, 62·36 grammes of nitrogen were eliminated by the urine. It was calculated that the increase in weight depended partially on the deposition in the system of 40·16 grammes of muscular matter from the food of 143·42 grammes of fat, 178 grammes salts with sulphur, and 134·15 grammes water. Such researches being made with pure animal matter as food, it is easy to perceive that the increase of the animal depends on the simple assimilation or deposition of the animal matter already formed; but when an animal becomes fat by the consumption of vegetables, the question of the origin of the muscle and fat from such a source becomes a legitimate subject of discussion. The nitrogenous matter of vegetables has now been identified with similar bodies found in animals, and therefore we can readily account, for the supply of the waste of muscle, by the assimilation of nitrogenous vegetable food. The origin of the fat in animals fed on the produce of plants is not so obvious.

John Hunter had long ago, in his admirable observations on bees, found (*Phil. Trans.* vol. lxxxii. 128, 1792) that these creatures collect farina or pollen, deposit it at the bottom of their cells, and that other bees knead it and "work it down into the bottom," or spread it over what was deposited there, before converting it into the consistence of paste (bee bread); this he discovered in the interior of the maggots: he therefore infers that it is the food of this early condition of the bee, and is not intended "to make wax." The bees when caught returning home, were found with the fine transparent terminal gullet-bag full of honey. When examined on going out in the morning this bag was empty, from which Hunter concluded that the honey was either regurgitated for preservation as future aliment, or passed into the stomach. He shows that the bee bread is not wax, and concludes that "the wax is formed by the bees themselves; it may be called an external secretion of oil, and I have found that it is formed between the scales of the under side of the belly." On examining the bees through glass hives while they were climbing up the glass, he could see that most of them had this substance, for it looked as if the lower or posterior edge of the scale was double, or that there were double scales, but he perceived it was loose, not attached. Finding that the substance brought in on their legs was farina, intended, as appeared from every circumstance, to be the food of the maggot, and not to make wax, and not having yet perceived anything that could give the least idea of wax, he conceived these scales might be it, at least he thought it necessary to investigate them, and therefore took several on the point of a needle, and held them to a candle, when they melted and immediately formed themselves into a round globe; on which he no longer doubted that this was the wax, which opinion was confirmed by not finding those scales but in the building season (*ib.*). It is a remarkable circumstance that foreign chemical physiologists who have interested themselves in this question, and who have merely confirmed Hunter's observations, omit to mention even his name, while they notice that of Huber, a subsequent inquirer.

But that the oil of the food is incapable of supplying the fat of the animal, or of the butter of milk, is clearly established. One of the earliest experiments on this subject may be cited: — two cows were found to have, in the total food consumed, 10·094 lbs. of oil and wax, while the butter of the milk amounted to 72·26 lbs., and the oil and wax in the dung was 52·5 lbs.; showing an excess of 23·82 lbs. of oil in the butter and dung over what originally existed in the food. The conclusion is inevitable that starch and sugar, assisted by the nitrogenous matter, must have yielded fatty material. — *R. D. Thomson, Trans. Med. Chirurg. Soc.*, 1846, vol. xxix.

According to the present views of those best acquainted with this subject, the non-nitrogenous food is that which is especially destined for the production of animal heat, the oxygen of the air yielding heat when it unites with its carbon and hydrogen. "The heat which is produced by respiration is similar to that which is produced by the inflammation of combustible bodies, with this difference, that in the latter instance the fire is separated from the air, in the former from the blood." (*Adair Crawford's Exper. on Animal Heat*, 1779, p. 76.) It is to Crawford that the theory of animal heat is usually attributed. The French claim the honour for Lavoisier. There is no doubt that the latter was engaged with the subject about the same period, but the date of his publication is doubtful, as at that period French writings were usually ante-dated. The doctrine of animal heat, as originally suggested by Crawford, still stands its ground. All the arguments opposed to it are merely trifling attacks upon little indentations in the great curve, which expresses the average theory. When we compare the staple articles of food with the blood, we shall find in the latter fluid corresponding bodies to those constituting the nutriment, as appears in the following parallel columns: —

	Milk.	Flour.	Blood.
Nitrogenous matter - -	Casein. Albumen.	Fibrin. Glutin. Casein. Albumen.	Fibrin. Casein. Albumen. Globulin. Colouring matter.
Non-Nitrogenous matter -	Butter. Sugar.	Oil. Starch.	Fats and oils. Sugar.
Salts - -	Chloride of potassium. " of sodium. Sulphate of soda. Carbonate of soda. Phosphate of soda. " of lime. " of magnesia. " of iron.	Ditto	Ditto.

Law of the Balance of the Food. — The older opinions respecting the nature of nutrition seems to have been that the stomach and digestive organs possessed the power of assimilation, as it was termed. Although this expression might still be used in a restricted sense, the former meaning, which was attached to it, was of a much more extensive nature, and implied a power in the animal system which we now know is not possessed by it. Indeed a comparatively slight acquaintance with medical writers, up to even a recent date, is sufficient to teach us, that a belief existed, that almost any species of organic matter, when subjected to the assimilating powers of digestion, could be rendered serviceable in the support of the body. The great discovery of Beccaria in 1742, in his analysis of flour, ought to have produced a greater revolution in dietetics than it appears to have done. He first observed, that if wheaten flour be washed with water on a sieve, the water becomes milky by the mechanical diffusion of the starch, which in time subsides, while a material like glue, which is not miscible with water, remains. He termed the portion carried away by the water starch, and the soft tenacious residue he denominated gluten (now known to consist of fibrin, glutin, casein). He identified the starch with vegetable matter, while the glutinous portion appeared to be endowed with the character usually attributed to animal matter, and this led him to propose two very simple tests by which the vegetable and animal substances, that is matters containing nitrogen, may be readily discriminated. When vegetable, or non-nitrogenous bodies are digested in water, they do not putrefy, but ferment and yield as a product a vinous or an acid fluid. With these starch corresponds. Animal substances, on the other hand, under the same conditions, putrefy and corrupt, and afford an urinous or ammoniacal fluid. Again, distillation supplies a valuable distinguishing test of the products of the two kingdoms. Vegetable or non-nitrogenous matter, when subjected to this operation, yields an acid product, and a heavy black oil, similar to pitch. Such are the characters of starch. Gluten, like animal or nitrogenous bodies, affords an alkaline spirit — a volatile alkaline salt (carbonate of ammonia), first a yellow, then a black oil, and finally there is left by intense heat, a black spongy matter (charcoal), which in an open fire becomes a white insoluble earth (bone earth). These remarkable observations struck Beccaria with surprise, as he found no traces of any such results in previous writers. For when he had discovered gluten by the simple process already detailed, it appeared to him so identical with animal matter that, if he had not himself extracted it from wheat, he should have mistaken it for a product of the animal world. (*Hist. de l'Acad. de Bologne. Collect. Acad.* x. 1.) These views, which are in exact consonance with the most recent ideas entertained by chemical physiologists, appear to have produced little fruit, although the question put by the author, "Are we composed of other substances than those which serve for our nourishment?" distinctly exhibits the view which he took of the subject. During the present century, a large amount of experiment has clearly demonstrated that animals cannot subsist on starch, sugar, or other foods destitute of nitrogen; and therefore the inference was fairly deduced that the animal system possessed no power of assimilating nitrogen from the air. (*Magendie.*) Further consideration led to the conclusion that milk constitutes the type of what nutriment should be, since it is supplied for animal support by nature at the earliest period of human existence (*Prout*), and contains nitrogenous matter, oil, and sugar. Afterwards experiments were made to determine the amount of nitrogen in food, and the relative value of nutriment was tabularly stated, in dependence on the ratio of nitrogen present in each species (*Boussingault, Ann. de Chim.* lxiii. 225, 1836), a method which has been superseded. It was subsequently inferred that nitrogenous matter supplied the waste of the muscular tissue, while the non-nitrogenous constituents of the food served for respiratory purposes, or the production of animal heat by obviating the too rapid transformation of the muscular elements of the body. (*Liebig, Organische Chemie*, 1842.) This was the true key to the solution of the problem as to the function of the nitrogenous and non-nitrogenous food, and it laid open a wide field for inquiry in reference to the application of rational systems of dieting to the animal system. For example, it was found in a series of experiments conducted for the British Government in 1845, that in a stall-fed cow in one day, taken from an average of several months, the amount of food conveyed into the circulation of the blood of the animal, was 14·56 lbs. weight, and when the nature of this mass of nutriment was subjected to chemical inquiry, it appeared that 1·56 lbs. consisted of nitrogenous matter, and 13 lbs. of non-nitrogenous food. When the relation between these two quantities is calculated, it results that the nitrogenous is to the non-nitrogenous food as 1 to 8·33, in the case of an animal at rest. This observation led to researches into the relative constitution of food as employed by different nations; and the deduction was made, that it is a law of nature, that animals under the different conditions of rest and exertion, require food in which the relation of the nutrient or nitrogenous food is different in reference to the non-nitrogenous or heat-producing (calorifiant) constituent: — that the animal system may be viewed, as, in an analogous condition to a field, from which different crops extract different amounts of matter, which must be ascertained by experiment;—an animal at rest consuming more calorifiant food, in relation to the nutritive constituents, than an animal in full exercise. From the analyses then instituted the following table was constructed.

Approximate relation of nutritive or nitrogenous to calorifiant matter:—

		Relation of Nutritive to Calorifiant Matter.
Milk food for a growing animal		1 to 2
Beans		1 „ $2\frac{1}{2}$
Peas, Linseed		1 „ 3
Scottish oatmeal		1 „ 5
Wheat flour, Semolina, Indian corn, Barley	Food for an animal at rest	1 „ 7 to 1 „ 8
Potatoes		1 „ 9
East Indian rice		1 „ 10
Dry Swedish turnips		1 „ 11
Arrowroot, Tapioca, Sago		1 „ 26
Starch		1 „ 40

These proportions will consequently vary considerably acccording to the richness of the grain or crop, and hence similar tables which have been subsequently published by others will be found to differ in some of the details from the preceding data; but the facts now stated—given as approximate—are probably as good averages as could be selected.—*R. D. Thomson*, *Medico-Chirurgical Trans.* xxix. and *Experim. Researches on the Food of Animals*, 1846, p. 162.

A consideration of the nature of the relations exhibited in this table is sufficient to afford an explanation of many practical results in the subject of diet. Thus in the young of the mammalia,—including the human race,—the heat-forming or non-nitrogenous food, is only two or three times greater than that of the nitrogenous food which is the supporter of the muscular tissue of the body, because the child requires a larger amount of matter to repair its daily waste, and likewise an additional portion to enable it to increase in bulk. Nature has so arranged that, in the milk of the mother, every three or four ounces of the solid particles of that fluid, shall supply one ounce of nitrogenous material. When we compare this result, which is a fact independent of all theoretical considerations, with the condition of the class of starches at the close of the table,— known under the names of arrow-root, tapioca, and sago,—we see, that to supply these to children, would be to deprive them of the possibility of obtaining the requisite nourishment demanded by the wants of their systems. Since to communicate one ounce of nitrogenous matter to them, it would be necessary that they should swallow 26 ounces of starch, a proceeding which upon mechanical considerations alone would be impracticable. Beans and peas have been found much more effective in supporting the strength of animals subjected to hard labour, than grass or other soft fodder; and the reason for this on the principles under review are obvious. A cow weighing about 1000 pounds was found to introduce into its system 15·28 pounds of the solid portions of grass daily; but this was extracted from 100 pounds weight of fresh grass, and contained 1·56 pound only of nitrogenous matter, and 13·1 of heat-forming or respiratory food. To convey this large mass of nutriment into the stomach required the action of the primary organs of digestion during the whole day. While to have introduced a similar amount of nitrogenous matter in the shape of beans, not above 20 pounds would probably have been necessary. Thus by substituting the concentrated form of beans for the bulky grass, a great saving of time is effected in conveying the digestive materials into the current of the blood. The bulky nature too of grass,—from 100 lbs. of which only $15\frac{1}{4}$ pounds of nutritive matter can be extracted,—affords an explanation of the more complicated nature of the stomachs of ruminant animals than of the human family, which practical experience, or instinct as some would term it, has taught to select more concentrated forms of food.

The primary and original food of man, whatever speculators may say to the contrary, is milk, a fluid of purely animal origin. If those who are to regulate diet are not guided by scientific knowledge, and do not exercise their judgment, they might be inclined to draw from this fact the inference, that the proper nutriment of man is animal food. This deduction might be defended with some show of reason to the exclusion of a vegetable diet. But observation having proved that animals can subsist upon a vegetable as well as upon an animal regimen, and scientific research having satisfactorily demonstrated that the constituents of the two kinds of nutriment, when well selected, are identical, the one-sided position must yield to the light of knowledge.

It will be now from these details, in some measure, understood how it happens that for all conditions of society, vegetable food may not be advisable; and that vegetarianism, while it may be applicable in some instances, would be prejudicial in other individual cases. The poetical and merciful sympathies of Pythagoras it is impossible altogether to set aside, although it is unnecessary to echo the sentiment that "the man of cultivated moral feeling shrinks from the task of taking the life of the higher grade of animals, and abhors the thought of inflicting pain and shedding blood;" for even the Greek philosopher, although he objected to slay cattle for the purposes of human food, sacrificed, in a fit of enthusiasm, without any compunction one hundred oxen in commemoration of his discovery, that a square on the hypothenuse of a right-angled triangle, is equal to the sum of the two squares on the base and the perpendicular. Indeed such a cruel result of a scientific discovery has appeared to his admirers so inconsistent, as to induce them to suggest that the oxen were made of wax. It is more probable that, as in modern times, other causes had tended towards a vegetarian conclusion. But his arguments may be heard: "Forbear mortals to pollute your bodies with abominable food. Wild beasts satisfy their hunger with flesh, although not all; for the horse, flocks, herds, feed on grass. But those which have a wild and cruel temper, Armenian tigers, angry lions, bears, and wolves rejoice in bloody food. What a wicked crime it is that bowels should be buried in bowels, and that one greedy body should fatten on another crammed into it, and that one animal should live by the death of another."—*Ovid, Metamorph.* xv. 2.

A practical application, of the law involved in the table, to the nourishment of horses will now be understood. If we represent the amount of muscle removed from the body of a horse to be 2 lbs per day, while the amount of food consumed in the production of heat is 12 lbs., it is obvious that to make up for this loss, we should never think of giving to the animal food containing 2 lbs. of albuminous or muscular matter and 52 lbs. of non-nitrogenous or heat-forming matter, such as sago; neither should we give a diet containing 2 lbs. of albuminous material and 22 of calorifiant ingredients, such as turnips; but we should endeavour to administer nourishment which contained as nearly as possible the ingredients which the animal's consumption required. This object would be nearly attained by the use of oats, which would give for every 2 lbs. of muscular material, 10 lbs. of heat-forming constituents; or by barley 2 to 14. A mixture then of the two grains would supply the nourishment required by the animal, or the same result would follow by the employment of beans and hay. The principle of the arrangement of the food being understood, the nature of the nutriment can be easily calculated for the different conditions in which the animal may be placed.

A continuous study of the table brings us to oatmeal, which constitutes even at the present day an essential element in the support of the Scottish peasant. Wheat is no doubt cultivated to a greater extent than formerly, in northern latitudes, but from the analyses which have been published, it appears to be an undoubted fact that the amount of nitrogen increases, within certain limits, in this species of the Cerealia as the plant advances from the equator. But one cause of the high nitrogenous position held by oatmeal is, that as it is usually prepared it retains much of the bran, which is rich in nitrogen; while in the predominant form of wheat-flour this ingredient is in a great measure removed. When, however, the bran is retained in the flour, as when the entire wheat-seed is ground up and not sifted, the superiority of the nutritious value of oatmeal over wheat-flour has not been demonstrated. The substance termed semolina in the table, consists of bruised wheat from the south of Europe, and corresponds with the manna croup of the north of Europe, and the soojee of India. Illustrations of the fatal effects of this practice have been afforded by feeding calves on sago, a form of farinaceous matter, as exhibited by the table, which is artificially disturbed in its natural equilibrium. For it will be remembered that arrow-root, tapioca, and sago, as they occur in commerce, are the starches of natural flours which have been washed by repeated applications of water, until they have been to a great extent deprived of their nitrogenous matter, and of their saline ingredients. Calves fed on this form of food, have been observed to become most ready victims to passing epidemics. (*Smith of Deanstone.*) For a brief period they seemed not to suffer, but on the approach of disease they were readily subjected to its action, and rarely recovered. The same reasoning will apply to the human species. For if a child were fed on milk entirely (its composition being 1 nutritive to 2 heat-forming, the proper blood salts), and throve as nature intended it should do on this species of aliment, could we expect that the infant would be equally nourished, when a portion of this type of food, was replaced by arrow-root, containing 1 nutritive to 26 of calorifiant material, without any of the saline ingredients required to produce blood? To expect such a result would be opposed to experience and to all analogy. From the table we may infer that the food destined for an animal in full exercise, should range between milk and wheat-flour, according to the nature and extent of the demands upon the system. Milk may therefore be employed with a certain amount of the cerealia with probable advantage. When the food is preserved by nature, by means of combining water as in succulent vegetables, from the severe effects of the vicissitudes of the atmosphere, the most efficient nutriment is afforded to the inferior animals. This is shown in the following table, where an average is given of the products of two cows, in milk and butter, by different species of aliment. The largest amount is obtained from grass, which preserves its equilibrium most firmly during the changes of the seasons, while hay and cereal crops from their want of succulence, and therefore of protection from the rain and fermenting influences, are less influential in effecting a steady product.

	Milk in 5 days. lbs.	Butter in 5 days. lbs.	Nitrogen in Food in 5 days. lbs.
1. Grass - - - - - -	114	3·50	2·32
2. Barley and hay - - -	107	3·43	3·89
3. Malt and hay - - -	102	3·20	3·34
4. Barley, molasses, and hay -	107	3·44	3·82
5. Barley, linseed, and hay -	108	3·48	4·14
6. Beans and hay - - -	108	3·72	5·27

It had been found by experiment, that, not only in hay-making is the colouring matter of the grass removed or altered, but, particularly in moist districts, the sugar or heat-forming portion of this form of provender is washed out by the rains or destroyed by fermentation, while a certain proportion of the soluble salts absolutely required for the production of animal blood and milk is also removed by every shower which falls during the drying of the hay. In this table the butter and milk of the cow may be supposed to represent the increase of bulk which a growing animal sustains during its infant years; while the richness of these forms of dairy-produce are the well-recognised tests of the value of the soil and pasturage upon which the animals have browsed. By a comparison of the relation of the different kinds of cerealia we may improve one species by mixing it with another. By mixing 1-third of Canada flour with 2 thirds of Indian corn, a very good loaf is produced, and when equal parts of flour and oatmeal, or of barley, or of pea-meal are employed, a nourishing bread is formed. Beneficial results have also followed from the admixture of two or three different kinds of grain, and many of these forms of bread might be substituted with advantage for wheat flour in peculiar conditions of the system. The superior advantage of good wheat flour depends on the presence of gluten, an adhesive nitrogenous principle, which, during fermentation by the resistance which it presents to the escape of the carbonic acid, engenders that vesicular spongy condition which is considered the test of a good loaf. From the absence of this substance in other kinds of grain, they are of themselves incapable of affording a spongy loaf, and hence the presence of wheat flour is essential in all well-raised bread. A loaf may be made of equal parts of oatmeal and flour, which when fermented will be highly spongy. It is advisable in such a case to use foreign flour, which contains a larger proportion of adhesive gluten than is found in the wheat flour grown in our northern climate. It may be objected that the recommendation of such mixtures is a direct invitation to bakers to adulterate their flour. But such mixtures are admitted by law with the provision that the letter M be affixed by the baker to the loaf. Indian-corn bread may be baked of good quality by a smaller admixture of flour than is necessary when oatmeal is the other ingredient. For this purpose it should be reduced to a fine meal, in smaller particles than is practised in the United States. It may then be mixed with one-third its weight of best flour, and be fermented in the usual way. When thus baked, the best Indian-corn bread is always dark coloured, and cannot be made much lighter than coarse wheat bread. The shade of colour is yellowish. When Indian corn bread appears white, the conclusion to be drawn is that the mixture consists of more than one-third of wheat flour. Even when one-half its weight of wheat flour is added to it, Indian corn exhibits in the mixture its characteristic dark tint. See BREAD. The position which potatoes hold in the nutritive scale, shows that although they are frequently used in the mode of preparing bread by fermentation, no advantage would be gained by augmenting their amount, since the aliment would thus be rendered more dilute and the statement of the poet confirmed:—

"Bread has been made (indifferent) from potatoes."—*Byron.*

At the present day the New Zealanders are affected, to the extent, in some districts, of 20 per cent., in others of 10 per cent., with external marks of scrofula, a fact which was not observed by Capt. Cook. This disease is therefore inferred to be a modern innovation, brought about by the natives having lived since Cook's time on potatoes, which have superseded fish and pig's flesh in a great measure. It is only necessary to see a child after a month's residence in the house of a European, to have an indication of the magic influence better diet would have on the whole race. The puny limbs of the young savage grow stout, the protuberent belly disappears, and traces of red blood can be seen through the nut-coloured skin of his infant face.—*A. S. Thomson's New Zealand*, i. 216.

Further support of the law enunciated has been afforded by subsequent experiments (*Fresenius*, *Knapp*, *Playfair*, *Liebig*). "A glance at these relations is sufficient to convince us that in choosing his food (when a choice is open to him), and in mixing the various articles of diet, man is guided by an unerring instinct which rests on a law of nature. This law prescribes to man as well as to animals a proportion between the plastic and non-nitrogenous constituents of his whole diet, which is fixed within certain limits within which it may vary according to his mode of life and state of body. This proportion may, in opposition to the law of nature and instinct, be altered beyond these limits by necessity or compulsion, but this can never happen without endangering the health and injuring the body and mental powers of man. It is the elevated mission of science to bring this law of nature home to our minds; it is her duty to show why man and animals require such an admixture in the constituents of their food for the support of the vital functions, and what the influences are which determine in accordance with the natural law changes in this admixture." (*Liebig*, *Fam. Letters on Chemistry*, 1851, p. 362.) It has been shown that when a French soldier is fed on 1 lb. $10\frac{1}{2}$ oz. of bread, he consumes in this ration 1 part of nitrogenous to $4\frac{3}{4}$ of non-nitrogenous material (*Knapp*), and that when pigs were fed on potatoes no augmentation could be detected in their weight. An increase was observed when the diet of the animal was potatoes, butter-milk, whey, and kitchen refuse, but the greatest improvement took place under what was termed a fattening fodder, consisting daily of 9·74 lbs. potatoes; ground corn, 9 lbs.; rye-meal, ·64 lb.; peas, ·68 lb.; butter-milk, whey, and kitchen refuse ·92 lb. (*Boussingault*). In these different modes of dieting, the following were the relations of the constituents of the food:—

	Nitrogenous.		Non-Nitrogenous.
Potatoes - - - -	1	to	$8\frac{3}{4}$
Mixed food - - - - - -	1	„	$7\frac{1}{10}$
Fattening fodder - - - -	1	„	$5\frac{1}{2}$

The German farmer renders the proportion more nearly allied, between the proximate principles of the potato, by fermenting and distilling from them a spirit, and giving the residue thus supplied with a less proportion of heat-forming material to his cattle. It has been supposed in other countries that the German agriculturist is a distiller. On the contrary the production of spirit is a result of what he has found to be by experience, a valuable method of improving the alimentary character of the potato (*Knapp*). All of these explanations have been deduced since the law of the equilibrium of the food detailed above was detected.

The following tables are illustrations of the same law:—

	Weekly Consumption.	Nitrogenous Matter.	Non-nitrogenous Matter.	Mineral Constituents.	Carbon.	Relation of nitrogenous to non-nitrogenous Matter.
	Grms.	Grms.	Grms.	Grms.	Grms.	As 1 to.
DIETARIES OF SOLDIERS AND SAILORS.						
English soldier - - - - -	11703	1119	3937	152	2219	3·50
„ „ in India - - -	9080	1057	3195	74	2053	3·02
„ sailor (fresh meat) - -	9350	1078	3185	98	2184	2·95
„ „ (salt meat) - -	8978	1274	4092	187	2706	3·69
Dutch soldier, in war - - -	6130	1090	3160	57	2293	2·90
„ „ in peace - - -	11857	759	3306	128	2191	4·35
French soldier - - - - -	10742	1029	3955	143	2639	3·84
Bavarian soldier - - - - -	7492	652	3161	103	1933	4·85
Hessian soldier - - - - -	13096	712	4210	- -	2384	5·91
DIETARIES OF CHILDREN.						
Christ's Hospital, Hertford - -	6687	531	1897	76	1213	3·57
„ London - -	7488	534	2378	88	1453	4·45
Chelsea Hospital boys' school - -	7585	401	2888	183	1785	7·20
Greenwich Hospital „ - -	7151	570	2685	81	1637	4·71

	Weekly Consumption.	Nitrogenous Matter.	Non-nitrogenous Matter.	Mineral Constituents.	Carbon.	Relation of nitrogenous to non-nitrogenous Matter.
	Grms.	Grms.	Grms.	Grms.	Grms.	As 1 to
DIETARIES OF AGED PERSONS.						
Greenwich pensioners - - -	8328	757	3784	109	2242	4·87
Chelsea " - - -	10278	905	3487	144	2416	3·85
Gillespie's Hospital, Edinburgh -	4829	651	2858	73	2210	4·39
Trinity Hospital " -	5944	608	3014	104	1774	4·95
DIETARIES OF AGED POOR.						
1st class - - - - -	- -	626	2743	101	1681	4·38
2nd " - - - - - -	- -	463	2773	89	1582	5·99
3rd " - - - - - -	- -	488	3092	121	1716	6·33
4th " - - - - - -	- -	595	3617	123	2101	6·08
5th " - - - - - -	- -	479	2988	111	1694	6·24
6th " - - - - - -	- -	454	2725	88	1535	6·00
Mean of all English counties - -	- -	681	3065	- -	1796	4·50
St. Cuthberts', Edinburgh - -	5418	458	2766	102	1454	6·04
City poorhouse " - -	3312	412	1547	54	975	3·75
DIETARIES OF ENGLISH PRISONS.						
2nd class, above 7 not above 21 days -	6393	472	3463	107	1834	7·34
3rd " 21 " 6 weeks' hard labour - - - - -	9144	565	3827	125	2091	6·77
4th, 7th, 8th classes, above 6 weeks' not above 4 months' hard labour -	8405	649	3900	156	2162	6·00
5th class, above 4 months' hard labour - - - - -	10092	628	4042	131	2270	6·43
BENGAL PRISONS.						
Without labour - - - - -	6935	571	5051	64	2364	8·85
With labour - - - - - -	9464	872	5917	92	2819	6·78
Contractor's insufficient diet - -	5185	393	4209	40	1899	10·71
BOMBAY PRISONS.						
All classes, without hard labour -	5634	867	3142	63	2130	2·08
With hard labour - - - - -	6935	1103	3987	76	2800	3·61
ARCTIC AND OTHER DIETARIES.						
Esquimaux - - - - - -	- -	7740	39628	- -	34830	5·12
Yacut - - - - - - -	- -	3093	19814	- -	29907	6·46
Boschesmen - - - - - -	- -	1777	11393	- -	17182	6·41
Hottentots - - - - - -	- -	1323	12384	- -	18699	9·36
Farm labourers, Gloucestershire -	5065	825	3299	34	2323	3·97
" Dorsetshire - -	3548	631	2243	36	1601	3·55
" Dharwar, Bombay — return in Bombay Prison Dietaries - - - - -	6749	434	4280	77	1905	9·86

In these tables the ounces of the original are calculated as grammes, and the last column gives the relation of the nitrogenous or flesh-forming part of the food, to the non-nitrogenous or heat-producing ingredients of the aliment, instead of, as in the original, the proportion between the carbon of these constituents of the food being estimated. The table is read thus:—an English soldier consumes weekly 11,703 grammes (a gramme equal to 15·44 grains) of food. In this food 1119 grammes are nitrogenous or flesh-forming matter; 3937 non-nitrogenous or heat-producing material; 152 mineral substance; the organic matter containing 2219 grammes carbon. The relation of the nitrogenous to the non-nitrogenous matter is as 1 to 3·50. From this table the results have been deduced that soldiers and sailors consuming 35 ounces of nitrogenous or flesh-forming food weekly, and 70 to 74 ounces of carbon, the proportion of the carbon in the flesh-forming, to that in the respiratory or heat-forming food, is as one to three. Older persons require only 25 to 30 flesh-forming matter weekly, and from 72 to 78 respiratory food; the relation of the carbon in these is as 1 to 5. Boys of from ten to twelve years of age require 17 ounces of flesh-forming matter, the relation of the carbon in the flesh-forming to the heat-producing aliment being as 1 to 5½. In workhouses and jails, less heat-producing matter is consumed, in consequence of the shelter and heat supplied artificially to the inmates. In prisons, where hard labour is in force, the consumption of flesh-forming or nitrogenous nutriment increases. It has been estimated that in a man weighing 140 lbs., the weight of the flesh-forming matter of the blood is 4 lbs., that of the muscular tissue 27½lbs., and in the bones 5lbs., making a total of 36½lbs.; and that in the course of 18 weeks these 36½lbs. are introduced into the system. (*Playfair New Edin. Phil. Journal*, 1854, 56,262.) The author of this elaborate and valuable table has justly remarked that the old mode of estimating the value of dietaries, by merely giving the total number of ounces of solid food used daily or weekly, and quite irrespective of its composition, is most erroneous; and he quotes an instance of an agricultural labourer, in Gloucestershire, who, in the year of the potato famine, subsisted chiefly on flour, consuming 163 ounces weekly, which contained 26 ounces of flesh-forming matter. When potatoes became cheaper, he returned to a potato diet, and now ate 321 ounces weekly, although they contained of true nutriment only about 8 or 10 ounces. A comparison of the six pauper dietaries formerly recommended, with the difference between the salt and fresh meat dietary of the sailor, &c., have no relation in equivalent nutritive value, but merely rely on absolute weight alone. It is by such dietaries, where the proper balance of the constituents is not preserved, that, although the appetite may be satisfied, the waste of the system is not adequately repaired. The health may appear not to be affected in the absence of epidemics, but, under such a dietary as that alluded to, a maximum of labour cannot be obtained from a workman; a frail constitution is engendered, which acts as a fertile soil to miasmata of various kinds. These seeds of disease taking root, are rapidly developed into maladies, like the rank fungi of damp and dismal cellars.

When the constitution of the food is compared in its relations of muscular to fatty matter, with the proportion of these ingredients deposited in animals, the result is of interest. Carefully conducted experiments on the large scale upon animals have shown that in fat animals killed and carefully analysed after death, the carcass of the fat ox contained 1 part of nitrogenous matter to 2⅓ fat; in that of the fat sheep the relation was 1 to 4; in that of the very fat sheep, 1 to 6; and in the moderately fat pig, 1 to 5. In the lean sheep the proportion was 1 to 1½; in the lean pig 1 to 2. The average composition of such well fattened and lean animals was found to be nearly

	Fat animal.	Lean animal.
Nitrogenous matter	12·5	12·87
Fat	33·	25·3
Mineral matter	3·	4·5
Water	51·5	57·33
	100·	100·

It was found by an analysis of some of the most important animals fed and slaughtered as human food, that the entire bodies, even when in a reputed lean condition, may contain more dry fat than dry nitrogenous substances. Of the animals ripe for the butcher, a bullock and a lamb contained rather more than twice as much dry fat as dry nitrogenous matter. While in a very fat pig and sheep, the proportion was 1 muscular matter to 4 fat, and in a moderately fat sheep the fat was three times greater than the nitrogenous matter.—*Lawes and Gilbert, Proc. Royal Society*, No. 32,348—*June*, 1858.

Use of fermented liquids in nutrition. — In the very earliest periods of human history wine appears to have been known, and to have been of the same nature with that which we now use, as the Hebrew term employed to designate the stimulating liquor indicates it as being derived from a fermenting origin (*Pareau. Antiq. Heb.* 396). This, together with its wide spread use, has frequently been considered as an argument in favour of its necessity. But its ubiquity cannot be substantiated. The native Indians of North America, amounting to some millions in number, were unacquainted with fermented products until they were visited by the white man (*Catlin*). When the Spaniards first visited South America, they were astonished at the constitutional temperance of the natives, which in their opinion, far exceeded the habits of the most mortified hermits (*Robertson*, iv.). In Patagonia, within the last 200 years the inhabitants when offered a bottle of brandy would not drink (*Sir J. Narbrough*, in 1669, 8vo. 1711, p. 50). If we refer to Africa, we have the authority of the great traveller who has penetrated into the interior of that mysterious continent, that true to their faith, the Mohammedans "drink nothing but water" (*Park*), and it is only among the Pagan negroes who have frequent intercourse with the coast in consequence of these being the reservoirs from which slavery emanates, and in such semi-civilised towns as Tripoli, that religion is placed in subjection to inebriating indulgences, and that "drunkenness is more common than even in most towns in England" (*Lyon*). It is true that the ancient Gauls and Germans who, however, were somewhat civilised, made use of beer, but whether they did so habitually, or to excess, before they were contaminated by Roman customs, seems unlikely. Certain it is that they had no wine of their own. The Gauls purchased their wine chiefly from Italy, and were exceedingly fond of it (*Diodorus*), and hence they are said to have been invited into that country by the delicacy of the Italian wines (*Livy*, v. 33). Even among the Romans however, in the virtuous days of the Republic, strong drinks were not universally in favour, since it was fashionable in order to make wine keep, to boil it down to one half (*Virgil*), or one third (*Pliny*), in other words, to distil away all the alcohol it contained. All the circumstances, indeed, with which we are acquainted seem to support the view of the historian that, "it is in polished societies where intemperance undermines the constitution" (*Robertson*). These facts seem to prove that alcohol is not a necessary of life. It remains to consider what its influence is upon the system. When fluids containing alcohol are introduced into the body of animals, the amount of carbonic acid evolved from the lungs speedily begins to diminish. The influence of even a small portion of wine begins to be appreciable in a very short space of time after it has been swallowed, so that we infer its power in this respect to be almost consentaneous with its arrival in the stomach. Alcohol itself possesses a similar effect, and the use of porter is attended by the same results. Numerous experiments have demonstrated that alcohol in every state, and in every quantity, uniformly lessens, in a greater or less degree, the quantity of carbonic acid elicited according to the quantity and circumstances under which it is taken. When taken on an empty stomach, its effects are remarkable; the depression is greatest almost instantaneously; after a short time, however, the powers of the constitution appear to rally, then it sinks again, and afterwards slowly rises to the standard. That the action of the alcohol in these cases depends on its influence on the nervous system, and not on its chemical action, is obvious from the fact that strong tea acts in a similar manner, and with the same degree of rapidity; three ounces of strong tea in five minutes after being swallowed depresses the amount of carbonic acid progressively (*Prout* 1813). Other experiments bear testimony to the wonderful effect of alcohol on the nervous system. *Two ounces* of alcohol when injected into the stomach of a rabbit, rendered it immediately insensible, just as if the animal had been violently struck on the head. Two drachms placed in the stomach of a cat, instantly made it struggle violently and fall on its side perfectly motionless and insensible. It is remarkable, too, that the effects of alcohol, and of injuries, more particularly concussion of the brain, so closely resemble each other, that the most accurate observer cannot often distinguish them, except from the history of the case (*Sir B. C. Brodie*). When alcohol is introduced *in excess* into the system, the arterial blood appears to retain the venous condition, and thus asphyxia may be produced (*Bouchardat*). Alcohol it is affirmed, has been detected in small proportion in the air exhaled from the lungs, and also in the blood of drunkards, while a considerable portion of acetic acid, one of the products of its combustion, has been observed in the blood after the use of this fluid (*ib.*). These views, therefore, tend to the conclusion that alcohol, in all its forms, produces an alteration in the usual phenomena consequent upon digestion; that this influence is analogous to that of those causes which produce depression of the nervous centres, and therefore its employment by preference as a heat-supplying agent to the animal system in cases of health, is a procedure involved in very great doubt. The argument in favour of the calorifiant nature of alcohol is, that as it disappears in the system it acts as an element of respiration, and although its constituents do not possess by themselves the property of combining with oxygen at the temperature of the body, and forming carbonic acid and water, yet it acquires, by contact with bodies susceptible of this combination, this property in a higher degree than fat, &c. (*Liebig.*) If then alcohol be thus capable of conversion into carbonic acid and water with facility, how are we to explain the fact that alcohol diminishes the amount of carbonic acid in the expired air? The answer has been that as alcohol contains a large amount of hydrogen, which by union with the oxygen of the air, passes off from the lungs in the form of vapour of water, the diminution of carbonic acid is a necessary result of the use of this stimulant. But there is a remarkable fact which appears to throw doubt on this view, viz. that in addition to the analogous and instantaneous action of tea, as long as the effects of alcohol are perceptible to the feelings of the individual who has swallowed it, the quantity of carbonic acid is *below* the standard. The effects of drinking go off with frequent yawnings and with a sensation as if awakening from a sleep. Under these circumstances the quantity is generally *much above the standard*, and hence it would seem that the system is freeing itself from the retained carbon (*Prout*). The phenomena of yawning, sighing, &c., appear to have evidently the effect of throwing off a quantity of carbonic acid retained in excess in the system, since sleep and depressing passions seem to operate by diminishing the amount of carbonic acid. There may be various reasons, too, for inferring that alcohol is not thrown off in the form of colourless, odourless, gases by the lungs. The offensive ethereal smell retained in the breath of the drunkard for many hours after the introduction into the stomach of the cause of his inebriation, seems to favour the view that other products besides carbonic acid and the vapour of water result from the use of alcohol. That alcohol does not occupy a very high position as a calorifiant agent, is evident from its comparative operation in heating the body when cooled and depressed by external cold.

Hot fluids are familiarly known to all to be much more efficient in raising the heat of the body, than *raw spirits* or *strong fermented fluids*, which have a depressing action unless combined with hot fluids. The influence of the use of spirits has been tested in the army, and it has been found in India, that when a regiment consumed from 10,000 to 14,000 gallons, the mean annual mortality was 76, and when the amount was reduced to 2000 to 3000, the mortality fell to 24, out of the same strength. An interesting experiment has been in operation during the last 20 years in the United Kingdom Provident Institution. During that period this society has insured a distinct section of abstainers who number above 5000, and it has likewise a more numerous section of the general public. During the first 6 years, out of 2060 members only 18 died, equivalent to a loss of ·9 per cent., while the office of the Society of Friends, who are distinguished for their care of health, lost in the corresponding period of their history 3·3 per cent. The most recent report from this institution after 15 years' existence, gives a return of 19 per cent. of profits in favour of the abstainers, over the section of non-abstainers ; although that division likewise contains many individuals of the latter class.

Influence of tea and coffee in nutrition.—The experiments already referred to indicate that tea delays the regular changes of the body of animals, since the carbonic acid exhaled from the lungs declines in quantity under the influence of tea. (*Prout*, 1813.) Coffee, from its containing the same principle, might be inferred to be possessed of a similar action, and this has been found to be the case ; but it has been found, in addition, that a decoction of coffee communicates greater activity to the circulation and nervous system. The delay which it effects in the metamorphosis of the tissues appears to be occasioned by the empyreumatic oil of the berry, which likewise produces increased action of the sweat pores, of the kidneys, and an accelerated motion of the intestinal canal; while the effects of caffein in excess are increased activity of the heart, headache, delirium, &c. (*Lehmann*,1853.) Coffee and tea, as usually employed, appear therefore to act as stimulants and as agents by which the conversion of the solids of the body into soluble and gaseous products is considerably delayed. Their influence is analogous to that of alcoholic fluids when these are taken in moderate quantities, although there is no evidence that they are capable of producing organic disease, such as inevitably attends the consumption of increased doses of alcoholic fluids. The Turcomans employ tea in their wanderings as an article of nutriment, and have discovered by long experience, what has been confirmed by chemical research, that the leaves of tea contain a large amount of nitrogenous matter, which is not however dissolved in the usual process of infusion. One ounce of tea leaves and an equal weight of carbonate of soda are boiled by the Turcomans in a quart of water for an hour. The liquor is then strained and mixed with ten quarts of boiling water, in which an ounce and a half of common salt have been previously dissolved. The whole is then put into a narrow cylindrical churn along with butter, and well stirred with a churning-stick till it becomes a smooth, oily, and brown liquid, of the colour and consistence of chocolate, in which form it is transferred into a teapot. (*Moorcroft*.) The soda has the effect of taking up the cassein or curd, a most nutritive nitrogenous compound, and which is present in large quantity.

Influence of tobacco and opium on nutrition.—It has been observed in favour of the practice of smoking tobacco, that even the most primitive tribes indulge in this practice. If it were a correct observation, the practice may be pronounced to be a savage one, and to be connected with the conditions of savage life. The North American Indians all smoke, but when uncontaminated by intermixture with the whites, tobacco is unknown to them. The material which they employ is the prepared bark of a species of willow. The presence of such products of combustion in the system appear like tea and coffee, which have also been discovered in primitive nations to delay the degradation of the tissues and husband the food. The American Indians, who live entirely upon animal food, and who have impressed on them a restless and wandering existence, from the nature of their food, — from the difficulty experienced in obtaining animal heat, — from the metamorphosis of the nitrogenous tissues,—use the smoke of vegetable matter to make their food last longer. Tobacco and opium when smoked appear to have a similar action, but they likewise influence the nervous system and occasion a stimulating influence, which is apparent in the vivacity of the eye, particularly with opium as it is smoked in China. The practice of opium eating, as in use among the Turks and the islands of the Indian Ocean, is totally distinct in its physiological results; a wild inebriety being often produced, which, if persisted in, conducts to a lamentable end. In a case which occurred to us the liver was entirely destroyed by fatty degeneration.—R. D. T.

NUX VOMICA; *Strychnos nux vomica*, Linn. The seeds of a tree growing in Coromandel and other parts of India and Ceylon. From these strychnine is obtained. See Strychnine.

Nux vomica bark was at one time confounded with Angustura or Cusparia bark, and serious consequences might have ensued by that, the error was discovered in time. It is now rarely seen.

In 1857 our imports of the nux vomica seeds amounted to 1,085 cwts.; but in the same year we exported 1,195 cwts., the excess being of course derived from the importations of former years.

O.

OAK. (*Chêne*, Fr.; *Eiche*, Germ.) This well-known European tree is so familiar that it scarcely requires any description. The varieties generally known in England are the

Quercus pedunculata, Common Oak, which is a native of Britain, and is largely employed in building ships.

Quercus ilex, Evergreen Oak. This tree is not a native, but has been cultivated in Britain from the most remote period.

Quercus cerris, Turkey Oak. Introduced into this country more than a century since.

Quercus coccinea, Scarlet Oak. The leaves changing with the first frosts to a brilliant scarlet.

Quercus sessiliflorus, Common short stalked Oak. This is said to excel for building purposes any other oak.

OAK BARK. The oak tree is generally barked from the beginning of May to the middle of July. The barkers make a longitudinal incision with a mallet furnished with a sharp edge, and a circular incision by means of a barking bill. The bark is then removed by peeling irons, the separation being promoted when necessary by beating the bark. It is collected and stacked in pieces about two feet long. Oak bark contains, according to Braconnot, tannic acid, tannates of the earths, gallic acid, pectin and lignin. Davy, in his Agricultural Chemistry, gave the following as the relative quantities of tannin contained in oak bark:—

480 lbs. of entire bark of a middle-sized oak cut in spring	29 lbs.
" " coppice oak	32 "
" " oaks cut in autumn	21 "
White interior cortical layers	72 "

See Tan, Tanning.

OAK, BOG. Oak trees, which have been buried for a long period in peat bogs, become intensely black; and in this condition the wood is employed in the manufacture of furniture and articles of ornament, especially in Ireland.

OAK, DYER'S. See Gall Nuts.

OATS. (*Avoine*, Fr.; *Hafer*, Germ.) The oat is extensively cultivated in these islands, especially in Scotland. In fact, Scotland is the country admittedly the best fitted for the growth of oats. The estimated number of acres of cultivated land in Scotland is 2,400,000, of which 220,000 are under wheat, 280,000, under barley, and 1,270,000 under oats.—Lawson's *Vegetable Products of Scotland*.

Mr. J. P. Norton, in Silliman's American Journal, has published an account of a most complete investigation of oats in the various stages of their growths. He gives the following as the result of his analysis of *Hopeton oats*:—

	Northumberland.	Ayrshire.	
		1.	2.
Starch	65·24	64·80	64·79
Sugar	4·51	1·58	2·09
Gum	2·10	2·41	2·12
Oil	5·44	6·97	6·41
Casein	15·76	16·26	17·72
Albumen	0·46	1·29	1·76
Gluten	2·47	1·46	1·33
Epidermis	1·18	2·39	2·84
Salts and loss	2·48	1·84	0·94
	100·00	100·00	100·00
Nitrogen	2·19	2·35	2·28

OBSIDIAN. A glassy looking mineral, so called, it is stated, from *Obsidius*, a Roman, who brought it from Africa. It is a true volcanic glass, and occurs in streams, or in detached masses near many volcanic mountains.

OCHRE. (*Ocre*, Fr.; *Ocher*, Germ.) Ochre is, truly a peroxide of iron and water; but a native earthy mixture of silica and alumina, with oxide of iron in various proportions, and sometimes calcareous matter and magnesia, is usually regarded as ochre. The term is applied, indeed, without any great degree of exactness, to any combinations of the earths with iron, which can be employed for pigments and the like. According as the colour is light or dark, we have *yellow*, *brown*, and *red* ochres.

In Cornwall considerable quantities of ochres are obtained by carefully washing the ferruginous mud, which is separated from poor tin and copper ores after they have been submitted to the action of the stamps, and the ordinary processes of washing and roasting (see ORES, DRESSING OF). Not less than 700*l.* worth of ochre was shipped from Truro in 1858.

The iron paints of Torbay must be regarded as ochres. They are found in connection with iron lodes which exist in the rocks around the coast. These paints are prepared by Mr. Wolston of Brixham, and they have been employed for several years in the Royal Naval Arsenals and other government establishments. The wood and iron huts at Shorncliff and Colchester camps have been painted with them. They have also been employed for coating the boilers of steam engines.

Reddle, employed for marking sheep in Devonshire, and a variety found near Rotterdam which is much used for grinding spectacle glasses at Sheffield, may be said to belong to this class. See OXIDES OF IRON, *for polishing.*

Anglesea produces some very fine varieties of ochres, so does also the Isle of Man.

In the more recent formations, 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 grey Plastic Clays, of a yellowish or reddish colour. The ochrey earths are prepared by grinding and washing; in some cases they are also exposed to the action of the fire, to increase the oxidation of the iron and deepen the colour.

The following is a section of the ochre pits at Shotover Hill, near Oxford, where the Oxford ochre is obtained:—

Beds of highly ferruginous grit, forming the summit of the hill	6 feet	
Grey land	3 "	
Ferruginous concretions	1 "	
Yellow sand	6 "	
Cream-coloured loam	4 "	
Ochre	0	6 in.

Beneath this there is a second bed of ochre, separated by a thin bed of clay.

Bole, *Armenian bole*, or Lemnian earth, may be ranked with the ochres. See BOLE; as may also the TERRA DI SIENNA, which see.

The *Ochre of Bitry* and *Italian rouge* are ochres which are found principally near Vierzon and St. Amand (Nièvre). The ochres from Holland are also much esteemed.

It will thus be apparent that ochre occurs in all formations, from the earliest known rocks, where it is probably due to the decomposition of the sulphides of iron—up to the alluvial deposits of yesterday—in many of which ochreous formations may be watched in the progress.

Ochre in mineralogy is applied to many products of decomposition, as. *Cobalt ochre bismuth ochre, chrome ochre, antimony ochre*, &c.

OIL OF VITRIOL is the old name of concentrated SULPHURIC ACID which see.

OILS (*Huiles*, Fr.; *Oele*, Germ.) form a class of valuable and interesting substances, and are divided into two great classes, viz. fixed or fatty oils, and volatile or essential oils. The members of one class differ greatly, in nearly every respect, from those of the other class. The former are usually bland and mild to the taste; the latter hot and pungent. The term distilled, applied especially to the last class, is not quite 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 some few of the essential oils, sulphur also; but, as a class, they are noted for containing a large proportion of carbon, which renders them valuable as food, and as sources of light.

Oils have been known and used from the remotest ages. The olive tree is frequently mentioned by Moses; and it appears to have been introduced into Europe at an early period, probably by the Greeks.

For the present, we shall only take notice of the fixed or fatty oils. These 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, or mixed in a liquid state with other animal matters, as in the milk.

Braconnot, but particularly Raspail, has 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 $\frac{1}{450}$ of an inch in diameter; in the hog they are kidney-shaped, and from $\frac{1}{70}$ to $\frac{1}{110}$ of an inch; in man they are polygonal, and from $\frac{1}{70}$ to $\frac{1}{900}$ of an inch; in insects they are usually spherical, and not more than $\frac{1}{600}$ 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 cruciferæ are the richest in oleiferous seeds; and next to these, are the drupaceæ, amentaceæ, and solaneæ. The seeds of the gramineæ 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 considers all the oils to be composed of two, and sometimes three different species, viz. stearine, margarine, and oleine; the consistence of the oil or fat varying as either of these predominates. These bodies are all compounds of *glycerine*, with a fatty acid. At all ordinary temperatures oleine is liquid, margarine is solid, and melts at 116° F. Stearine is still more solid, and melts at about 130° F. The two latter may be prepared from pure mutton fat, by melting it in a glass flask, and then shaking it with several times its weight of ether; when allowed to cool, the stearine crystallises out, leaving the margarine and oleine in solution. The soft mass of stearine may be strongly pressed in a cloth, and further purified by recrystallisation from ether. It forms a white friable mass, insoluble in water, and nearly so in cold alcohol; but boiling spirit takes up a small quantity. It is freely soluble in boiling ether; but, as it cools, nearly all crystallises out.

Margarine may be prepared from the ethereal mother-liquor, from which the stearine has separated, by evaporating it to dryness; the soft mixture of margarine and oleine, is then pressed between folds of blotting-paper; the residue again dissolved in ether, from which the margarine may now be obtained tolerably pure. It very much resembles stearine, but, as above-mentioned, has a lower melting point.

It is rather doubtful if oleine has ever been prepared in a perfectly pure state, the separation of the last particles of margarine being very difficult. It may be obtained by subjecting olive oil to a freezing mixture, when the margarine will nearly all separate, and the supernatant fluid oil may be taken as oleine.

Oleine may also be procured by digesting the oils with a quantity of caustic soda, equal to one half of what is requisite to saponify the whole; the stearine and margarine are first transformed into soap, then a portion of the oleine undergoes the same change, but a great part of it remains in a nearly pure state. This process succeeds only with recently-expressed or very fresh oils.

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 in this case are the same as we obtain when we distill separately the different constituents (stearine, margarine, &c.), that is to say, a little water and carbonic acid, some gaseous and liquid hydrocarbons, some solid fatty acids (particularly margaric acid and some sebacic acid, provided by the decomposition of the oleine), small quantities of the odoriferous acids (acetic, butyric, &c.), and some *acroleine.* The acrid and irritant odour which this last substance gives out, especially characterises the decomposition of fatty bodies by heat. It is produced from the glycerine only. If, instead of raising the heat gradually, we submit the fats or oils directly to a red heat, as by passing them through a redhot tube, they are decomposed completely, and are almost entirely transformed into gaseous carburetted hydrogens, the mixture of which serves for illuminating purposes, and yields a far better light than ordinary coal gas. In places where the seed and fish oils can be procured at a low price, these substances might be employed with great advantage for this purpose.

Action of alkalies on the oils.— When the fats or oils are boiled with potash or soda, they are decomposed into glycerine and the fatty acids, with assimilation of water by both the glycerine and the fatty acids. Thus oleine yields glycerine and oleic acid, margarine, glycerine and margaric acid, and stearine, glycerine and stearic acid. The glycerine dissolves in the water and the fatty acids unite with the alkalies, forming soaps (which see). The action of ammonia on the oils is much less energetic; it, however, readily mixes with them, forming a milky emulsion, called volatile liniment, used as a rubefacient in medicine. Upon mixing water with this, or by neutralising the ammonia by an acid, or even by mere exposure to the air, the ammonia is removed and the oil again collects. By the prolonged action of ammonia, however, on the oils, true ammoniacal soaps are formed, and at the same time a peculiar body is formed, called by its discoverer (Boullay) *margaramid.* It corresponds exactly with the ordinary *amides*, its composition is $(C^{34}H^{35}NO^2) = NH^2(C^{34}H^{33}O^2)$, or margarate of ammonia minus 2 equivalents of water.

$$\underbrace{NH^4O,C^{34}H^{33}O^3}_{\text{Margarate of ammonia.}} - 2HO = \underbrace{NH^2\,(C^{34}H^{33}O^2)}_{\text{Margaramid.}}$$

It is obtained by boiling the ammoniacal soap with water, when the margaramid swims on the top, and when allowed to cool solidifies. It is purified by solution in boiling alcohol, which deposits it again on cooling in the crystalline state. It is a white, perfectly neutral solid, unalterable in the air, insoluble in water, very soluble in alcohol and ether, especially by the aid of heat. It fuses at about 140°

Fahr., and burns with a smoky flame. It is decomposed when boiled with potash or soda, forming true soaps, with the liberation of ammonia, and also by acids of a certain degree of concentration.

The alkaline earths and some metallic oxides unite with the fatty acids, forming insoluble soaps, which in the case of lead is called a plaister.

After glycerine and the fatty acids have once been separated, they do not readily again unite; but Berthelot has succeeded in effecting this, by enclosing them for a considerable time in a sealed tube, and subjecting them to a more or less elevated temperature, when the true oils are again produced.

Action of acids upon the oils.—Sulphuric acid (concentrated), when added to the oils, unites with them energetically, the mixture becomes heated, and, unless cooled, chars with the liberation of sulphurous acid. When the mixture is cooled the fats and oils undergo a similar change to that which the alkalies effect. There is formed some sulpho-glyceric acid, as well as combinations of margaric and oleic acids with sulphuric acid; these latter are again decomposed when mixed with water, liberating the fatty acids.

Nitric acid (concentrated) attacks the fatty bodies very rapidly, sometimes causing ignition. Dilute nitric acid acts less powerfully, forming the same compounds which we obtain by acting on the several constituents of the oils separately.

Hyponitric acid, or *nitrous acid*, converts the oleine of the non-drying oils into a solid fat, *elaidine*.

Chlorine and *bromine*, act on the fatty oils, producing hydrochloric and hydrobromic acids, and some substitution compounds containing chlorine or bromine.

When moist chlorine gas is passed into the oils, the temperature rises, but it does not cause explosion. Bromine on the contrary acts with violence. The chlorine and bromine products thus obtained, are generally of a yellow colour, without taste or smell. They are heavier than water, and possess a greater consistence than the pure oils. Exposed to the air when slightly heated, they become considerably harder.

Iodine also attacks the oils forming substitution compounds.

The fatty oils are divided into two classes, drying and non-drying oils, which are characterised by their different deportments when exposed to the atmosphere. In close vessels, oils may be preserved unaltered for a very long time, but with contact of the atmosphere 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 on this account used in the preparation of varnishes and painters' colours. Other oils do not dry up, though they become thick, less combustible, and assume an offensive smell. These are the *non-drying oils*. In this state they are called *rancid*, and 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 disengaged, 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 dockyards.

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, especially when wrapped or piled in a heap, and placed in contact with the sun and air, they very soon spontaneously become 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.

Although most of the fixed oils and fats are mixtures of two or more of the substances *oleine*, *margarine*, and *stearine*, yet there appears to be different modifications of these substances in drying and non-drying oils, for instance it is only the oleine of the non-drying oils that solidifies when treated with nitrous acid or nitrate of mercury; and again the difference is shown in the fact of some oils drying completely, while others only thicken and become rancid.

The following is a list of the non-drying oils and their specific gravity:—

No.	Plants.	Oils.	Specific Gravity.
1	Olea Europea	Olive oil	0·9176
2	Amygdalus communis	Almond oil	0·9180
3	Sesamum orientale	Oil of sesamum	
4	Guilandina mohringa	Oil of behen or ben	
5	Fagus sylvatica	Beech oil	0·9225
6	Sinapis nigra et arvensis	Oil of mustard	0·9160
7	Brassica napus et campestris	Rapeseed oil	0·9136
8	Prunus domestica	Plum-kernel oil	0·9127
9	Theobroma cacao	Butter of cacao	0·8920
10	Cocus nucifera	Cocoa nut oil	
11	Cocus butyracea vel avoira elais	Palm oil	0·9680
12	Laurus nobilis	Laurel oil	
13	Arachis hypogæa	Ground-nut oil	
14	Valeria Indica	Piney tallow	0·9260
15	Brassica campestris oleifera	Colza oil	0·9136
16	Brassica præcox	Summer rapeseed oil	0·9139
17	Rhapanus sativus oleifera	Oil of radish seed	0·9187
18	Prunus cerasus	Cherry-stone oil	0·9239
19	Pyrus malus	Apple seed oil	
20	Euonymus Europæus	Spindle-tree oil	0·9380
21	Cornus sanguinea	Cornilberry-tree oil	
22	Cyperus esculenta	Oil of the roots of Cyprus grass	0·9180
23	Hyosciamus niger	Henbane-seed oil	0·9130
24	Æsculus hippocastanum	Horse-chestnut oil	0·9270

The non-drying oils are used as food, for illuminating purposes, and for the greasing of machinery, &c.

The following is a list of the drying oils:—

No.	Plants.	Oils.	Specific Gravity.
1	Linum usitatissimum et perenne	Linseed oil	0·9347
2	Corylus avellana	Nut oil	0·9260
3	Juglans regia		
4	Papaver somniferum	Poppy oil	0·9243
5	Cannibis sativa	Hemp oil	0·9276
6	Cucurbita pepo, et melapepo	Cucumber oil	0·9231
7	Helianthus annuus et perennis	Oil of sunflower	0·9262
8	Ricinus communis	Castor oil	0·9611
9	Nicotiana sabacum et rustica	Tobacco-seed oil	0·9232
10	Vitis vinifera	Grape seed oil	0·9202
11	Hesperis matronalis	Oil of Julienne	0·9281
12	Myagrum sativa	Oil of camelina	0·9252
13	Reseda luteola	Oil of weld-seed	0·9358
14	Lepidium sativum	Oil of garden cresses	0·9240
15	Atropa belladonna	Oil of deadly nightshade	0·9250
16	Gossypium Barbadense	Cotton-seed oil	
17	Pinus abies	Pinetop oil	0·9285

The drying oils are used principally for varnishes and for painters' colours. As the quicker they dry the more valuable they are for these purposes, it is desirable still to increase their natural siccative properties as much as possible, and this is generally effected by boiling the oils with litharge (oxide of lead), by which a certain portion of the litharge is dissolved by the oil; but in what way this process tends to increase the siccative properties of the oil is not understood; various opinions have been given upon the subject; oxide of manganese, oxide of zinc, and magnesia have also been used for this purpose. Chevreul states that it is not necessary to boil the oils, that a much lower heat acts quite as well. Liebig imagines that the boiling with litharge effects the separation of the mucilaginous and other foreign matters, which tend to protect the oils from the action of the oxygen of the atmosphere, and has proposed a process for their separation without the aid of heat. It consists in shaking the oil, previously triturated with litharge, with a solution of the basic acetate of lead for some time, and afterwards allowing the whole to remain still, when the oil separates, and will then dry in twenty-four hours. The solution of acetate of lead which remains, may be again used by converting it into the subacetate. A portion of oxide of lead is dissolved by the oil, and when its presence would be prejudicial, it may be removed by shaking the oil with dilute sulphuric acid. In boiling the oils with acetate of lead and litharge, some painters add about an eighth part of resin, which in that proportion greatly improves the appearance of the paints when dry.

Before describing these oils separately, it is necessary to show the means used for obtaining them from the seeds, &c.

Fat Oil Manufacture.

Olive oil.—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 af 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 mucilage. The olives are then crushed under the stones of an edge-mill, and next put into a screw-press, being enclosed in bulrush-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. 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 the water is then drawn off from the bottom by a plug-hole: the oil which remains after this 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 60° 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.

In Spain the olives are pressed by conical iron rollers elevated above the stage or floor, round which they move on two little margins to prevent the kernel being injured, the oil from which is said to have an unpleasant flavour. Spanish olive oil, however, is inferior to other kinds, from the circumstance of the time which elapses between the gathering and the grinding of the olives. This is unavoidable on account of the small number of mills, which are not in proportion to the quantity of fruit to be pressed. The olives are therefore allowed to lay in heaps to wait their turn, and consequently often undergo decomposition.

The machinery employed by the Neapolitan peasants in the preparation of the Gallipoli oil is of the rudest kind. The olives are allowed to drop from the trees when ripe, when they are picked up chiefly by women and children, and carried to the mill. The oil, when expressed, is sent in sheep or goat skins, carried on mules, to Gallipoli, where it is allowed to clarify in cisterns cut in the rock on which the town is built. From these it is conveyed in skins, to basins near the sea-shore, and from these basins the casks are filled.

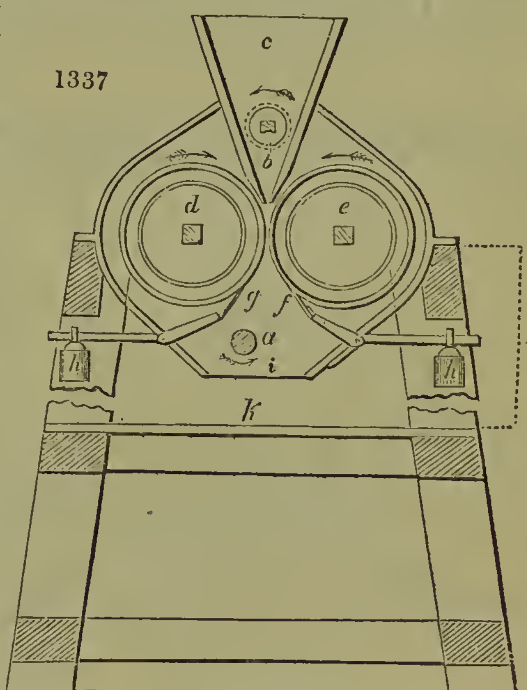
According to Sieuve, 100 lbs. of olives yield about 32 lbs. of oil; 21 of which come from the pericarp, 4 from the seed, and 7 from the woody matter of the nut. That obtained from the pericarp is the finest.

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.

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 haircloths, 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.* 1337 and 1338. 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 equally 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*.

1337



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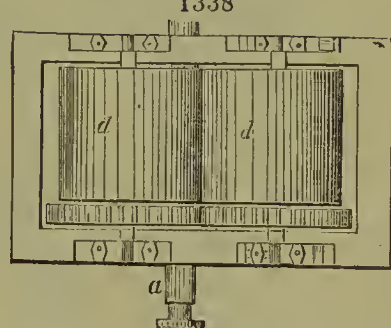
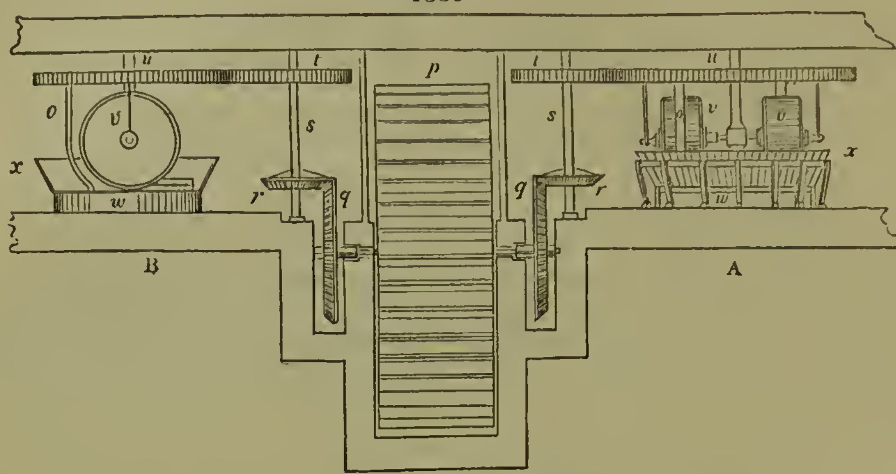


Machines of this kind are now usually driven by steam-power. Hydraulic presses have been of late years introduced into many seed-oil mills in this country; but it is still a matter of dispute whether they or the old Dutch oil-mill, with bags of seed compressed between wedges, driven by cam-stamps, be 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 represented in *fig.* 1339. *p* is the water wheel, which may drive several pairs of horizontal bevel wheels working in *q*, *q*, and turning the shafts *s*, *s*; *t*, *t*, two horizontal spur wheels fixed to the upper part of the vertical shafts, and driving the large wheels *u*, *u*. To the shafts of these latter wheels are fixed the runners *v*, *v*, which traverse upon the bed stone *w*, *w*; *x*, *x*, are the curbs surrounding the bed stone to prevent the seeds from falling off; *o*, is the scraper. Mill A represents a view, and mill B, a section of the bed stone and curb. Some hoop the stones with an iron rim, but others prefer the rough

1339



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

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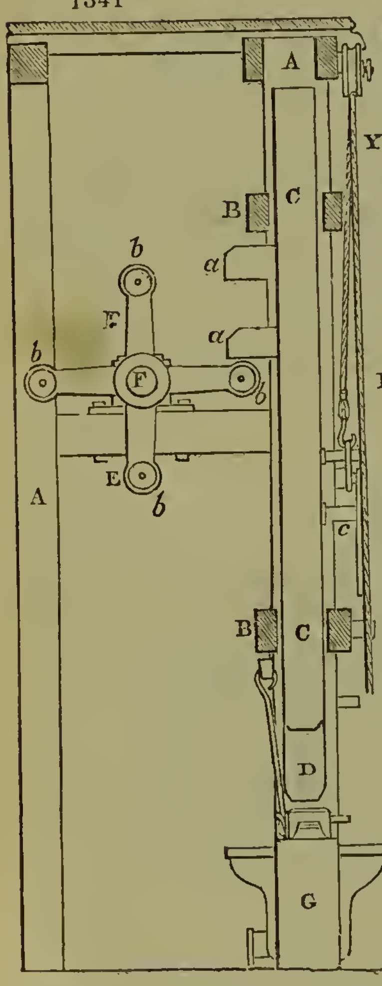

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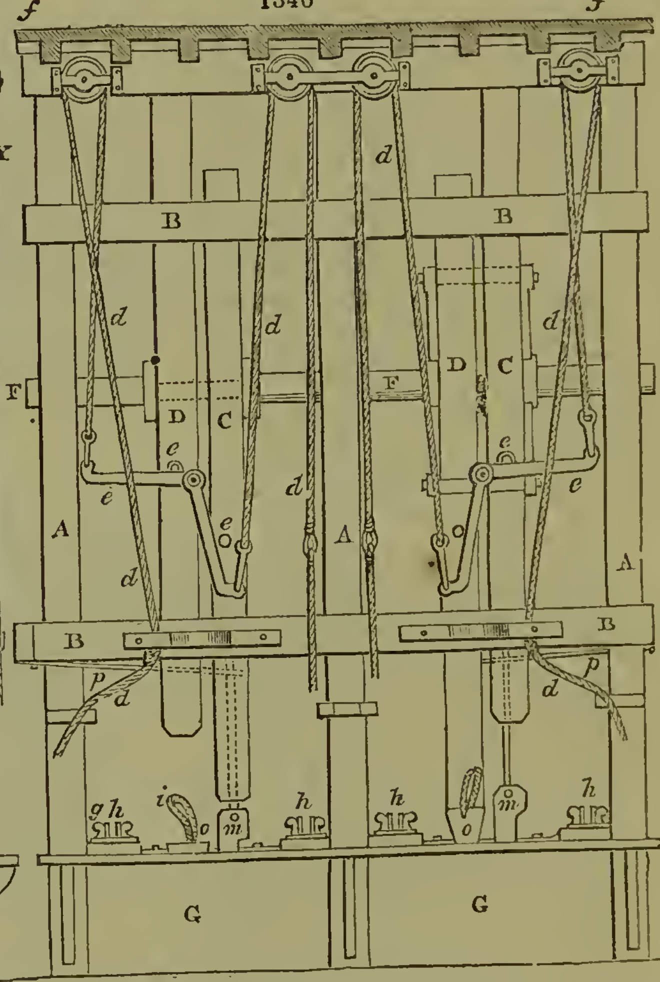


bed of masonry or iron in a minute. The centre of the bed, where it is perforated for the passage of the strong vertical shaft which turns the stones, is enclosed by a circular box of cast-iron, firmly bolted to the bed-stone, and furnished with a cover. This box serves to prevent any seeds or powder 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 following are drawings of the wedge or Dutch seed-crushing machines.

Fig. 1340, front elevation of the wedge seed-crushing machine, or wedge-press.
Fig 1341, section in the line X X of *fig.* 1342.

Fig 1342, horizontal section in the line YY, of *fig.* 1341.

A, A, upright guides, or framework of wood.

B, B, side guide-rails.

D, 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. E is the lifting shaft, having rollers, *b*, *b*, *b*, *b*, *fig.* 1341, which lift the stampers by the cams, *a a*, *fig.* 1341. F is the shaft from the power-engine, on which the lifters are fixed.

G is the cast-iron press-box, in which the bags of seed are placed for pressure laterally by the force of the wedge.

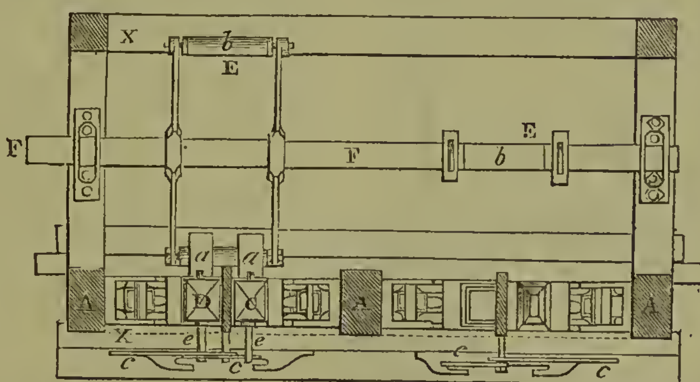
o, *figs.* 1339 and 1343; the spring, or relieving wedge.

e, lighter rail; *d*, lifting-rope to ditto.

f, *f*, *f*, *f*, flooring overhead.

g, *figs.* 1340, and 1343; the back iron, or end-plate minutely perforated.

1342

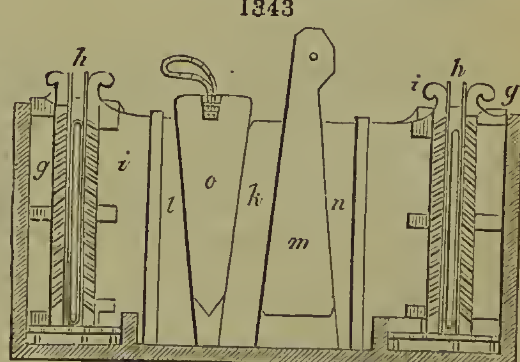


h, the horse-hair bags (called hairs), containing the flannel bag, charged with seed; *i*, the dam-block; *m*, the spring wedge.

Fig. 1342, A, upright guides; C, and D, spring and driving stampers; E, lifting roller; F, lifting shaft; *a*, *a*, cams of stampers.

Fig. 1343, a view of one set of the wedge-boxes, or presses; supposing the front of them to be removed; *o*, driving-wedge; *g*, back iron; *h*, hairs; *i*, dam-block; *k*, speering or oblique block, between the two stampers; *l*, ditto; *n*, ditto; *m*, spring wedge.

1343



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.

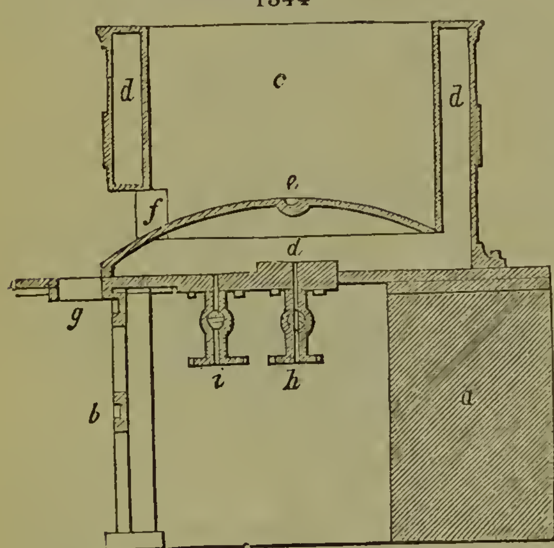
The seeds which have been burst between the rolls, or in the mortars of the Dutch mills, are to be spread as equally as possible, by a shovel, upon the circular path of the edge-stones, and in about half an hour the charge will be sufficiently ground into a paste. This should be put directly into the 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. 1344 is a vertical section of the steam-kettle of Hallette, and *fig.* 1345 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 *c*; *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 *i*, the eduction pipe which serves also to run off the condensed water.

When, in the course of a few minutes, the bruised seeds are sufficiently heated in the pans, the double door *f* is withdrawn, and they are received in the bags, below the aperture *g*. These bags are made of strong twilled woollen cloth, woven on purpose. They are then wrapped in a hair-cloth, lined with leather.

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 2½ inches diameter for a ram of 10 inches, and the second pump 1 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 days' work of one week, with the labour of one man at 20*s.* and three boys at 5*s.* each; and will require a 12-horse power to work it well, along with the rolls and the edge-stones.

1344



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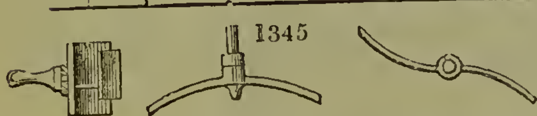


The apparatus for heating the seeds by naked fire, as used in Messrs. Maudsley and Field's excellent seed crushing mills, on the wedge or Dutch plan, is represented in the *Figs.* 1346, 1347, 1348, and 1349.

Fig. 1346 is an elevation, or side-view of the fire-place of a naked heater; *fig.* 1347 is a plan, in the line U U of *fig.* 1346. *Fig.* 1348 is an elevation and section parallel to the line V V of *fig.* 1347. *Fig.* 1349 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.

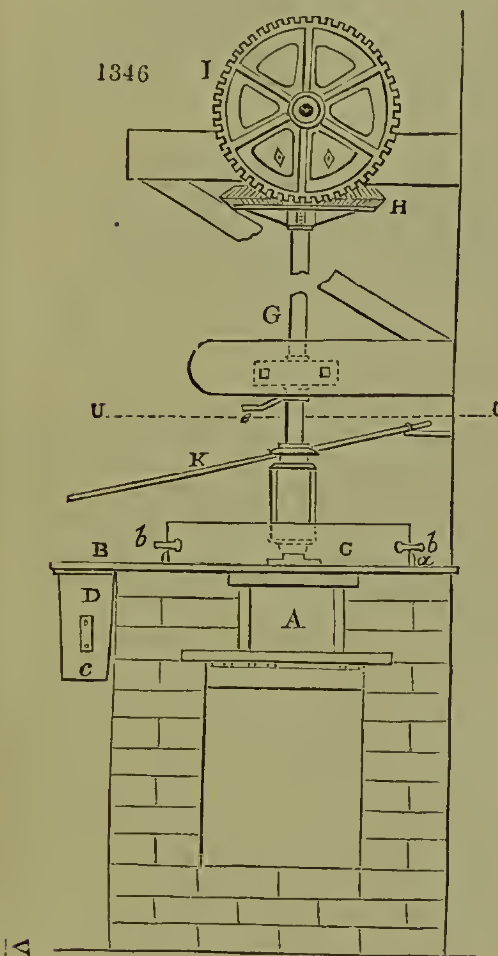
C, iron ring-pan, resting on the plate B, for holding the seeds, which is kept in its place by the pins or bolts *a*.

D, funnels, *britchen*, into which by pulling the ring-case C, by the handles *b b*, the seeds are made to fall, from which they pass into bags suspended to the hooks *c*.

E, *fig.* 1348, 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 E. *c*, a catch for holding up the lever K, when it has been raised to a proper height.

A patent was taken out in May, 1849, by Messrs. Bessemer and Heywood for a machine to be used for expressing oils from seeds. *Fig.* 1350 is a drawing of it. The bedplate of framing, *a*, which should be cast in one piece, forms, at a^1, a cistern for the reception of the oily matters which fall therein as they are expressed. At the opposite end of the bedplate there are formed projections, a^2, in which brasses, b, are fitted, and with the caps, c, form bearings for the crank shaft, d, to turn in. There are also two other projections, a^3, a^3, cast on to the bedplate, and are provided with



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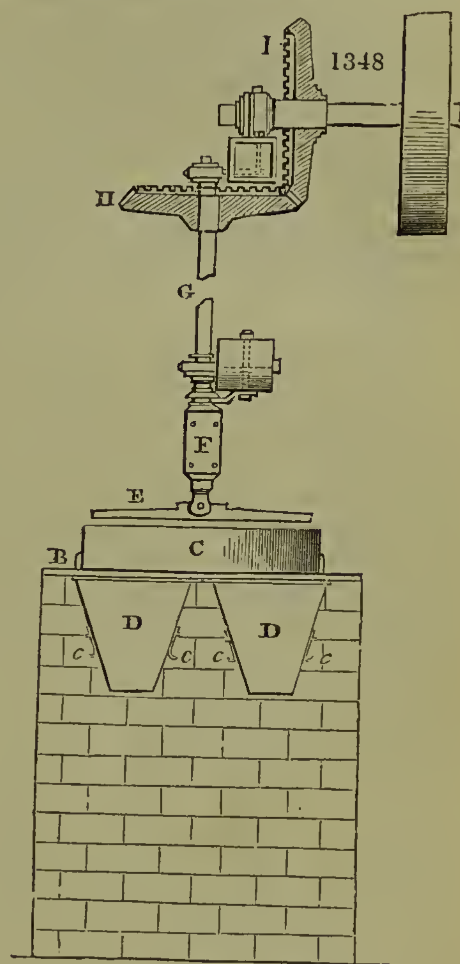

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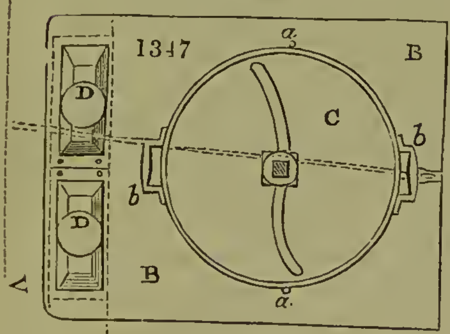

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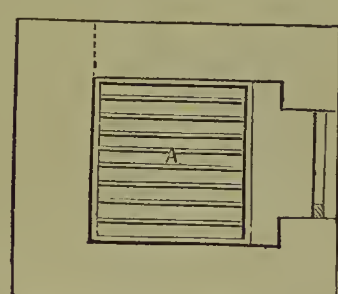
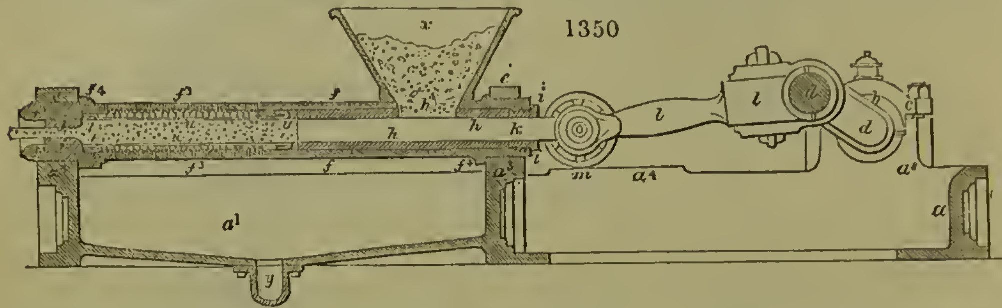


1349

caps, e, in a similar manner to the caps of plummer blocks. These caps are for the purpose of retaining firmly in its place the pressing cylinder, f, which should be made of tough gun metal, and of such thickness as to be capable of withstanding a considerable amount of internal pressure. Within the cylinder, f, is fitted a *lining*, which consists of a gun-metal tube, n, having a spiral groove, r, cut on the outside of it, and presenting the appearance of an ordinary square-threaded screw. At very short intervals all along the spiral groove there are conical holes, s, drilled through the tube, n, and communicating with the interior of it. At n^1 the inside of the tube is enlarged, and is provided with a steel collar, t. The opposite end of the tube at n^1 is reduced in diameter, and is provided externally with a steel collar, u. A plain cylindrical bag v, with open ends, formed of fustian, hair-cloth, or similarly pervious material, is made of such a diameter as will fit closely to the inside of the tube n; and within this bag is placed a cylinder, w, of wire gauze or finely perforated metal. The steel collar t is forced into the end of the wire gauze, by which it becomes driven into the recess formed at n^1, and is securely held there by the pressure of the collar t. The bag v and wire gauze w are then tightly stretched over the end n^2 of the tube, and the collar u driven tightly on, by which means the bag and wire gauze are securely held in their places. The lining tube n is then put into the pressing cylinder as far as the shoulder g. A tubular piece h is next put in and brought into contact with the collar u, and then the gland i is screwed home, whereby the lining n is firmly retained within the pressing cylinder. The end of the pressing cylinder is contracted at f^1, and forms a shoulder for the abutment of the collar j, the diameter of the aperture in which regulates the pressure to which the matters under operation are subjected.

1350



Within the tube n there is fitted a solid plunger k, which receives motion from the crank d by means of the connecting rod l, the parallel motion being obtained by the wheels m, on the cross head o, traversing on the side of the bedplate at a^4. x is a hopper, bolted to a flange f^2 on the pressing cylinder, and communicating therewith. There is also an opening in the tube n at n^1, corresponding with the opening into the hopper, so that any materials placed in the hopper may fall into the tube n, when the plunger k is withdrawn from beneath the opening. At that part of the pressing cylinder which is occupied by the "lining" there are drilled numerous small holes, f^3, which communicate at various points with the spiral groove in the tube n. On the outside of the pressing cylinder there are formed two collars, f^4, f^4, which abut against the projecting pieces a^3 and caps e, and cause the pressing cylinder to be retained firmly in its place. When steam power is to be employed to give motion to the oil press, it is preferable to have the crank which is actuated by the steam piston formed on the end d^1, on the crank shaft of the oil press, and placed at such an angle to the crank d, that when the crank d is pushing the plunger k to the end of its stroke, the steam piston will be at the half stroke, whereby the motive power applied will be the greatest at the time that the press offers the most resistance, and the steam piston also, when passing its dead points, will have to overcome the friction of the machinery only, as the plunger k will be in the middle of its back stroke. When any other motive power is applied to turn the crank d, it will be necessary to put a fly wheel on the shaft d^1, as also such cog-wheels as will be necessary to connect it with the first mover. When this apparatus is to be employed in expressing linseed oil, the seed, after having been ground and treated in the way now commonly practised, is put into the hopper, and motion being transmitted to the crank in the manner before described, the plunger k will commence a reciprocating movement in the tube n of the pressing cylinder. Each time that it recedes in the direction of the crank it will move from under the opening in the hopper, and allow a portion of the seed to fall into the tube, while the reverse motion of the plunger will drive it towards the open end of the cylinder, its passage being much retarded by the friction against the sides of the tube lining, but chiefly by the contraction of the escape aperture through the collar j, which will produce a considerable amount of resistance, and consequently the plunger will have to exert an amount of pressure upon the seed in proportion as the escape aperture is made larger or smaller. The collar j is made movable, and by withdrawing the plunger entirely from the tube, it can be exchanged at any time for another having a larger or smaller opening. The lining may at any time be removed from the cylinder, and the worn parts removed when found requisite. The action of the plunger is somewhat like that of the plunger of an hydraulic press pump, the seeds being pumped in at one end of the pressing cylinder, and allowed to escape at the other, while the whole of the interior of the pressing cylinder that contains seed is lined with hair-cloth or other suitable pervious material, and that it may be protected from injury, is covered with wire gauze or finely perforated metal. The bag is thus completely defended from within, while it is supported at every part by the tube n on the outside, and is thus subjected to a very little wear and to no risk of bursting. The expressed oil, passing through the wire gauze and bag, finds its way through the perforation s into the spiral channel r, and from thence it finds ready egress by the perforations f^3 in the pressing cylinder, and as it falls is received by the cistern a^1, from which it can be drawn by the pipe y.

Two or more presses may be used side by side, actuated either by one crank throw or by separate throws upon one shaft, placed with reference to each other in such manner as greatly to equalise the amount of resistance throughout the revolution of the crank shaft. Although the one here described is a cylindrical pressing plunger, an angular section may be given to the pressing vessel and plunger, and may of course be used to express oils from any seeds containing them. In the drawing no method is shown for heating the seed cake to be subjected to pressure therein, but as it is known to be desirable to heat some matters from which oil is to be expressed, the following method is described. When heat is to be applied during the process of pressing, it is desirable to make the pressing cylinder of somewhat larger diameter, and of greater length, and to divide the cistern a^1 into two separate compartments over both of which the pressing cylinder is to extend; a strong wrought-iron tube is to enter the open end of the pressing cylinder, and to extend about half way to the hopper, where it terminates in a solid pointed end; this tube is to occupy the centre of the pressing cylinder, and will consequently leave an annular space around it, which will be occupied by the seed, meal, or other matters under operation. Steam is let into this iron tube, and its temperature thereby raised to any desired point. The end of the tube which extends beyond the pressing cylinder is to be securely attached to a bracket projecting from the bed-plate, so that it may be firmly held in its position, notwithstanding the force exerted against the pointed end of it. The effect of this arrangement will be, that, as the seed, meal, &c. fall into the pressing cylinder and are pushed forward by the plunger, they will give out a portion of their oil in that state known as *cold drawn*, which will fall into the first compartment of the cistern a^1. The further progress of the meal along the pressing cylinder will bring it in contact with the pointed end of the heating tube; here it will have to divide itself, and pass along the annular space between the heating tube and the lining, and being thus spread into a thin cylindrical layer around the tube, it will readily absorb heat therefrom, when a second portion of oil will be given out and received by the second compartment of the cistern; and thus will the operations of cold and hot pressing be carried on simultaneously.

Bessemer and Heywood's patent also mentions another machine for the expression of oils from the seeds, &c., by pressure in connection with water, or water rendered slightly alkaline. A sectional drawing of it is represented in *fig.* 1351. A is a cast-iron cistern, having semicircular ends, and open on the upper side. At one end of it is fixed a cylindrical vessel, B, with hemispherical ends. This vessel is of considerable strength, and should be capable of withstanding a pressure of 5000 pounds to the square inch. It is held in an upright position by a flange, C, formed upon it, and extending around one-half of its circumference. This flange rests upon a similar one formed around the upper side of the cistern A, and is bolted thereto. At the upper part of the vessel B is formed a sort of basin, B^1, the edge of which supports an arch-shaped piece of iron, D. At the centre of the basin there is an opening into the vessel, and an hydraulic cup leather, E, is secured within the opening by means of the collar G. In the bottom of the vessel B there is also an opening, into which is fitted a cup leather, H, secured in its place by the ring *j*, which is firmly bolted to the vessel B. A strong wrought-iron rod, K, extends from the top of the arch D, down through the vessel B, having two enlargements or bosses, K^1, K^2, formed upon it, which are fitted to the cup leathers. The upper part of rod K has a screw formed upon it at K^3, which passes through the boss D^1 and enters the boss N, in which a screw thread is formed. The boss N is provided with handles, P, by turning which the rod K may be raised or lowered when required. R is a pipe, through which water may be injected into the vessel B by a force pump, such as is generally employed to work hydraulic presses. S is a cock, whereby a portion of the contents of the vessel B may be run off, and the pressure relieved when

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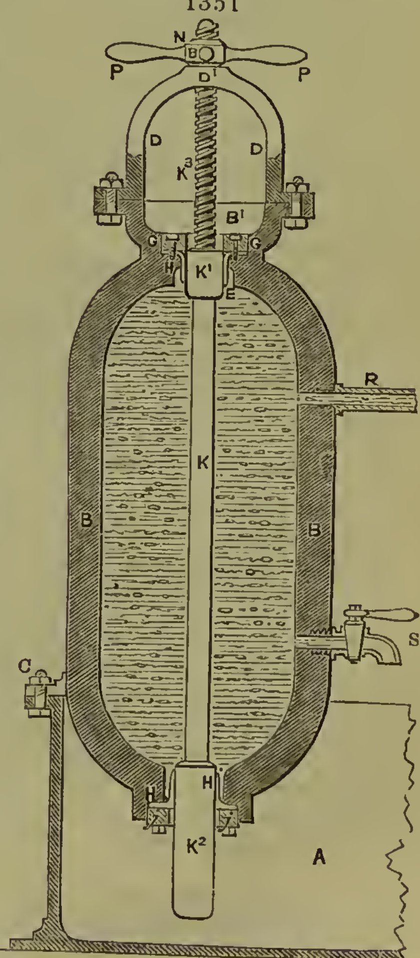

necessary. The two bosses, K^1 and K^2, being of equal area, whatever pressure may be exerted within the vessel B, it does not tend to raise or lower the rod K, but such pressure, acting on the cup leathers, will keep the joint tight, and prevent the matters under pressure from leaking out. After a certain quantity of oil or oleaginous matters have been expressed from vegetable or animal substances, the remaining portions which they contain are more difficult to obtain, and we therefore treat the oil in combination with the substances in which it is contained in the following manner: — The aforesaid substances, after coming from the oil press or mill, are mixed with as much warm water, or water slightly impregnated with alkaline matter, as will reduce them to a semi-fluid state. They are then to be operated upon in the apparatus last described. For this purpose the handles P P are turned round, and the boss K^1 withdrawn from its opening, while the boss K^2, which is much longer, will still close the lower aperture. The semi-fluid materials are then put into the basin B^1, and fall from thence into the vessel B; when it is fully charged the rod K is again lowered into the position shown in the figure. The communication with the hydraulic press pump is then made by means of a cock attached to the pump, from which the water flows through the pipe R into the vessel B, and thus with a few strokes of the pump the whole of the contents of the vessel B will be subjected to the requisite pressure. An interval of a few minutes is then allowed for the combination of the oil and water, and the cock S is then opened, and a small portion of the fluid contents of the vessel allowed to escape into the cistern. The pressure being thus relieved, the handles P P are to be again turned so as to lift the rod K sufficiently high to withdraw the boss K^2 from the lower opening; the contents of the vessel B will then flow out into the cistern A; and the boss K^2, being again lowered so as to close the lower aperture, the refilling of the vessel may take place for another operation. The pressure thus brought upon the mixture of oleaginous matters and water will cause the oil therein contained to mix with the water, and form a milky-looking fluid, from which the oil may be afterwards separated from the water, either by repose in large vessels or by evaporating the water therefrom by heat. When the oil is to be used for soap making, and some other purposes, this combination of oil and water may be used without such separation. When seed oil is thus obtained the mucilaginous matters assist in combining these fluids. After the materials have been drawn off from the cistern A, and passed through a strainer, the solid portions are to undergo another pressing, in order to displace the remaining portion of their fluid contents. In some cases it will be found advantageous to boil up the milky-looking fluid resulting from the operation last described, in order to coagulate the albuminous portions and otherwise assist in the purification of the oil.

The quantities of oil produced by the various seeds vary greatly and also different samples of the same kind of seed.

The following notes of Mr. E. Woolsey, taken by him at sundry mills for pressing oils; and remarks upon the subject of seed-crushing in general, will doubtless be valuable: —

"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 14½ galls. of 7½ 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 7½ lbs. each)
Best Odessa - - - - - -	18 and even 19	do.
Good crushing seed - - - - - - -	15½	do.
Low seed, such as weighs 48 lbs. per bushel - -	13½	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 14½ gals. per quarter. I had some American seed which weighed 52¼ 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 $\frac{56}{100}$ per cent. A friend of mine, who is a London crusher, told me the oil varied according to the seed from 14 to 17 gals.; 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, prices of seed.	E. India linseed worth -	52*s.*	per quarter.
	Petersburg linseed	48 to 52	do.
	Odessa - - - -	52	do.

The difference of 4*s.* must be paid for in the quantity of oil, which at 38*s.* 6*d.* per cwt. (the then price) requires about 11½ 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 gals.; Sicilian seed 16 gals.

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, 200 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, 80 tons.	13 light stampers.	1 pair rolls.	2 pr. edge-stones,	8 table kettles small size heated by fire.	2 English quarters per 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.	⅞ 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.	1¼ English quarter per working hour.	1 ditto.
Ditto -	22 horse engine	none	6 very heavy stampers.	2 pair rolls	2 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

3½ lbs. of best Cambray rape-seed yielded - - 1 lb. oil.
3¾ — common rape-seed - - - - 1 lb. oil.
4¼ — — poppy-seed - - - - 1 lb. oil.

"Rape-seed weighs from 52 to 56 lbs. per imperial bushel."

The following tables of the quantity of oils obtained from some seeds, fruits, &c., may be found useful:—

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 *acanthe*, or bear's foot - - -	25
Poppy seeds - - -	56 to 63	Hemp seed - - -	14 to 25
Oily radish seed - -	50	Linseed - - -	11 to 22
Sesamum (jugoline) -	50	Black mustard seed -	15
Lime-tree seeds - -	48	Beech mast - - -	15 to 17
Cabbage seed - -	30 to 39	Sunflower seeds - -	15
White mustard - -	36 to 38	Stramonium, or thorn-apple, seeds - -	15
Rape, colewort, and Swedish turnip seeds -	33·5	Grape-stones - - -	14 to 22
Plum kernels - -	33·3	Horse-chestnuts - -	1·2 to 8
Colza seed - - -	36 to 40	St. Julian plum - -	18
Rape seed - - -	30 to 36		
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 Hectolitre.	Produce in Litres.
Summer colza - - - -	54 to 65 kilogs.	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
Madia sativa - - - -	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 kilogs.	46 to 50
Sweet almonds - - - -	— 100 —	44 to 48
Olives - - - - - -	— 100 —	10 to 12

Purification of oils — As the oils are obtained from the mills they generally contain some albuminous and mucilaginous matter and some other impurities which require to be removed, in order to render the oil perfectly clear and fit for burning, &c. Several processes have been proposed for this purpose, the one most generally used is that known as Thénard's process.

Although concentrated sulphuric acid acts so strongly on the oils, it is found that, when added only in small quantities, it attacks principally the impurities first. Thénard's process consists in adding gradually 1 or 2 per cent. of sulphuric acid to the oil, previously heated to 100°, and well mixing them by constant agitation. To effect this the process may be carried on in a barrel fixed on an axis and kept revolving, or in a barrel which is itself immovable, but having fixed in its axis a movable fan. After the action of the acid is complete, which is known by the oil, after twenty-four hours' rest, appearing as a clear liquid, holding flocculent matter in suspension, there is added to it a quantity of water, heated to 140°, equal to about two-thirds of the oil; this mixture is well agitated until it acquires a milky appearance. It is then allowed to settle, when, after a few days, the clarified oil will rise to the surface, while the flocculent matter will have fallen to the bottom of the acid liquid. The oil may then be drawn off, but requires to be filtered to make it perfectly clear. The filtration is always a difficult matter, and is conducted in various ways. It is sometimes placed in tubs, in the bottom of which there are conical holes filled with cotton, but the holes become speedily choked with solid matters. Another and more speedy process is by the means of a displacing funnel, the apertures in the diaphragm being stopped with cotton.

Several patents have been taken out for the purification of oils. Some passing hot air through the oil while at the same time exposed to the action of light; others passing steam through the oil.

Cogan's process is a combination of the latter with Thénard's. He operates upon about 100 gallons of oil, and for this quantity he uses about 10 pounds of sulphuric acid, which he dilutes previously with an equal bulk of water. This acid mixture is added to the oil, placed in a suitable vessel, in three parts, the oil being well stirred for about an hour between each addition. It is then stirred for two or three hours in order to insure a perfect mixture, and thus let every particle of the oil be acted on by the acid. It then has assumed, a very dark colour. After being allowed to stand for twelve hours, it is transferred to a copper boiler, in the bottom of which are holes, through which steam is admitted, and passing in a finely divided state through the oil, raises it to the temperature of 212°. This steam process is carried on for six or seven hours; the oil is then transferred to a cooler, having the shape of an inverted cone, terminating in a short pipe, provided with a stop-cock inserted in its side a little distance from the bottom. After being allowed to stand till the liquids are separated, which generally takes about twelve hours, the acid liquor is drawn off through the pipe at the bottom, and the clear oil by the stop-cock in the side of the cooler, all below this tap is generally turbid, and is clarified by subsidence or mixed with the next portion of oil.

Sometimes an infusion of nut-galls is used to separate the impurities, the tannic acid contained in which renders the impurities less soluble; the infusion is well mixed with the oil by agitation, and after separating the two liquids, the oil is deprived of any tannic acid it may have retained, by treating it with acetate of lead, or sulphate of zinc. When the oil is to be used for machinery it must be dried by treatment with freshly calcined sulphate of lime, or carbonate of soda.

General Remarks on the Non-drying Oils.

Olive oil. — Few vegetables have been so repeatedly noticed and so enthusiastically described by the ancient writers as the olive tree. It seems to have been adopted in all ages as the emblem of benignity and peace. The *preserved* or *pickled olives*, so admired as a dessert, are the green unripe fruit deprived of part of their bitterness by soaking them in water, and then preserved in an aromatised solution of salt. There are several varieties met with in commerce, but the most common are the *small French* or *Provence olive* and the *large Spanish olive*. When ripe the fruit abounds in a bland fixed oil. The processes for extracting it have already been mentioned. Olive oil is an unctuous fluid, of a pale yellow or greenish yellow colour. The best kinds have scarcely any smell; a bland and mild taste. In cold weather it deposits white fatty globules (a combination of oleine and margarine). It is soluble in about 1½ times its weight of ether; but is only very slightly soluble in alcohol. By admixture with castor oil, its solubility in spirit seems to be increased. Pure olive oil has less tendency to become rancid than most other fixed oils, but the second qualities rapidly become rancid, owing probably to some foreign matters. It is not a drying oil, and is less apt to thicken by exposure to the air, and for this reason is preferred for greasing delicate machinery, especially watch and clock-work. Brande describes a process for preparing it for these latter purposes. The oil is subjected to cold, when it principally solidifies; the portion however which still remains liquid is poured off from the solid portion. A piece of sheet lead, or some shot, are then placed in it, and it is exposed in a corked phial to the action of sunshine. A white matter gradually separates, after which the oil becomes clear and colourless and is fit for use. Some oils prepared by this process kept its consistence very well for four or five years while in a stoppered bottle, but when exposed to the atmosphere it began to thicken, and did not answer so well as was expected by the watchmaker who tried it from its appearance before exposure to the air.

The principal object in the process appears to be to get as pure oleine as possible, but the purer the oleine the more likely is it to become thick. According to Kerwych, oleine of singular beauty may be obtained by mixing two parts of olive oil with one part of caustic soda lye, and macerating the mixture for twenty-four hours with frequent agitation. Weak alcohol must then be poured into it, to dissolve the margarine soap, whereby the oleine, which remains unsaponified, is separated, and floats on the surface of the liquid. This being drawn off, a fresh quantity of spirit is added, till the separation of the oleine be complete.

It has a slightly yellowish tint, which may be removed by digesting with a little animal charcoal in a warm place for twenty-four hours. By subsequent filtration, the oleine is obtained limpid and colourless, and 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 four different kinds of olive oil known in the districts where it is prepared: — 1. *Virgin* oil; 2. *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 two or three 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, the ordinary oil of Montpellier and Aix, rarely the oil by fermentation, and never the oil of the infernal regions.

When olive oil is mixed with *nitrous acid* or *nitrate of mercury*, it solidifies after some time, and forms a solid fat, of a light yellow colour, which is called *elaidine*. It is the oleine of the oil that is affected, and appears to undergo a molecular change, for the *elaidine* is said to have the same ultimate composition as oleine itself.

Olive oil is used as food and in salads, hence is often called *salad oil;* and also in medicine in making ointments, &c., and for various other purposes.

The analyses of olive oil give the following results: —

	Saussure.	Gay Lussac and Thénard.	Lefort.	
Carbon	76·03	77·21	77·51	77·20
Hydrogen	11·55	13·36	11·56	11·35
Oxygen	12·07	9·43	10·93	11·45
Nitrogen (?)	0·35			
	100·00	100·00	100·00	100·00

Owing to the high price of olive oil it is frequently adulterated with oils of less value, as poppy oil, &c. This will be more fully treated of when speaking of the adulteration of oils in general.

Oil of almonds. — The tree (*Amygdalus communis*) which yields the almond is a native of Syria and Barbary, but is now abundant throughout the south of Europe, and grows even in England, though here the fruit seldom ripens. The oil is obtained by expression from the bitter or sweet almonds, but most generally from the former, from the fact of their being cheaper, and the residual cake being more valuable, yielding by distillation with water the *essential oil of almonds;* when the presence of water is carefully avoided, the oil obtained from them is quite as good as that obtained from the sweet almonds; but when water is present with the almonds, as would be the case if they were deprived of their skins by maceration in water, the oil would possess a more or less acrid taste. The average produce is from 48 to 52 lbs. from 1 cwt. of almonds (*Pereira*). When recently expressed it is turbid, but by rest and filtration becomes perfectly transparent. It possesses generally a slight yellow colour, which becomes considerably paler by exposure to sunshine. It has a mild bland taste, and little or no odour. It is less easily congealed by cold than olive oil. It speedily becomes rancid, and should be kept in well stoppered bottles. It is soluble in 25 parts of cold alcohol, and in 6 parts of boiling alcohol, and mixes in all proportions with ether. It is used for the same purposes as olive oil, in medicine, &c. it is nutritious, but difficult of digestion; it is often used mixed with gum or yolk of egg as an emulsion.

Oil of almonds has the following composition: —

	Saussure.	Lefort. Oil of sweet almonds.		Lefort. Oil of bitter almonds.	
Carbon	77·40	70·42	70·68	70·36	70·72
Hydrogen	11·48	10·77	10·67	10·50	11·01
Oxygen	10·83	18·81	18·65	19·14	18·27
Nitrogen (?)	0·29				
	100·00	100·00	100·00	100·00	100·00

Almond oil is sometimes adulterated with olive oil, poppy, and teel oil, and some commercial samples of oil seem to be only olive, mixed with a little almond oil.

Teel oil, or *oil of sesamum.*—The seeds which yield this oil are obtained from the *Sesamum orientale*, and are much esteemed in South Carolina, where they are called *oily grain;* and are made into soups and puddings, like rice. The fresh seeds yield a warm pungent oil, which loses its pungency after a year or two, and is then used for salad: it is often mixed with olive oil for soups, &c.

Oil of Behen or Ben. —This oil is obtained by expression from the seeds of a plant (*Moringa aptera*) indigenous to Arabia and Syria, and cultivated in the West Indies.

It is colourless or slightly yellow, without odour, and possesses a mild taste. It separates by standing into two parts, one of which bears a very low temperature without congealing. It is neutral to test paper, and becomes slowly rancid. It is used in the manufacture of some perfumes, to dissolve out the odoriferous principle of the flowers. See PERFUMERY.

By saponification it appears to yield two peculiar acids in small quantities, *benic* and *moringic acids.*

Beech oil. — The nuts of the beech tree (*Fagus sylvatica*) yield about 12 per cent. of a clear oil, and 5 per cent. of a turbid oil. The clear oil is slightly yellow, without odour, and very thick. Its density at 60° F. is ·9225. At 1° F. it becomes a yellowish mass. It is employed in cooking in France, and also for illuminating purposes.

The poor people of Silesia use this oil instead of butter.

Oil of mustard. — The seeds of white mustard (*Sinapis alba*) yield about 36 per cent. of a yellow fatty oil, without odour, of a density of ·9142 at 60° F., and does not solidify by cold. The seeds of the black mustard (*Sinapis nigra*) yield about 18 per cent. of a similar oil. It may be used for soups, &c.

Rape seed oil.—This oil is prepared by expression from the seeds of several kinds of *brassica*; the *Brassica napus* yields about 33 per cent. of oil of sp. gr. ·9128; and the *Brassica rapæ* a much smaller quantity of a similar oil of sp. gr. ·9167. None but the driest seeds are used, and these are often submitted to heat in order to coagulate the albumen; but the oil, when first obtained, requires considerable purification before being fit for the purposes to which it is applied. Thénard's process, before mentioned, answers well. Dr. Rudolph Wagner has found that a solution of chloride of zinc may be advantageously substituted for sulphuric acid in the clarification of rape oil. The solution of the chloride used is of sp. gr. 1·85, and is used in the proportion of 1½ per cent. of the crude oil. The mixture is then shaken, and at first the oil becomes yellow, then dark brown, and after a few days a dark brown deposit takes place. The oil is still turbid, but by adding hot water and passing steam through it, it is rendered clear, and the chloride of zinc separated.

Deutsch recommends to subject the rape oil to heat until it begins to decompose, and keep it in a state of gentle ebullition for a few hours; a scum forms and separates, and the oil becomes transparent and greenish. After two or three days' repose the clear oil is drawn off and is fit for use.

Warburton's method is to agitate the oil with a certain quantity of a solution of caustic soda, which dissolves the impurities, these separating with the small quantity of soap formed; the oil is afterwards well washed with water and collected.

Rape oil is of a light yellow colour, peculiar taste and smell, which increase as the oil is heated.

It is employed for illuminating, for the manufacture of soft soaps, for the oiling of woollen stuffs in the process of their manufacture, in the preparation of leather, and also for lubricating machinery.

The English rape seed seems to yield the best oil.

Butter of cacao. — This is obtained from the cacao nut, the seed of a tree (*Theobroma cacao*) which is largely cultivated in South America. The nuts yield about 50 per cent. of this substance, which is either expressed by the aid of heat, or by boiling the crushed seeds with water. It is yellowish, but may be obtained almost colourless by melting in hot water. It has the consistence of suet. It presents the odour and taste of the cacao nut. Its density is ·91; it fuses at 86° F., but does not solidify again till cooled to 73° F. It is composed in a great part of stearine, with very little oleine. It may be kept for a very long time without becoming rancid, and on this account it is sometimes used in pharmacy.

Plum kernel oil. — The kernels of the plum (*Prunus domesticus*) deprived of their skin, yield about 33 per cent. of a transparent oil, of a brownish yellow colour, and of a taste resembling that of oil of sweet almonds. Its sp. gr. is ·9127; and solidifies at 16° F. It speedily becomes rancid. It is prepared especially in Wurtemburg, and is employed for lighting, for which it answers very well.

Cocoa nut oil.—The trees (*Cocos nuciferæ*, &c.) which yield the cocoa nut are natives of tropical climates, five varieties being indigenous to Ceylon. A powerful oil is extracted from the bark, and is used by the Cingalese as an ointment in cutaneous diseases. The cocoa nut oil of commerce is obtained from the kernel of the nut. Two processes are used for its extraction in Malabar and Ceylon; viz. by pressure, aided by heat, or by boiling the bruised kernel with water, and skimming off the oil as it forms on the surface. It is a white solid, possessing a peculiar odour and mild taste. It fuses at about 70° F. It is composed principally of a peculiar fat, *cocinine*, and a small quantity of oleine. It speedily becomes rancid. We receive it principally from South America. It is employed in the manufacture of candles and soap, and serves particularly for the manufacture of a marine soap, which forms a lather with sea-water. It is used largely in India and Ceylon as a pomatum, and is there prized for that purpose, but its speedily becoming rancid prevents its use here.

Palm oil. — This oil is extracted from the fruit of one of the palm trees, some say the *Cocos butyracea*, and others the *Avoira elæis.* The oil resides in the fleshy portion of the fruit, which is about the size of pigeons' eggs, ovate, somewhat angular, deep orange yellow, collected in heads. They have a thin epicarp, a fibrous, oily, yellow sarcocarp, which covers and closely adheres to the hard stony putamen or endocarp, within which is the seed. The oil is obtained from the sarcocarp, and in this respect resembles the olive. It is obtained either by expression, or by boiling the fruit with water, when the oil separates and rises to the surface. It is imported principally from Cayenne and the coasts of Guinea. It is, when freshly imported, of the consistence of tallow, of an orange colour, and possesses the smell of violets, and fuses at about 80° F. It speedily becomes rancid and decomposes with liberation of glycerine and the fatty acids, and as this change progresses, its fusing point gradually rises till it sometimes even reaches 97° F. It is composed principally of a peculiar fat, *palmitin*, and a little oleine and colouring matter. It is used in the manufacture of soap and candles, and is imported in very large quantities. The following is a general outline of the treatment of palm oil at Price's Candle Company's works in 1855 (*Pharmaceutical Journal*, vol. xv. p. 264). The crude palm oil is melted out of the casks in which it has been imported, and allowed to remain in a melted state in large tanks until the mechanical impurities have settled to the bottom. The clear oil is then pumped into close vessels, where it is heated and exposed to the action of sulphuric acid. The glycerine and fatty acids are thereby separated, and the colouring matter and impurities are carbonised and partly rendered insoluble. The mixture has now a greyish-brown colour, and is washed with water to remove the acid. From the washed product, distillation now separates the mixed fatty acids (palmitic and palm-oleic acids), as a white crystalline fat, while the residuum in the still is converted into a fine hard pitch. This pitch is fit for any of the purposes to which ordinary pitch is applicable. The mixed fatty acids may be made directly into candles, or they may be separated by hydraulic pressure, aided, if necessary, by heat. This effects the separation of the liquid part (oleic acid), which, after purification, is fit for burning in lamps and other purposes. The hard cake left in the presses is nearly pure palmitic acid, it is brilliantly white, not at all greasy, and has a melting point of 135° to 138°. It is fit for the manufacture of the finest candles, either alone or in admixture with the stearine of the cocoa nut oil.

Palm oil often requires to be bleached for its various uses, and there are several processes used to effect it, viz. chlorine, powerful acids, and the combined influence of air, heat, and light.

M. Pohl has bleached palm oil by heating it quickly to 464° F. and keeping it at that temperature for a few minutes, without the aid of light or air. And he says this process has been carried on for some time in a factory. The heating of the palm oil is effected as rapidly as possible in cast-iron pans ; it is kept for ten minutes at the temperature of 464° F., and the bleaching is complete. Ten or twelve hundred-weight of palm oil may be conveniently heated in one pan, which, however, must only be two-thirds full as the oil expands greatly by the heat. It must be covered with a well fitted cover, which prevents inconvenience from the disagreeable vapours which arise. This answers better on the large scale than on the small. By this process it acquires an empyreumatic odour, which disappears after a little time, and the original odour of the palm oil returns.

The yellow fat which is used to grease the axle-trees of the railway carriages is prepared with a mixture of palm oil and tallow, with which is mixed a little soda lye. (*Gerhardt.*)

For the properties of *palmitin* and *palmitic acid* see PALMITIC ACID.

Laurel oil.—This oil is known also under the name of "*oil of bays.*" and is obtained from either the fresh or dried berries of the *bay tree* (*Laurus nobilis*), which grows principally in the south of Europe ; and is also cultivated in our gardens, the leaves being used by the cook on account of their flavour. The berries were analysed by Bonastre in 1824, and amongst other things, were volatile oil, 0·8, laurin (camphor of the bay berry), 1·0, and fixed oil, 12·8, in 100 parts of the berries. Duhamel states that the fixed oil is obtained from the fresh and ripe berries by bruising them in a mortar, boiling them for three or four hours in water, and then pressing them in a sack. The expressed oil is mixed with the decoction, and on cooling is found floating on the surface of the water. When the dried berries are used they are first subjected to the vapour of water until they are well soaked, and are then rapidly pressed between heated metallic plates. By the latter process they yield one-fifth of their weight of oil. It is imported in barrels from Trieste. It has a butyraceous consistence and a granular appearance. Its colour is greenish, and its odour like that of the berries. Cold alcohol extracts from it the essential oil and green colouring matter, leaving the *lauro-stearine*, which composes the principal part of it. With alkalies it forms soaps. But its principal use is in medicine, and more particularly in veterinary medicine. It has been used as a stimulating liniment in sprains and bruises, and in paralysis.

Native oil of laurel (*Hancock*); *Laurel turpentine* (*Stenhouse*).—Imported from Demerara; obtained by incisions in the bark of a large tree, called by the Spaniards "*Azeyte de sassafras*," growing in the vast forests between the Orinoco and the Parime. This oil is transparent, slightly yellow, and smells like turpentine, but more agreeable, and approaching to oil of lemons. Its sp. gr. at 50° F. is 0·8645. It consists of two or more oils isomeric with each other, and with oil of turpentine. Its colour is due to a little resin. It is an excellent solvent for caoutchouc. (*Pereira*).

Ground-nut oil.—This is obtained from the fruit of the *ground-nut* plant (*Arachis hypogæa*). Ostermeier states, that a considerable quantity of the earth-nut having been imported into Bremen, without finding a market, the importers expressed the oil, which is sold under the name of *earth-nut oil.* According to Dr. Buchner, this plant belongs to the leguminosæ, and the fruit is a netted yellowish grey pod, of from one to three inches long, and four to nine lines thick, in which are contained two or three brownish-red ovate seeds, of the size of a small hazel-nut. Their parenchyma is white, very nutritious and oily, on which account the *Arachis*, which is indigenous to the tropical parts of America, has been transplanted to Asia and Africa, and even to the south of Europe; and is in that climate frequently cultivated and employed for the manufacture of the oil. The oily seeds possess a sweet taste, somewhat like that of haricot beans, and are used in tropical climates, partly raw, and partly prepared into a sort of chocolate, which however is not equal to that prepared from cacao. The oil is employed for the same purposes as olive oil. It is of a somewhat greenish colour, and has a sp. gr. of ·9163 at 60° Fahr. It is only slightly soluble in alcohol (one part in 100). Its smell at ordinary temperatures is scarcely perceptible, but if heated to 122° or 167° Fahr. it acquires a smell like sweet oil, and the haricot beans, but is not disagreeable. Its taste is not quite so agreeable as that of almond oil and olive oil. At about 34° Fahr. the arachis oil (from Bremen) congeals into a viscid mass like a liniment, without depositing anything, by which it is distinguished from oil of almonds and olive oil. Although not a drying oil, it does not solidify when treated with nitrous acid or nitrate of mercury, and by this also may be known from olive oil, &c.

Colza oil.—See the article Colza Oil.

Piney tallow.—This is prepared from the fruit of the *Valeria Indica*, a tree which grows in Malabar. It is obtained by boiling the fruit with water, and collecting the fat which rises to the surface. It is white, greasy to the touch, and of an agreeable odour. Its fusing point is at about 95°. Its sp. gr. at 59° is 0·926, and at 95° 0·8965. Alcohol extracts from it about 2 per cent. of oleine, possessing an agreeable odour. It answers well for the manufacture of soap and candles, but is little known in this country.

Spindle-tree oil.—The oil of spindle-tree (*Euonymus Europæus*), is yellowish, rather thick, with the odour of colza oil, of a bitter and acrid taste. It is solid at 5° Fahr. It gives to hot water a bitter substance. It is but little soluble in alcohol, and the solution has an acid reaction. It contains margarine, and oleine, and some benzoic and acetic acids.

Butter of nutmegs.—This is commonly known in the shops as *expressed oil of mace*, and is prepared by beating the nutmegs to a paste, placing them in a bag and exposing them to steam, and afterwards pressing between heated plates. It is imported in oblong cakes (covered by some leaves), which have the shape of common bricks, only smaller. It is of an orange colour, firm consistence, fragrant odour, like that of nutmegs. Schroder found 16 parts of the oil, expressed by himself, contained 1 part of volatile oil, 6 parts of brownish yellow fat, and 9 parts of a white fat. The volatile oil, and yellow fat are both soluble in cold alcohol and cold ether; the white fat soluble in alcohol and ether, when boiling, but insoluble in them when cold. By saponification it yields glycerine and myristic acid ($C^{28}H^{27}O^{3},HO$). A false article is sometimes made, composed of animal fat, boiled with powdered nutmegs, and flavoured with sassafras (*Playfair*). The genuine article may be known by being soluble in four times its weight of boiling alcohol, or half that quantity of boiling ether. Its principal use is in medicine. It must not be confounded with *essential oil of mace.*

The Drying Oils.

Linseed oil.—The oil is obtained by expression from the seeds of the common flax (*Linum usitatissimum*), either with or without the aid of heat; the latter, being known as *cold drawn linseed oil*, is better than that expressed by heat. By cold expression the seeds yield about 20 per cent. of oil, but by the aid of heat from 22 to 27 per cent. The cold drawn oil is of a light yellow colour, while that obtained by heat is brownish, and easily becomes rancid. It has a peculiar smell and taste. According to Saussure its sp. gr. is 0·9395 at 53·6° Fahr.; 0·9125 at 122° Fahr.; and 0·8815 at 201° Fahr. At 4° Fahr. it becomes paler without solidifying; but at —17·5° Fahr. it forms a solid mass. It is soluble in 5 parts of boiling alcohol, in 40 parts of cold alcohol, and in 1·6 parts of ether.

It consists principally of a liquid oil, which differs, however, as before mentioned, from the oleine of olive oil and the non-drying oils in general, and is called *linoleine*, and yields by saponification, *linoleic acid*. It also contains some margarine, and generally some vegetable albumen and mucilage.

Pure linseed oil has the following composition:—

	Sacc.			Lefort.	
Caroon	78·05	78·18	-	75·19	75·14
Hydrogen	10·83	11·09	-	10·85	11·12
Oxygen	11·12	10·73	-	13·96	13·74
	100·00	100·00		100·00	100·00

Linseed oil is easily saponified, yielding a mixture of oleate and margarate of the alkali, and a large quantity of glycerine.

It is acted on rapidly by nitric acid, producing margaric acid, pimelic acid, and some oxalic acid.

Chlorine and bromine act on it, yielding thick coloured products: when linseed oil is heated in a retort, it gives off, before entering into ebullition, large quantities of white vapours, which condense to a limpid colourless oil, possessing the odour of new bread. As soon as the ebullition commences these vapours cease; the oil froths up, and at length there is left a thick gelatinous residue, very much resembling caoutchouc.

The principal use of linseed oil is in making paints and varnishes. It attracts oxygen rapidly from the air and solidifies, and this property is what renders it so valuable for these purposes: it is the most useful of all the drying oils. The small quantities of vegetable albumen and mucilage which the oil naturally contains appear, according to Liebig, to impair, to a certain extent, its drying properties, and the real object which is obtained by boiling these oils with litharge, or acetate of lead and litharge, is the removal of these substances; the oil then being brought more directly in contact with the oxygen of the atmosphere, dries up more rapidly. It was previously thought that some of the litharge was reduced to metallic lead, oxidising at the same time some of the linoleine; but Liebig's opinion seems to be more likely to be correct. The boiling of the oil requires some little care. A few hundredths of litharge is added to the oil, or some use acetate of lead and litharge, and, as before stated, about an eighth part of resin; this is boiled with the oil, the scum removed as it forms, and when the oil has acquired a reddish colour, the source of heat is removed, and the oil allowed to clarify by repose. Liebig thinks heat is not necessary, and his process for treating the drying oils, in order to increase their siccative properties, has already been mentioned. According to MM. E. Barruel et Jean, the resinification of the drying oils may be effected by the smallest quantities of certain substances, which would act in the manner of ferments. The borate of manganese acts in this way; a thousandth part of this salt being sufficient to determine the rapid desiccation of these oils.

Linseed oil is used in the manufacture of printer's ink; being heated in a vessel until it takes fire, it is allowed to burn some time, then it is tightly covered; and subsequently mixed with about one-sixth of its weight of lamp black.

The thin gummed silks receive the last of their many layers with boiled linseed oil; it is also used for leather varnishes, and for oil-cloths.

The residue after the expression of the oil from the seeds, is called oil-cake, and is sold for feeding cattle; that obtained from the English linseed is the best.

Walnut oil.—This is obtained by expression from the ordinary walnuts deprived previously of their skin, which are the produce of a tree (*Juglans regia*) which is a native of Persia, but cultivated in this country for the sake of the nuts.

When recently prepared it is of a greenish colour, but by age becomes a pale yellow. According to M. Saussure its sp. gr. at 53·6° Fahr. is 0·9283, and at 201° Fahr., 0·871. It has no odour and an agreeable taste. At 5° Fahr. it thickens, and at 17·5° Fahr. it forms a whitish mass. The nuts yield about 50 per cent. of oil. It dries still more rapidly even than the linseed oil. It is principally used for paints and varnishes, and from its lighter colour, it is often used for white paints.

Oil of the hazel-nut.—This is extracted from the seeds of the *Corylus avellana*, which yield about 60 per cent. of the oil. It is liquid, has only a slight colour, no odour, and a mild taste. Its sp. gr. at 59° Fahr. is 0·9242. At 14° Fahr. it solidifies.

Poppy oil.—This is expressed from the seeds of the common poppy (*Papaver somniferum*), which grows wild in some parts of England. It is cultivated in very large quantities in Hindostan, Persia, Asia Minor, and Egypt, for the sake of the opium which is obtained from the capsules. It is cultivated in Europe for the capsules, which are used in medicine, or for the oil extracted from the seeds. The oil is obtained, by expression, from the seeds, which do not possess any of the narcotic properties of the capsules. These seeds are sold for birds, under the name of *maw-seed.*

This oil resembles olive-oil in its appearance and taste, and is often used to adulterate it. Its sp. gr. at 59° Fahr. is 0·9249. It becomes solid at 0° Fahr. It is soluble in 25 parts of cold alcohol, and in 6 parts of boiling alcohol, and may be mixed in all proportions with ether. It is used sometimes for lighting, and after treatment with litharge or subacetate of lead is used for paints.

Hemp-seed oil. The seeds of the common hemp (*Cannabis sativa*) yield, by expression, from 14 to 25 per cent. of their weight of a fixed oil. It is obtained principally from Russia, but the native places of the plant are Persia, Caucasus, and hills in the north of India. The seeds are small ash-coloured shining bodies. They are demulcent and oleaginous, but possessing none of the narcotic properties of the plant. They are employed for feeding cage-birds, and it has been stated that the plumage of certain birds, as the bull-finch and goldfinch, becomes changed to black by the prolonged use of this seed. When fresh, this oil is greenish, but becomes yellow by age. It has a disagreeable odour, and insipid taste. It is soluble in all proportions in boiling alcohol, but requires 30 parts of cold alcohol to dissolve it. It thickens at 5° Fahr., and becomes solid at 17·5° Fahr. It is sometimes used for illuminating purposes, but being a drying oil, it forms a thick varnish and thus clogs the wick ; it is used also in making soft soap, and in paints. When boiled with litharge or subacetate of lead it forms a good varnish.

Sunflower oil. —The seeds of the sunflower (*Helianthus annuus*) yield about 15 per cent. of a limpid oil, having a clear yellow colour ; it has an agreeable odour, and mawkish taste ; its sp. gr. at 60° is ·9263°. At 9° Fahr. it becomes solid. It is sometimes employed as food, as well as for illuminating purposes, and for making soap.

Castor oil. —The castor-oil plant has been known from the remotest ages. Caillaud found the seeds of it in some Egyptian sarcophagi, supposed to have been at least 4000 years old. Some people imagine it is the same plant that is called the *gourd* in scripture. It was called *κρότων* by the Greeks, and *ricinus* by the Romans. It is a native of India, where it sometimes grows to a considerable size, and lives several years. When cultivated in Great Britain, it is an annual, seldom exceeding three or four feet. There appear to be several varieties of the *ricinus*, the officinal is the *Ricinus communis*, or *Palma Christi.*

The seeds are oval, somewhat compressed, about four lines long, three lines broad, and a line and a half thick ; externally they are pale grey, but marbled with yellowish-brown spots and stripes.

The oil may be obtained from the seeds by expression, by boiling with water, or by the agency of alcohol. Nearly all that is consumed in England is obtained by expression.

In America the seeds cleansed from the dust and fragments of the capsules, are submitted to a gentle heat, not greater than can be borne by the hand, which is intended to render the oil more liquid, and therefore, more easily expressed. They are then submitted to pressure in a screw-press: the whitish oily liquid thus obtained, is boiled with a large quantity of water, and the impurities skimmed off as they rise to the surface. The water dissolves the mucilage and starch, and the albumen is coagulated by the heat, forming a layer between the oil and water. The clear oil is now removed, and boiled with a *very* small quantity of water until aqueous vapour ceases to arise, and a small portion of the oil taken out in a phial remains perfectly transparent when cold. The effect of this operation is to clarify the oil, and to get rid of the volatile acrid matter. Great care is necessary not to carry the heat too far, as the oil would thus acquire a brownish colour and acrid taste.

In the West Indies the oil is obtained by decoction, but none of it appears in commerce in this country.

In Calcutta it is thus prepared : — The fruit is shelled by women ; the seeds are crushed between rollers, then placed in hempen cloths, and pressed in the ordinary screw or hydraulic press. The oil thus obtained, is afterwards heated with water in a tin boiler until the water boils, by which means the mucilage and albumen are separated. The oil is then strained through flannel and put into canisters.

Two principal kinds of castor seeds are known, the large and the small nut; the latter yields the most oil (*Pereira.*) The best East Indian castor oil is sold in London as "cold drawn."

In some parts of Europe castor oil has been extracted from the seeds by alcohol, but the process is more expensive, and yields an inferior article.

Castor oil is a viscid oil, generally of a pale yellow colour, a nauseous smell and taste. Its sp. gr. according to Saussure is 0·969 at 53° F. The acrid taste which it sometimes possesses, may be removed from it by magnesia (*Gerhardt*). At about 0° F. it forms a yellow, solid, transparent mass. By exposure to the air, it becomes rancid, thick, and at last dries up, forming a transparent varnish. It dissolves easily in its own volume of absolute alcohol; castor oil and alcohol exercise a mutual solvent power on each other (*Pereira*). It is also equally soluble in ether.

Pereira states that there are chiefly three sorts of castor oil found in the London market; viz. the oil expressed in London from imported seeds, East Indian oil, and the American or United States castor oil. Castor oil is imported in casks, barrels, hogsheads, and duppers. It is purified by decantation and filtration, and bleached by exposure to sunlight.

It is not quite decided how many kinds of fats castor oil contains; according to Gerhardt, several, but Saalmuller says only two. It is, however, principally composed of *ricinoleine*, with perhaps a little stearine and palmitine, and an acrid resin. Its ultimate composition is shown by the following analyses:—

	Ure.	Saussure.	Lefort.	
Carbon	74·00	74·18	74·58	74·35
Hydrogen	10·29	11·03	11·48	11·35
Oxygen	15·71	14·79	13·94	14·30
	100·00	100·00	100·00	100 00

When castor oil is heated in a retort to 509° F. an oleaginous liquid distills over, without the liberation of much gaseous matter; about the third part of the oil thus passes over. If after this it is further heated it froths up, but if the distillation is stopped before it begins to froth up, there remains in the retort a substance insoluble in water, alcohol, ether, the fatty and essential oils; this is treated with ether to remove any undecomposed castor oil, then dissolved in potash; the soap thus formed yields a fatty acid, viscid at ordinary temperatures, very soluble in absolute alcohol, but little soluble in weak spirit. The volatile products of the distillation contained *œnanthole*, *œnanthylic acid*, some *acroleine*, and solid fatty acids.

Hyponitric acid solidifies castor oil, and nitric acid when boiled with it converts it into œnanthylic and suberic acids.

Castor oil is said to be adulterated sometimes with croton oil to increase its activity; this is a dangerous sophistication; it is also mixed with some cheap fixed oils. The latter adulteration has been said to be detected by the solubility of castor oil in alcohol, but unfortunately castor oil may contain as much as 33 per cent. of another fixed oil, and yet be soluble in its own volume of alcohol (*Pereira*), this oil possessing the property of rendering other oils soluble in spirit.

Grape-seed oil.—The grapestones (*Vitis vinifera*) yield about 11 per cent. of their weight of a fixed oil, which is, when fresh, of a clear yellow colour, but becomes brown by age. It has an insipid taste, and little or no odour. Its sp. gr. at 60° F. is ·9202; at 3° F. it becomes solid. It is not of much value for illuminating purposes, but in some southern localities it is used for food.

Oil of the pine and fir trees. — In the Black Forest in Germany, an oil is extracted from the cleaned seeds of the *Pinus picea* and *Pinus abies*. It is limpid, of a golden yellow colour, and resembles in smell and taste the oil of turpentine. Its sp. gr. is 0·93 at 60° F. It is very fluid and dries rapidly. It only congeals at — 22° F. It answers well for the preparation of colours and varnishes.

Oil of camelina.—This is extracted from the seeds of the *Myagrum sativum*; it is of a clear yellow colour, with but little smell or taste, and dries rapidly by exposure to the air. It is used for lighting.

The oil of belladonna seeds. — This oil is extracted in Wurtemburg from the seeds of the *Atropa belladonna*, and is there used for lighting and cooking. It is limpid, of a golden yellow colour, insipid taste, and no odour. All the poisonous principles of the plant are left in the seed cake, which cannot, therefore, be given to cattle. The odour which is given off during its extraction, stupefies the workmen.

Oil of tobacco seeds. — The seeds of the *Nicotiana tabacum* yield about 31 per cent. of their weight of a drying oil, which is limpid, of a greenish-yellow colour, and no odour. It does not possess any of the narcotic principles of the plant.

Cotton seed oil. — Many attempts have been made to render fit for use the oil obtained from the seeds of the cotton plant (*Gossypium Barbadense*), as immense quantities of these seeds are allowed to rot, or used only as manure upon the cotton lands of the south of the United States of America. When obtained by expression, the oil which runs from the press is of a very dark red colour. It, however, deposits some of the colouring matter by standing, as well as a portion of semi-solid fat; and in cold weather this is precipitated in large quantities; and only partially redissolves again by increase of temperature. The great obstacle to the use of the oil thus obtained is its colour, which appears to be derived from a dark resinous substance, presenting itself in small dots throughout the seed. These may readily be seen by examining a section of the seeds with a lens, or even with the naked eye (*Mr. Wayne, Pharmaceutical Journal*, xvi. 335). In bleaching, the oil loses from ten to fifteen per cent., a portion of which may be again recovered and used for making soap, for which purpose cotton seed oil seems best fitted. It is a drying oil, and consequently not well fitted for machinery; and when burnt, rapidly clogs the wick. A very good soap for common purposes is made from it in New Orleans. Mr. Wayne also states, "that the oil, to be made profitably, should either be manufactured in the vicinity of the cotton plantation, as the seeds, from the attached fibre, are bulky, and the cost of transportation great; or the seed should be hulled at the spot, and shipped to the place where it is to be pressed in that condition, as it requires three or four bushels of seed in the wool to produce one bushel of hulled seed ready for the mill. The hull and attached fibre are useful for paper stock; and the cake, left after the extraction of the oil, is nearly as valuable a food for cattle as that of linseed.

"It appears that boiling the crushed seeds with water yields a very bland, light-coloured oil.

"The desire to bring this oil into use still exists, for a sample of it was sent a few months since from a merchant in America to a friend of mine to see if he could succeed in purifying it, which no doubt will ultimately be effected by some one."

The cotton plant grows principally in the south of the United States of America; but it has of late years been cultivated in India.

Croton oil.—This oil is obtained from the seeds of the *Croton Tiglii*, by expression, or by the use of alcohol. It is a most violent purgative, and its only use is in medicine. (For a lengthened account of this oil see *Pereira's Materia Medica.*)

Animal Oils.

The mode of the formation of fats in animals has been explained upon two theories. That of Dumas, and supported by some high authorities, which considers that the fats are not formed in the animals, but that they receive the fat already formed from the vegetable kingdom, the *herbivora* obtaining it from the vegetables which serve them for food, and the *carnivora* obtaining it from the herbivora on which they feed. No doubt some of the animal fats are thus obtained, but doubtless some are formed in the manner accounted for in the opposing theory, of Liebig. He considers that the fat is formed principally by the deoxidation of the amylaceous and saccharine matters taken in the food. These substances are principally consumed in respiration when the animal takes much exercise, being converted again into water and carbonic acid, from which they were formerly produced by the plants. When the animal is kept without exercise, the respiration is less vigorous, and if the animal at the same time be fed with these amylaceous or saccharine substances, the excess of these is converted into fat.

Huber of Geneva, several years since, found that bees did not obtain their wax entirely from plants; he kept some bees in a confined place and fed them entirely on honey, and they formed quite as much wax as when they were perfectly at liberty amongst the flowers: in this way he proved that wax, which is a true fat, was a *secretion* of the bee. See Nutrition.

The only oils which will be mentioned here are lard-oil, tallow-oil, and neat's-foot oil. The solid fats will be described under their different heads. See Stearine.

Lard oil.—This oil is now imported largely from America, and is obtained by subjecting ordinary hog's-lard to pressure, when the liquid part separates, while the lard itself becomes much harder. It is employed for greasing wool, for which purpose it answers very well, and may be obtained at a low price. According to Braconnet, lard yields 0·62 of its weight of this oil, which is nearly colourless. Sp. gr. 0·915 (*Chevreul*). 100 parts of boiling alcohol dissolve 123 parts of it.

Tallow oil.—This oil is obtained from tallow by pressure. The tallow is melted, and when separated from the ordinary impurities by subsidence, is poured into vessels and allowed to cool slowly to about 80°, when the stearine separates in granules, which may be separated from the liquid part by straining through flannel, and is then pressed, when it yields a fresh portion of liquid oil. It is employed in the manufacture of some of the best soaps.

Neat's-foot oil.—After the hair and hoofs have been removed from the feet of oxen, they yield, when boiled with water, a peculiar fatty matter, which is known under the name of *Neat's-foot oil;* after standing it deposits some solid fat, which is separated by filtration; the oil then does not congeal at 32°, and is not liable to become rancid. It is often mixed with other oils. This oil is used for various purposes, especially, owing to its remaining liquid at so low a temperature, for oiling church clocks, which require, in consequence of the cold they are exposed to, an oil which is not liable to solidify.

Fish Oils.

Although the whale is not, truly speaking, a fish, the oil obtained from it is classed among the fish oils, and those which will be described here are, whale oil, porpoise oil, seal oil, and cod-liver oil. The three former are all known under the name *train oil.*

Whale oil.—The capture of the whales is a large commercial undertaking; many well-manned ships, and fitted out at great expense, proceed every year from England, Holland, France, and other nations, into the arctic zone in search of these animals, and especially the Greenland species (*Balæna mysticetus*). This valuable animal has produced to Britain 700,000*l.* in one year, and one cargo has been known to be worth 11,000*l.* The Greenland whale inhabits the polar seas; its length is from 60 to 70 feet, when full grown. When the whales are captured they are secured along side the ship, and the process of flensing commences. The men having shoes armed with long iron spikes to maintain their footing, get down on the huge and slippery carcass, and with very long knives and sharp spades make parallel cuts through the blubber, from the head to the tail. A band of fat, however, is left around the neck, called the *kent,* to which hooks and ropes are attached for the purpose of shifting round the carcass. The long parallel strips are divided across into portions weighing about half a ton each, and being separated from the flesh beneath are hoisted on board, chopped into pieces, and put into casks. During the homeward voyage the animal matters, &c., attached to the blubber, undergo decomposition to a certain extent, while there is at the same time a peculiar fat formed, which is a compound of glycerine and *phocenic acid,* and which imparts the disagreeable odour peculiar to train oil. Dumas has shown that this acid is identical with valerianic acid. After the decomposition of the blubber, the oil runs from it easily, and the whole is put into casks with perforated bottoms, placed over tanks for receiving the oil. The oil is heated to about 212°, to facilitate the separation of the impurities, and in order to further purify it, some use a solution of tannin, to precipitate the gelatine present; others use different metallic salts, as acetate of lead. On the western coast of Ireland the whale is sometimes captured, and yields a large quantity of very good oil, superior to sperm oil for illuminating purposes. The sperm whale (*Physeta macrocephalus*) does not yield so much oil as the Greenland whale, but yield considerably more of the valuable substance *spermaceti.*

Train oil is of a brownish colour, with a disagreeable odour; it is used for lighting, in the manufacture of soft soaps, and in the preparation of leather.

Referring to the American whale fishery for 1859, the *Peterhead Sentinel* says: "The result is not so satisfactory as we had anticipated; indeed it will be seen that there are indications of a gradual decline. Going back seven years, we find that the number of vessels was nearly 670; on the 1st of January, 1860, it was only 571, showing a decrease as compared with the previous year of 54 vessels, with an aggregate of 18,066 tons; and it is calculated that there will be as great a falling off during the current year. The whole imports of 1859 were as follows:—Sperm, 9141 tons; whale, 19,041 tons; bone, 1,923,850 lbs. From this it appears that there has been an excess over the year 1858 in sperm of 946 tons; whale, 819 tons; and in bone, 323,250 lbs. The exports of oil and bone were, sperm, 5,221 tons; whale, 818 tons; and bone, 1,707,929 lbs. This shows that the export of sperm oil in 1859 largely exceeds that of 1858, while that of the whale has been light. As regards prices, the average of whale oil was, in 1858, 2*s.* 3*d.*, and in 1859, 2*s.* 0½*d.* per gallon. During the same periods the prices in this country were respectively 2*s.* 9*d.* and 2*s.* 5*d.* per gallon. In America sperm oil, in 1858, was 5*s.* 5*d.* and in 1859, 5*s.* 8*d.* per gallon, against 7*s.* to 8*s.* in this country."

Seal oil.—The seal fishery of Newfoundland has now become the most important part of the trade of that colony. Although perhaps not so extensive a staple as the cod-fishery, yet when capital and time employed, &c., are taken into consideration, it is the most profitable business of that colony, or perhaps of any other part of the British Empire.

A quarter of a century ago, there was only about 50 vessels, varying from 30 to 60 tons burthen, engaged in this branch of trade; but it has since 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 year 1852, the outfit consisted of 367 vessels of 35,760 tons, employing about 13,000 men. There were 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 this 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 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, who 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 despatches 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 3000, many with 5000 and 6000, and some with as many as 7000, 8000, and 9000. 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 2*s*. 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 are 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 vats. 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. 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 remain 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.

Mr. S. G. Archibald directed his attention 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 received letters-patent under the Great Seal of the Island of Newfoundland.

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 percentage is saved in the yield, and what is termed *pale seal*, produced from the old as well as from the young 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.

In the United States the great consumption of oil is for domestic purposes. 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.

Porpoise oil.—This oil very much resembles whale oil.

Cod-liver oil.—This oil is obtained principally from the livers of the common cod (*Callarias; Gadus Morrhua*), previously called *Asellus major*, and also from some allied species, as the Dorse (*Gadus callarias*), the Coal Fish (*Merlangus carbonarius*), the Burbot (*Lota vulgaris*), the Ling (*Lota molva*), and the Torsk (*Brosimus vulgaris*). The mode of preparing this oil varies in different countries; that found in the London market is the produce of Newfoundland, where, according to Pennant, it is thus procured:—Some spruce boughs are pressed hard down into a half tub, having a hole through the bottom; upon these the livers are placed, and the whole exposed to the sun. As the livers become decomposed the oil runs from them, and is caught in a vessel placed under the tub.

De Jongh describes three kinds of cod-liver oil,—the *pale*, *pale brown*, and *brown*.

Pale cod-liver oil.—This is golden-yellow; without disagreeable odour; not bitter, but leaves a peculiar acrid, fishy taste in the mouth; has a slight acid reaction; sp.

gr. 0·923 at 63·5° F. Cold alcohol dissolves from 2·5 to 2·7 per cent. of the oil; hot alcohol from 3·5 to 4·5 per cent. It is soluble in ether in all proportions.

Pale brown cod-liver oil.—Colour of Malaga wine; odour not disagreeable; bitterish, leaving an acrid, fishy taste in the throat; reacts feebly as an acid; sp. gr. 0·924 at 63·5° F. A little more soluble in alcohol than the *pale oil.*

Dark brown cod-liver oil.—This is dark brown, and by transmitted light is greenish; it possesses a disagreeable odour, bitter and empyreumatic taste, which remains sometime in the fauces; it is slightly acid; sp. gr. 0·929 at 63·5° F. Still more soluble in alcohol than the *pale brown oil.*

Cod-liver oil is principally used in medicine; for a fuller description of it see *Pereira's Materia Medica.*

Dugong oil.—This oil has been used instead of cod-liver oil, principally in Australia; but as very little, *if any*, real Dugong oil has reached England, it will merely require a short notice here. The Dugong is an animal belonging to the class of herbivorous cetacea, and is found on the northern coast of Australia, in the Red Sea, the Persian Gulf, and also in the Indian seas. It has received different names by different nations. In the Indian seas it is sometimes found of a large size, from 18 to 20 feet long; but in Australia it is seldom caught of more than 12 or 14 feet. In its general form it resembles the common whale. Its favourite haunts are the mouths of rivers and straits between proximate islands, where the depth of water is but trifling (3 or 4 fathoms), and where, at the bottom, grows a luxuriant pasturage of submarine algæ and fuci, on which it feeds. The oil is obtained by skinning the animal and then boiling down the "speck." It was used by the natives of Australia originally for burning.

Statistics.—The quantity of oils *imported* in 1857 and 1858, are given below:—

	1857.	1858.
	Cwts.	Cwts.
Castor oil	40,621	21,475
Cocoa-nut oil	207,239	197,788
Palm oil	854,791	778,230
	Tons.	Tons.
Olive oil	18,862	25,121
Fish oil	21,176	19,445
Seed oils of all kinds	13,110	9,170

Adulteration of the oils.—Owing to the large quantities of oil of various kinds which are now used, and their difference in price, many are the adulterations which take place. Thus the best olive oil for the table is mixed with oils of less value, as poppy oil, sesame oil, or ground nut oil; and the second olive oil, for the manufactures, with colza oil; and again colza oil itself mixed with poppy, camelina, and linseed oils, but more frequently with whale oil, &c. Various means have been proposed to discover these admixtures. M. Lefebvre proposed to take advantage of the difference of density of the several oils, but this is a very insufficient test, as many of the oils have nearly the same density.

M. Poutet treats the oil to be tested with one twelfth of its weight of a solution of nitrate of mercury, containing hyponitric acid; this latter substance converts the oleine of most of the non-drying oils into a solid substance, *elaidine.* By this means pure olive oil will become perfectly solid after an hour or two, whereas poppy oil and the drying oils in general remain perfectly liquid; it would therefore result that olive oil adulterated with these latter oils, would be prevented from solidifying more or less, according to the quantity of these oils present. An improvement in this process is to substitute nitric acid, saturated with hyponitric acid, for the nitrate of mercury solution. The sample to be tested is shaken with two or three per cent. of this acid, and then placed in a cool place, and the moment of solidification noticed. It is always better also to treat a sample of oil of known purity to the same test at the same time and compare the results. If the sample tested be pure, it will solidify quite as quickly as the sample which serves for comparison. One hundredth of poppy oil present will delay the solidification 40 minutes (*Gerhardt*), and of course the greater the quantity of admixture, the more will it be delayed.

M. Maumène takes advantage of the greater amount of heat given out by the admixture of concentrated sulphuric acid with the drying oils, than takes place with olive oil under the same circumstances. MM. Heydenreich and Penot employ sulphuric acid also to detect the different oils, but they notice the peculiar colorations which take place on contact of the concentrated acid with the different kinds of oils. Their test is thus performed:—one drop of concentrated sulphuric acid is added to 8 or 10 drops of the oil, placed on a piece of white glass, resting on a sheet of white paper; different colorations appear, which they state are characteristic of the different oils; thus olive oil gives a deep yellow tint, becoming greenish by degrees; colza oil a greenish blue; poppy oil, a pale yellow tint, with a dirty grey outline; hempseed oil, a very deep emerald tint; and linseed oil becomes brownish red, passing directly into blackish brown, &c. These reactions are however uncertain; the age of the oil, mode of extraction, &c., altering them greatly.

Marchand states that a mixture of poppy oil and olive oil, when thus treated, develop, after a certain time, on their outline, a series of colours, rose, lilac, then blue, and more or less violet-coloured, according to the proportion of poppy oil, while pure olive oil becomes of a dirty grey, then yellow and brown.

As the means of detecting the various fraudulent admixtures is of great commercial value, I shall conclude by giving the heads of F. C. Calvert's valuable paper on the adulteration of oils. (*Pharmaceutical Journal*, xiii. 356.) He there recommends that samples of *pure* oil should always be tested comparatively with those suspected of being adulterated, and never to rest contented with only one of the tests mentioned.

As the reactions presented by the various oils depend upon the special strength and purity of the reagents, not only should great care be taken in their preparation, but also in the exact mode and time required for the chemical action to become apparent. These points will be described with each reagent.

Solution of caustic soda, sp. gr. 1·340.

The reactions given in the following table are obtained by adding one volume of this test-liquor to five volumes of oil, well mixing them, and then heating the mixture to its point of ebullition.

Dark Colourations.		Light Colourations.	
Fish Oils.	Vegetable Oils.	Animal Oils.	Vegetable Oils.
Sperm, Seal, Cod-liver — red.	Hempseed — thick brown-yellow. Linseed — fluid yellow.	Neat's-foot — dirty yellowish-white. Lard — pinkish-white.	Pale rapeseed, Poppy, French nut, Sesame — dirty yellow-white. Castor, India nut (thick) — white. Gallipoli, Olive — yellow.

The principal use of this table is to distinguish fish from animal and vegetable oils, owing to the distinct red colour which the former assume, and which is so distinct that one per cent. of fish oil can be detected in any of the others. Hempseed oil also becomes brown-yellow, and so thick that the vessel containing it may be inverted, for an instant, without losing any of its contents, whilst linseed oil acquires a much brighter yellow colour, and remains fluid. India nut oil is characterised by giving a white mass, becoming solid in five minutes after the addition of the alkali, which is also the case with Gallipoli and pale rape oils, while the others remain fluid.

The next test he uses is dilute sulphuric acid, and as the reactions vary with the strength of the acid, he employs three different strengths.

Sulphuric acid of sp. gr. 1·475.

The mode of applying this acid consists in agitating one volume with five volumes of oil until complete admixture, and after standing fifteen minutes the appearance is taken as the test reaction.

Not coloured.		Coloured.		
Animal.	Vegetable.	Fish.	Animal.	Vegetable.
Lard, dirty.	India nut. Pale rape-seed. Poppy. Castor.	Sperm, Seal — light red. Cod-liver — purple.	Neat's-foot — yellow tinge.	Olive, Gallipoli, Sesame — green tinge. Linseed — green. Hempseed — intense green. French nut — brownish.

The most striking reactions in this table are those presented by hempseed and linseed oils, for the green colouration which they acquire is such, that if they were used to adulterate any of the other oils, they would be immediately detected if only present to the amount of ten per cent.

The red colour assumed by the fish oils with this test is also sufficiently marked to enable us to detect them in the proportion of one part in 100 of any other oil, and it is at the point of contact of oil and acid, when allowed to separate by standing, that the red colour is principally to be noticed.

Sulphuric acid, sp. gr. 1·530.

One volume of this acid is mixed, as before, with five volumes of oil and allowed to stand five minutes.

Light Colourations.		Marked Colourations.	
Animal.	Vegetable.	Fish.	Vegetable.
Lard - dirty white.	Olive - greenish white.	Sperm, Seal - red.	Gallipoli -, French nut: intense grey.
Neat's-foot: brownish dirty white.	Sesame - greenish dirty white.	Cod-liver: purple.	Hempseed, Linseed -: intense green, dirty green.
	India nut -, Poppy -, Castor -: dirty white.		
	Pale rape-seed -: pink.		

As hempseed, linseed, fish, Gallipoli, and French nut oils are the only ones that assume with the above reagent a decided colouration, they can be discovered in any of the others.

Sulphuric acid of sp. gr. 1·635.

This acid is used in a similar manner to those above, and the colouration noted after two minutes.

Not coloured.	Distinctly coloured.		
Vegetable.	Fish.	Animal.	Vegetable.
Poppy. Sesame. Castor.	Sperm, Seal -, Cod-liver: intense brown.	Lard - light brown. Neat's-foot: brown.	Olive (light) - -, Hempseed (intense) -, Linseed - - -: green. Gallipoli - - -, Pale rapeseed - -, French nut - -, India nut (light) -: brown.

The colourations produced by sulphuric acid, sp. gr. 1·635, are so marked, that they may be consulted with great advantage in many cases of adulteration: for example, Mr. Calvert has been enabled to detect distinctly ten per cent. of rape seed in olive oil, of lard oil in poppy oil, of French nut oil in olive oil, of fish oil in neat's-foot oil.

This appears to be the maximum strength that can be used, for nearly all the oils begin to carbonise, and their distinct colouration to be destroyed

Action of nitric acid, of different strengths, on oils:—

Nitric acid of sp. gr. 1·180.

One part of this acid, by measure, is agitated with five parts of oil, and the appearance, after standing five minutes, is described in this table.

Not coloured.			Coloured.		
Fish.	Animal.	Vegetable.	Fish.	Animal.	Vegetable.
Cod-liver.	Lard.	India nut. Pale rape-seed. Poppy. Castor.	Sperm — slight yellow. Seal - pink.	Neat's-foot — light yellow.	Olive -, Gallipoli — greenish. Hemp-seed - — dirty green. French nut -, Sesame (orange), Linseed - — yellow.

This test is sufficiently delicate to detect distinctly 10 per cent. of hempseed oil in linseed oil, as the mixture assumes the greenish hue so characteristic of the former. Although olive acquires a green colour, still its shade is such that it is entirely distinguished from that of hempseed.

Nitric acid of sp. gr. 1·220.

The proportion of acid used, and the time of contact are the same as the last.

Not coloured.			Coloured.		
Fish.	Animal.	Vegetable.	Fish.	Animal.	Vegetable.
Cod-liver.	Lard.	India nut. Pale rape-seed.	Sperm — light yellow. Seal - — light red.	Neat's-foot — light yellow.	Poppy (yellow), French nut -, Sesame - — red. Olive -, Gallipoli — greenish. Hemp-seed - — greenish dirty brown. Linseed - yellow.

The chief characters in the above table are those presented by hempseed, sesame, French nut, poppy, and seal oils, and they are such that they not only may be employed to distinguish them from each other, but are sufficiently delicate to detect their presence when mixed with other oils, in the proportion of 10 per cent.

Nitric acid of sp. gr. 1·330.

One part of this acid is mixed with 5 parts of oil by measure, and remains in contact 5 minutes.

Not coloured.	Coloured.		
Vegetable.	Fish.	Animal.	Vegetable.
India nut. Pale rape-seed. Castor.	Sperm, Seal -, Cod-liver — red.	Neat's-foot — light brown. Lard - — very slight yellow.	Poppy - - -, French nut (dark) -, Sesame (dark) - - — red. Olive - - -, Gallipoli - - - — greenish. Hempseed - - — greenish dirty brown. Linseed - - - — green, becoming brown.

The colourations here described are very marked, and can be employed with advantage to discover several well-known cases of adulteration; for instance, if 10 per cent. of sesame or French nut oil exists in olive oil; but the same proportion of poppy oil cannot be thus detected, as the colour produced is not so intense as in the other cases. But if any doubt remained in the mind of the operator, as to whether the adulterating oil was sesame, French nut, or poppy, he would be able to decide it by applying the test described in the next table, where he will find that French nut oil gives a fibrous semi-saponified mass, sesame a fluid one, with a red liquor beneath, and poppy, also a fluid mass, but floating on a colourless liquid.

The successive application of nitric acid of sp. gr. 1·330, and of caustic soda of sp. gr. 1·340, can be also successfully applied to detect the following very frequent cases of adulteration; first, that of Gallipoli with fish oils, as Gallipoli oil assumes no distinct colour with the acid, and gives with a soda a mass of a fibrous consistency, whilst fish oils are coloured red, and become mucilaginous with the alkali.

Secondly, that of castor oil with poppy oil, as the former acquires a reddish tinge, and the mass with the alkali loses much of its fibrous appearance.

Thirdly, rapeseed oil with French nut oil, as nitric acid imparts to the former a more or less intense red tinge, which an addition of the alkali increases, and renders the semi-saponified mass more fibrous.

Mr. Calvert here remarks that the colourations which divers oils assume under the influence of the three test nitric and sulphuric acids, clearly show that the reason why chemists had not previously arrived at satisfactory results in distinguishing oils in their various adulterations, was that the acids they employed were so concentrated that all the distinctive colourations were lost; the oils became yellow or orange; but there is no doubt that the above reagents will enhance the value of Mr. F. Baudet's, as they afford very useful data to specify the special oils mixed with olive oil.

Caustic soda of sp. gr. 1·344.

The following reactions were obtained on adding 10 volumes of this test liquor to the 5 volumes of oil which had just been acted upon by 1 part of nitric acid: —

A fibrous mass is formed.		A fluid mass is formed.		
Animal.	Vegetable.	Fish.	Animal.	Vegetable.
Neat's-foot — white.	Gallipoli, India nut, Castor — white.	Sperm. Seal. Cod-liver.	Lard.	Olive, Pale rapeseed — white.
	French nut — red.			Linseed — yellowish.
	Hemp-seed — light brown.			Poppy (light) — red.
				Sesame — brown liquor beneath — amber.

Having given in a previous paragraph some of the most useful reactions noted in this table, attention will simply be called to the following mixtures: neat's-foot with rape, Gallipoli with poppy, castor with poppy, hempseed with linseed, sperm with French nut, and Gallipoli with French nut. It is necessary also here to mention that the brown liquor on which the semi-saponified mass of sesame oil swims, is a very delicate and characteristic reaction.

The next test used is *phosphoric acid.*

One part by measure of syrupy trihydrated phosphoric acid is agitated with 5 parts of oil. The only reaction to be noticed is the dark red colour, rapidly becoming black, which phosphoric acid imparts exclusively to the fish oils, as it enables us to detect 1 part of these oils in 1000 parts of any other animal or vegetable oils, and even at this degree of dilution, a distinct colouration is communicated to the mixture.

Mixture of sulphuric and nitric acid.

This test is formed of equal volumes of sulphuric acid of sp. gr. 1·845, and nitric acid of sp. gr. 1·330, and is thus used: one volume of this mixture is mixed with 5 volumes of oil, and allowed to stand 2 minutes. By this test 3 of the oils remain nearly colourless, viz., those of poppy, olive, and India nut, while all the others become brown, except sesame, hempseed, and linseed, which become green, turning after, sesame, intense red, and hempseed and linseed, black.

Aqua regia.

This test is composed of 25 volumes of hydrochloric acid of sp. gr. 1·155, and 1 volume of nitric acid of sp. gr. 1·330, and allowed to stand about 5 hours; the reactions in the following table are those which take place when a mixture of 5 volumes of oil and 1 of the aqua regia is agitated and allowed to stand 5 minutes.

Not coloured.		Coloured.		
Animal.	Vegetable.	Fish.	Animal.	Vegetable.
Lard.	Olive. Gallipoli. India nut. Pale rapeseed. Poppy. Castor.	Sperm (slight), Seal (slight), Cod-liver — yellow.	Neat's-foot — slight yellow.	French nut, Sesame, Linseed (greenish) — yellow. Hempseed - greenish.

When the facts contained in this table are compared with the preceding ones, we are struck with their uniformity, and are led to infer that no marked action had taken place; but this conclusion is erroneous, as most of them assume a vivid and distinct colouration on the addition of solution of soda of sp. gr. 1·340, as seen in the following table:—

A fibrous mass is formed.		A fluid mass is formed.		
Animal.	Vegetable.	Fish.	Animal.	Vegetable.
Neat's-foot — brownish yellow.	Gallipoli (yellowish), India nut, Pale rapeseed (yellowish) — white. Castor - pale rose. French nut - orange. Hempseed — light brown.	Sperm, Seal, Cod-liver — orange-yellow.	Lard, pink.	Olive - white. Poppy — intense rose. Sesame — orange with brown liquor beneath. Linseed - orange.

The effects described in this table are such that we can discover with facility 10 per cent. of a given oil in many cases of adulteration; for example, poppy in rape, olive in Gallipoli and India nut, as all of them assume a pale rose colour; but when poppy is mixed with olive or castor oils, there is a decrease in the consistency of the semi-saponified matter.

By the aid of the above reagents we can also ascertain the presence of 10 per cent. of French nut in olive or linseed oils, as the semi-saponified mass becomes the more fluid, and the presence of French nut in pale rape, Gallipoli, or India nut oils, is recognised in consequence of their white mass acquiring an orange hue; linseed oil is detected in hempseed oil, as it renders the fibrous mass of the latter more mucilaginous.

Sesame oil also gives with this reagent the same reaction as with nitric acid and alkali, and poppy oil is distinguished from all other oils, by giving, in this case, a semi-saponified mass of a beautiful rose colour.

To give an idea how the above tables are to be used, Mr. Calvert supposes a sample of rapeseed oil adulterated with one very difficult to discover. He first applies the caustic alkali test, which, on giving a white mass, proves the absence of the fish oils, together with those of hempseed or linseed; and as no distinct reaction is produced by the sample of oil under examination with the 3 sulphuric and nitric acids above mentioned, poppy and sesame oils are thrown out as they are reddened, neat's-foot oil, India nut, castor, olive, and lard oils resting only in the scale of probability. In order to discover which of these is mixed with the suspected oil, a portion of it is agitated first with nitric acid of sp. gr. 1·300, and then with caustic soda, and their mutual action excludes neat's-foot, India nut, and castor oils, as the sample does not give a fluid semi-saponified mass. The absence of olive oil is proved by no green colouration being obtained on the application of syrupy phosphoric acid. As to the presence of lard oil, it is ascertained on caustic soda being added to the oil which has

General Table of Reactions.

Oils.	Caustic Soda. Sp. Gr. 1·340.	Sulphuric Acid. Sp. Gr. 1·475.	Sulphuric Acid. Sp. Gr. 1·530.	Sulphuric Acid. Sp. Gr. 1·635.	Nitric Acid. Sp. Gr. 1·180.	Nitric Acid. Sp. Gr. 1·220.	Nitric Acid. Sp. Gr. 1·33.	+ Caustic Soda. Sp. Gr. 1·310.	Phosphoric Acid. Syrupy.	Sulphuric Acid + Nitric Acid.	Aqua Regia.	+ Caustic Soda. Sp. Gr. 1·340.
Olive - - - -	Slight yellow.	Green tinge.	Greenish-white.	Light green.	Greenish	Greenish	Greenish	Fluid white mass.	Slight green.	Orange-yellow.	- -	Fluid white mass.
Gallipoli - - - -	Ditto	Ditto	Grey	Brown	Ditto	Ditto	Ditto	Fibrous ditto.	Ditto	Dark brown.	- -	Fibrous yellowish-white mass.
India nut - - - -	Thick and white.	- -	Dirty white.	Light brown.	- -	- -	- -	Ditto	- -	Orange-white.	- -	Fibrous white mass.
Pale rapeseed - - -	Dirty yellowish-white.	- -	Pink	Brown	- -	- -	- -	Fluid ditto	- -	Dark brown.	- -	Fibrous yellowish-white mass.
Poppy - - - -	Ditto	- -	Dirty white.	- -	- -	Orange-yellow.	Red	Light red fluid mass.	- -	Slight yellow.	- -	Fluid intense rose-coloured mass.
French nut - - -	Ditto	Brownish	Grey	Brown	Yellow	Red	Dark red	Fibrous red mass.	Brown-yellow.	Dark brown.	Yellow	Fibrous orange-mass.
Sesame - - - -	Ditto	Green tinge.	Greenish dirty white.	- -	Orange-yellow.	Ditto	Ditto	Fluid red mass, with brown liquor underneath.	- -	Green becoming intense red.	Ditto	Fluid orange mass with brown liquor beneath.
Castor - - - -	White	- -	Dirty white.	- -	- -	- -	- -	Fibrous white mass.	- -	Brownish-red.	- -	Fibrous pale rose-coloured mass.
Hempseed - - -	Thick brownish-yellow.	Intense green.	Intense green.	Intense green.	Dirty green.	Greenish dirty brown.	Greenish dirty brown.	Fibrous light brown mass.	Green	Green becoming black.	Green	Fibrous light brown mass.
Linseed - - - -	Fluid yellow.	Green	Dirty green.	Green	Yellow	Yellow	Green becoming brown.	Fluid yellow mass.	Brown yellow-green.	Ditto	Greenish-yellow.	Fluid orange mass.
Lard - - - - -	Pinkish-white.	Dirty white	Dirty white.	Light brown.	- -	- -	Very slight yellow.	Fluid mass	- -	Brown	- -	Fluid pink mass.
Neat's-foot - - -	Dirty yellowish-white.	Yellow tinge.	Brownish dirty white.	Brown	Light yellow.	Light yellow.	Light brown.	Fibrous white mass.	- -	Dark brown.	Slight yellow.	Fibrous brownish-yellow mass.
Sperm - - - -	Dark red	Light red	Red	Intense brown.	Slight yellow.	Ditto	Red	Fluid mass	Dark red	Ditto	Ditto	Fluid orange-yellow mass.
Seal - - - - -	Ditto	Ditto	Ditto	Ditto	Pink	Light red	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto.
Cod-liver - - - -	Ditto	Purple	Purple	Ditto	- -	- -	Ditto	Ditto	Ditto	Ditto	Yellow	Ditto.

been previously acted on by aqua regia, as the latter gives a fibrous yellowish semi-saponified mass, whilst the former yields a pink fluid one.

In order to facilitate the detection of any adulteration, Mr. Calvert, gives a general table of the preceding reactions. (See table on preceding page.)—H. K. B.

OILS, VOLATILE, ETHEREOUS, OR ESSENTIAL. 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 *labiatæ* 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 sufaee, 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 volatilised 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.

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 limonium* and *bergamia*, or the lemon and the bergamot. 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. See Perfumery.

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 product 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.

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 gas; nor was it yet completely saturated with oxygen. The stearescence 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 oxidisement 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.

They 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. Such combinations form the odoriferous 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 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 alcohol 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.

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. Perfumers formerly employed a great quantity of this oil in scenting their soaps. But nitro-benzole is now used instead of the essential oil of bitter almonds in flavouring. See BENZOLE; NITRO-BENZOLE. A similar 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*), 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 anise-seed, is extracted by distillation from the seeds of the *Pimpinella anisum*.

Oil of bergamot, is extracted by pressure from the rind of the ripe fruit of the *Citrus bergamia*.

Oil of cajeput is prepared in the Moluccas, by distilling the dry leaves of the *Melaleuca cajeputi*. 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.

The oil of caraway is extracted from the seeds of the *Carum carui*.

The oil of cassia, from the *Cinnamomum cassia*, is yellow passing into brown.

The oil of chamomile is extracted by distillation from the flowers of the *Anthemis nobilis*. It has a blue colour when quite fresh, but becomes yellow by exposure; it possesses the peculiar smell of the plant.

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.

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. It is one of the least volatile oils.

The oil of elder, is extracted by distillation from the flowers of the *Sambucus nigra.*

Oil of fennel, is extracted by distillation from the seeds of the *Anethum fœniculum.*

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.

The oil of lavender, is extracted from the flowering spike of the *Lavandula vera.*

Oil of lemons, is extracted by pressure from the yellow peel of the fruit of the lemon or *Citrus limonium.*

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.

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.

The oil of parsley is extracted from the *Apium petroselinum.*

The oil of pepper is extracted from the *Piper nigrum.*

The oil of peppermint is extracted from the *Mentha piperita.*

The oil of pimento is extracted from the envelopes of the fruit of the *Eugenia pimenta*, which afford 8 per cent. of it.

The oil of rhodium is extracted from the wood of the *Convolvulus scoparius.*

The oil of roses, called the *attar* or *otto*, is extracted from the petals of the *Rosa centifolia* and *sempervirens.*

The oil of rosemary is extracted from the *Rosmarinus officinalis.*

The oil of saffron is extracted from the *stigmata* of the *Crocus sativus.* It is narcotic.

The oil of sassafras is extracted from the woody root of the *Laurus sassafras.*

Oil of savine is extracted from the leaves of the *Juniperus sabina.*

Oil of thyme is obtained from the *Thymus vulgaris.*

Oil of wormwood is distilled from the *Artemisia absinthium.*

Oil of turpentine. See TURPENTINE.

In the last edition there appeared a somewhat long paper on the tests of purity for the essential oils. It has not been thought desirable to preserve this, for, although it contained much valuable matter, a skilled chemist could alone avail himself of the facts stated by Dr. Ure.

For all general purposes, the few remarks on page 307, on the mixture of the fat oils with the essential oils, are quite sufficient.

OLD RED SANDSTONE. A geological formation so called; named by Sedgwick and Murchison, DEVONIAN, as portions of the system are peculiarly developed in Devonshire. See SANDSTONE.

OLEATES are saline compounds of oleic acid with the bases.

OLEFIANT GAS is the name originally given to bi-carburetted hydrogen. See CARBURETTED HYDROGEN.

OLEIC ACID. A neutral oil, obtained by saponifying mutton fat with potash, and decomposing the soap with sulphuric acid. The fat acids are dissolved in hot alcohol; the solution on cooling is expressed, and the operation frequently repeated. Oleic acid is insoluble in water, but soluble in alcohol and ether. Its formula appears to be $C^{36}H^{33}O^{3}$,HO.

OLEINE, OR LIPYLE. Obtained by boiling tallow in alcohol. It is regarded as an *Oleate of oxide of glyceryle.* It constitutes the more fluid portion of oils.

OLIBANUM is a gum-resin, used only as incense in Roman-catholic churches.

OLIVE OILS. See OILS.

ONICOLO, OR NICOLO. A variety of onyx having a ground of deep brown, in which is a band of bluish white. It is used for cameos, and differs from the ordinary onyx in a certain blending of the two colours.—H. W. B.

ONYX. A mineral belonging to the chalcedonic variety of quartz. It resembles agate, excepting that the colours are arranged in flat horizontal planes. When the layers consist of *sard* and white *chalcedony*, the stone is called *sardonyx.*

These stones were formerly more prized than they are at present, and were frequently cut in cameo and intaglio.

OOLITE. (*Oolith*, Germ. From ὠον, an egg, and λίθος, *a stone.*) Those varieties of limestone which are composed of an aggregation of small spherical concretions resembling in appearance the roe of a fish; and bound together by a calcareous cement. When first quarried they are generally soft, but harden by exposure to the air and the evaporation of the water.

The particles are generally formed of concentric layers of carbonate of lime arranged round a grain of sand, a fragment of shell, or some organic substance, forming the nucleus around which the calcareous matter has been deposited.

The name roestone, from the fanciful resemblance of these oolitic concretions to the roe of a fish, has likewise been given to this kind of limestone when the grains are of small sizes; when of comparatively large dimensions, as in some beds of Inferior Oolite in the neighbourhood of Cheltenham, they are distinguished by the name of peastone or pisolite (from *πισον, a pea*, and *λίθος, stone*).

In geological nomenclature, the term oolite has a more extended signification, and is applied indiscriminately to the entire accumulation of strata consisting of limestones, marls, clays, sands, intervening between the Trias or New Red and the Wealden formations, in consequence of the limestones of those deposits frequently possessing an oolitic structure. Of these, Portland stone, Coral Rag, Bath or Great Oolite, and Inferior Oolite are the most important in an economical point of view, owing to their furnishing fine descriptions of freestone, suitable for building and ornamental purposes, both from their tints, which are either white or cream coloured, and the large blocks in which they can be obtained.

The well-known white freestone obtained from Caen in Normandy is an Oolitic limestone belonging to the Bath or Great Oolite formation.

Although the oolite formations constitute the chief repositories of limestones possessing an oolitic structure, they are not confined to those groups of strata, but are met with in other formations, as for instance in some beds of carboniferous or mountain limestone in the neighbourhood of Bristol, as well as very largely in that of Ireland. — H. W. B.

OOST, or OAST. The provincial name of the stove in which the picked hops are dried.

OPAL. An ornamental stone.

The following are the more important varieties of the opal: —

The precious opal, exhibiting a play of rich colours.

Fire opal or *girasol*, with hyacinth red and yellow reflections.

Common opal, semi-opal; non-opalescent varieties.

Hydrophane; non-transparent, but becoming so by immersion in water.

Cacholong; nearly opaque, of a bluish white colour.

Hyalite; colourless, pellucid, or white.

Opal jasper, wood opal, and several others.

All these are composed of silica in the gelatinising state, with more or less water, and occasionally, as accidental admixtures, other bodies in small proportions.

By analyses the following results have been obtained as it regards the silica: —

The precious opal of Hungary	92	silica.
The fire opal of Mexico	92	"
Ditto of Faroe	88·73	"
Semi-opal of Hanau	82·75	"
Ditto Kaschan	92·16	"
Cacholong of Faroe	95·82	"

Opal may be regarded as an uncleavable quartz. Its fracture, conchoidal; lustre, vitreous or resinous; colours, white, yellow, red, brown, green, grey. 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 tuberose concretions. The phenomena of the play of colours in precious opal have not been satisfactorily explained. It seems to be connected with the regular structure of the mineral. Haüy attributes the play of colours to the fissures of the interior being filled with films of air, agreeably with the law of Newton's coloured rings. Mohs, however, thinks this would produce iridescence merely. Brewster concludes that it is owing to fissures and cracks in the interior of the mass of a uniform shape. It is said that the opal which grows after a while dull and opaque may be restored to its former beauty if put for a short time in water or oil. (?)

The precious opal stands high in estimation, and is considered one of the most valuable gems, the size and beauty of the stone and the variety of the colours determining its value. The so-called "mountain of light," an Hungarian opal in the Great Exhibition of 1851, weighed 526½ carats, and was estimated at 4000*l.* sterling. In Vienna is a precious opal weighing 17 oz.; and it is said a jeweller of Amsterdam offered half a million of florins for it, which was refused.

Hydrophane, or oculis 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 long been 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 Gracios 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. 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 asteria, or star-stone.

OPEN CAST. *A mining term*, signifying that the mineral, whatever it may be, is obtained by open workings, and not by mining.

OPERAMETER is the name given to an apparatus invented by Samuel Walker, 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.

A similar clock-work mechanism, called a *counter*, has been for a great many years employed in the cotton factories and in the pumping engines of the Cornish and other mines, to indicate the number of revolutions of the main shaft of the mill or of the strokes of the piston. 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.

OPIUM is the juice which exudes from incisions made in the heads of ripe poppies (*Papaver somniferum*), rendered concrete by exposure to the air. 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.

Dr. Eatwell has, in the *Pharmaceutical Journal* for 1852, given an admirable account of the cultivation of the poppy, and the preparation of opium in India, We quote briefly from his paper. At about three or four o'clock in the afternoon individuals repair to the field and scarify the poppy capsules with sharp iron instruments called *nushturs.* These are four narrow bars of iron, each about six inches in length. At one extremity each bar does not exceed a quarter of an inch in breadth, but it gradually expands, until it has acquired the breadth of one inch at the opposite end, where it is deeply notched. The sides of the notch are somewhat curved and ground to sharp edges, and the external edges are brought to sharp points. The four little bars being placed side by side are bound firmly together by strong cotton thread, and the points at their cutting extremities are kept separated from each other, to the extent of $\frac{1}{18}$ of an inch by means of the cotton thread, which is passed between each pair of contiguous blades. With this instrument the poppy heads are scarified, and from these scarifications a milky juice exudes.

The capsules having been scarified in the afternoon, the collection of the juice is made at an early hour the following morning. This is effected by means of instruments called *seetoahs*, which are made of sheet iron, and resemble concave trowels. With these the juice is scraped off from the surface of the scarifications, until the instrument becomes filled, when the contents are emptied into an earthen pot, which the collector carries by his side. When first collected, the juice from the capsules presents the appearance of a wet granular mass, of a pinkish colour, and in the bottom of the vessel which contains it is found collected a dark fluid resembling infusion of coffee, to which the name of *pussewah* is given. This juice when brought home is placed in a shallow earthen vessel, which is tilted to such a degree, that all the pussewah can drain off. This is placed in a covered vessel, and receives no farther attention until it is taken to the government factory for the purpose of being weighed. For many additional particulars relating to this drug, we must refer to the complete article on opium in Dr. Pereira's *Materia Medica*.

The following list contains most of the varieties of opium known in commerce.

Smyrna opium, from *Turkey* or the *Levant*.
Constantinople opium.
Egyptian opium.
Trebizond opium, *Persian opium*.
Indian opium. *Benares*, *Malwa*, and *Patna*.
English opium.
French and German opium.

With the chemistry of opium this work cannot deal. In *Ure's Dictionary of Chemistry* every information on this head will be given. Our *importation* of opium in 1858 was 97,746 lbs. Our *exportation* of opium in the same year was 82,085 lbs.

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. Arnotto alone dyes orange ; but it is a fugitive colour.

ORCHELLA WEEDS. The cylindrical and flat species of Roccella used in the manufacture of *Orchil* and *Cudbear*, are so called by the makers. The following list of orchella weeds is given by *Pereira*.

Angola orchella, *Rocella fuciformis.*
Madagascar orchella, *R. fuciformis.*
Mauritius orchella.
Canary orchella, *R. tinctoria.*
Cape de Verd orchella, *R. tinctoria.*
Azore orchella, *R. tinctoria.*
Madeira orchella, *R. tinctoria* and *R. fuciformis.*
Lima orchella, large and round, *R. tinctoria.*
Lima orchella, small and flat, *R. fuciformis.*
Cape of Good Hope orchella, *R. hypomecha.*
Barbary orchella, *R. tinctoria.*
Corsican and Sardinian orchella, *R. tinctoria.*

Dr. Pereira says Mr. Harman Visger, of Bristol, "informs me that every lichen but the best orchella weed is gone, or rapidly going out of use, not from deterioration of their quality, for, being allowed to grow, they are finer than ever ; but because the Angola weed is so superior in quality, and so low priced and abundant, that the product of a very few other lichens would pay the expense of manufacture." In the *Philosophical Transactions* for 1848, Dr. Stenhouse has a valuable paper on the colouring matters of the lichens. From it we extract his directions for estimating the colouring matter in lichens by means of a solution of hypochlorite of lime.

Any convenient quantity of the orchella weed may be cut into very small pieces, and then macerated with milk of lime, till the colouring matter is extracted. Three or four macerations are quite sufficient for this purpose, if the lichen has been sufficiently comminuted. The clear liquors should be filtered and mixed together. A solution of bleaching powder of known strength should then be poured into the lime solution from a graduated alkalimeter. The moment the bleaching liquor comes in contact with the lime solution of the lichen, a blood-red colour is produced, which disappears in a minute or two, and the liquid has only a deep yellow colour. A new quantity of the bleaching liquid should then be poured into the lime solution, and the mixture carefully stirred. This operation should be repeated so long as the addition of the hypochlorite of lime causes the production of the red colour, for this shows that the lime solution still contains unoxidised colorific principle. Towards the end of the process, the bleaching solution should be added by only a few drops at a time, the mixture being carefully stirred between each addition. We have only to note how many measures of the bleaching liquid have been required to destroy the colouring matter in the solution, to determine the amount of the colorific principle it contained. Dr. Stenhouse suggests the following method for extracting the colorific principle for transport. Cut the lichens into small pieces, macerate them in wooden vats with milk of lime, and saturate the solution with either muriatic or acetic acid. The gelatinous principle is then to be collected on cloths and dried by a gentle heat. In this way the whole of the heat can be easily extracted, and the dried extract transported from the most distant localities.

Imports of ORCHAL (so called in returns), in 1857 and 1858:

	1857. Cwts.	1858. Cwts.
Hanse Towns	645	
Hamburg	-	1,593
France	-	5,248
Canaries	-	509
Portugal	12,595	8,645
West Coast of Africa	2,175	2,454
Cape Verd Islands	1,180	
Ecuador	1,613	1,729
Chili	1,202	14,741
Peru	1,297	4,838
St. Helena	2,842	3,948
Other parts	1,463	516
	25,012	44,221

ORCIN is the name of the colouring principle of several of the lichens. The lichen dried and pulverised 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 orcin. The taste of orcin 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 orchil 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 orcin is exposed to air charged with vapours of ammonia, it assumes by degrees a fine violet colour. To obtain this result, the orcin 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 orcin has required a dark brown cast, it must be withdrawn from under the bell, and the excess of ammonia be allowed to volatilise. As soon as the smell of ammonia is gone, the orcine is to be dissolved 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. The researches of *Stenhouse*, of *Schunck*, of *Rochleder*, and *Heldt* should be consulted. See Lichen; Litmus.

ORE. The natural compound of a metal with some other substance, such as oxygen, sulphur, arsenic, &c. These have been sometimes termed the *mineralisers;* and when metals are found free from such combinations they are called *native* metals and not *ores.*

ORES, DRESSING OF. In metalliferous veins the deposits of ore are extremely irregular and much intermixed with gangue or vein stone. In excavating the lode, it is usual for the miner to effect a partial separation of the valuable from the worthless portion; the former he temporarily stows away in some open place underground, whilst the latter is either employed to fill up useless excavations, or in due course sent to surface to be lodged on the waste heaps. From time to time the valuable part of the lode is drawn to the top of the shaft, and from thence conveyed to the dressing floors, where it has to be prepared for metallurgic treatment.

This process is known as dressing, and in the majority of instances includes a series of operations. In this country it is chiefly restricted to mechanical treatment, the chemical manipulation being performed by the smelter. Hand labour, picking, washing, sizing, and reducing machinery, together with water-concentrating apparatus, comprise the usual resources of the dresser, but sometimes he may find it useful to have recourse to the furnace, since 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 often calcined, which, by separating the arsenic and oxidising the iron and copper, 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, crushing, or stamping processes.

Before entering upon the description of machinery employed in the concentration of ores, it is important to notice the principles upon which the various mechanical operations are based.

If bodies of various sizes, forms, and densities be allowed to fall into a liquid, in a state of rest, the amount of resistance which they experience will be very unequal, and consequently they will not arrive at the bottom at the same time. This necessarily produces a sort of classification of the fragments, which becomes apparent on examining the order in which they have been deposited.

If it be supposed that the substances have similar *forms* and dimensions, and *differ* from each other in *density* only, and it is known that the resistance which a body will experience in moving through a liquid medium depends solely on its form and extent of surfaces, and not on its specific gravity, it follows that all substances will lose under similar circumstances an equal amount of moving force.

This loss is proportionally greater on light bodies than in those having more considerable density. The former for this reason fall through the liquid with less rapidity than the denser fragments, and must therefore arrive later at the bottom, so that the deposit will be constituted of different strata, arranged in direct relation to their various densities, the heaviest being at the bottom, and the lightest at the top of the series.

Supposing, on the contrary, that all the bodies which fall through the water possess similar forms and equal specific gravities, and that they only differ from each other in point of volume, it is evident that the rapidity of motion will be in proportion to their *sizes*, and the larger fragments will be deposited at the bottom of the vessel.

As the bodies on starting are supposed to have the same forms and densities, it follows that the resistance they experience whilst descending through water will be in proportion to the surface exposed, and as the volumes of bodies vary according to the cubes of their corresponding dimensions, whilst the surfaces only vary in accordance with the squares of the same measurements, it will be seen that the force of movement animating them is *regulated by their cubes*, whilst their *resistance* is in proportion to their *squares*.

If, lastly, it be imagined that all the fragments have the same volume and density but are of various forms, it follows that those possessing the largest amount of surface will arrive at the bottom last, and consequently the upper part of the deposit will consist of the thinnest pieces.

It is evidently then of the greatest importance that the grains of ore which are to be concentrated by washing should be as nearly as possible of the *same size*, or otherwise the smaller surface of one fragment, in proportion to its weight, will in a measure compensate for the greater density of another, and thus cause it to assume a position in the series to which by its constitution it is not entitled.

This difficulty is constantly found to occur in practice, and, in order as much as possible to obviate it, care is taken to separate by the use of sieves and trommels into distinct parcels, the fragments which have respectively nearly the same size. Although by this means the grains of ore may to a certain extent be classified according to their regular dimensions, it is impossible by any mechanical contrivance to regulate their forms, which must greatly depend on the natural cleavages of the substances operated on, and hence this circumstance must always in some degree affect the results obtained.

Each of the broken fragments of ore must necessarily belong to one of the three following classes:—the *first* class consists of those which are composed of the mineral sought without admixture of earthy matter. The *second* will comprehend the fragments which are made up of a mixture of mineral ore and earthy substances, whilst the *third* division may be wholly composed of earthy gangue without the presence of metallic ore. By a successful washing these three classes should be separated from each other.

The most difficult and expensive vein stuff for the dressing floors is that in which the constituents have nearly an uniform aggregation, and where the specific gravity of the several substances approximate closely to each other. In such cases the ore is only separated from the waste after much care and labour, and often at the loss of a considerable portion of the ore itself. When, however, the ore is massive and distinct from the gangue, and the specific gravity of the latter much less than the former, then the operation of cleaning is usually very simple, effected cheaply, and with but little loss on the ore originally present.

The losses which may be sustained in the manipulation and enrichment of ores is a matter of great importance, and demands not only direct attention from the chief agent, but also calls for the constant vigilance of the dresser. No one can approve of a system which omits to record the initial quantity of ore brought to the surface, noting only the tonnage and percentage of the parcel produced for sampling.

Yet such inattention prevails generally in the mining districts of this country. What would be thought of a smelter who might systematically purchase and receive ores without ascertaining their produce, and reduce them in furnaces totally unfitted for the purpose, without regarding the losses which might be sustained? If he became insolvent it would excite no surprise, but, on the contrary, the public would most likely look upon his position as the inevitable result of a defective and reprehensible mode of working.

It will be admitted that mineral exploitations are of a highly hazardous nature, and that the risk of profit ought not to be increased either by ignorance or carelessness. When ores are discovered, usually after the expenditure of much money, a certain amount of productive and dead cost is incurred before they can be rendered at the dressing floors; if then the least waste takes place there is not only a loss *per se*, but the mine expenditure is augmented upon the lessened quantity, hence in no department of mining economics is it more essential to secure higher practical talent than in the dressing and management of vein stuff. The individual entrusted with this duty should be competent to assay the ores, have a knowledge of the losses resulting from their metallurgic treatment, and know approximately the cost of enriching them on the floors as well as of smelting them; he will then conduct his operations so that the cost and loss in dressing will be less than the cost and loss in smelting.

Some of the more friable ores, when simply exposed to the influence of water, exhibit a large mechanical loss, so much so, that it is considered oftentimes more profitable to put them to pile without attempting their enrichment. Now it may be laid down as an axiom that water will always steal ore, and the longer it is exposed to its influence, and the more complicated the manipulation, the greater will be the loss incurred. In addition, the constitution of certain ores is so peculiar and delicate, that any attempt to concentrate them beyond a given standard, by varying the treatment, is seen to lead to an enormous loss, as will be apparent by inspecting the following memoranda of practical results : —

(A.)—The ore operated upon was sulphide of lead, associated with finely disseminated iron pyrites, oxide of iron, quartz, and a small portion of clay slate. In each case the vein stuff assayed 17 per cent. of metal.

	Quantity by weight.		Quantity by weight.		
Assayed 17 %	1	washed and concentrated to	·25	The loss on metal originally present in the ore by varying the mechanical treatment was - - -	61 per cent.
	1	”	·40		39 ”
	1	burnt, roasted, and do.	·20		57 ”
	2·4	washed and do.	·43		$37\frac{1}{2}$ ”
	1·56				
	20	loss by roasting			
	1·36	washed and concentrated to	·40		50 ”
	·8	roasted, washed, do.	·42		33 ”
	·8	” ”	·69		$16\frac{3}{4}$ ”

(B.)—Took two parcels of argentiferous lead ore, associated with carbonate of iron, a little quartz, and blende. Weight $34\frac{6}{20}$ tons, which assayed $42\frac{1}{2}$ per ceut. for lead, and 29 oz. of silver per ton of metal. Crushed and carefully elaborated the same through jigging and buddle apparatus, obtained $14\frac{13}{20}$ tons of ore, giving $54\frac{1}{2}$ per cent. for lead, and 22 ounces of silver per ton of metal. The produce for lead was therefore raised 12 units at a loss of 49 per cent. of the initial quantity of metal and 95 ounces of silver. The commercial loss attending this operation, after making the several charges and allowances incident to the metallurgic reduction, was £91 14*s*., or equal to £2 14*s*. per ton on the original weight.

Additional instances of heavy losses incurred in the concentrating process could be adduced if space permitted; but it may not be unwise to direct special attention to the great waste often connected with the manipulation of both tin and argentiferous ores. In the former it occurs chiefly from the oxide of tin being much diffused through hard vein stone, requiring severe mechanical treatment in order to liberate it, whilst in the latter the silver (not unfrequently combined mechanically), imperceptible to the eye, floating away when subjected to water, and so subtle as to evade the most delicately devised apparatus. The loss accruing in one large undertaking from this source alone upon 1100 tons of ore was 3026 ounces of silver worth £830, or equal to the interest on £16,600, at the rate of 5 per cent. per annum.

In order to determine the loss of metal which may arise in enriching ores, accurate assays and notations should be made of the quantity of vein stuff lodged on the floors, which should be compared with the metallic contents rendered merchantable, and the differences estimated.

It is not possible to ascertain the value of an improvement which would secure an additional one per cent. from the quantity of orey stuff annually sent to surface from the several mines in the United Kingdom; but if it be reckoned only upon the sale value it would be scarcely less than 40,000*l*. per annum.

In determining the site for a dressing floor, and in making the mechanical arrangements, various points suggest themselves; since, if they were overlooked, much loss would ensue to the undertaking, or otherwise it is evident that they could only be corrected by involving the proprietary in an increased outlay as well as a greater current expenditure. The first consideration should be to secure an ample supply of water, with a good fall, and an extensive area of ground. With advantages of this nature the machinery will be worked cheaply, the stuff gravitate through the various processes without returning to create double carriage expenses, whilst the castaways may be sent to the waste heaps at a mimimum cost. The second point to be settled, is the class of machinery to be employed. This must obviously be based upon the character which the ores may present. If massive, and associated with light waste, simple apparatus will suffice, but if the ore be sparsely diffused among heavy vein stone, it is probable that the various apparatus will have to be constructed with great nicety, varied in their principles of action, and that much precaution will have to be observed in order to create as little slime as possible, as well as to secure the initial quantity of ore against undue loss. In the disposition of the machinery there is also considerable scope for practical intelligence; it is not enough to wash, crush, jig, and buddle the ores, mixing the resulting smalls incongruously together; but a judicious sorting should be commenced at the wash kilns, and upon this basis the various sizes kept distinct whilst passing through the washing floors. The dresser should also take care to keep the several ranges of mineral produces and degrees of fineness together.

With the view of assisting the judgment in deciding upon the machinery to be employed, the following table of specific gravities, applicable to ordinary vein stuff, is given:—

Table of specific gravities.

		Hardness.	Specific gravity.
Lead:	Sulphide (galena)	2·5 to 2·75	7·5 to 7·6
	Sulphate	2·3 „ 2·7	6·25 „ 6·29
	Carbonate (white)	3·0 „ 3·5	6·46 „ 6·48
	Phosphate (green and brown)	3·5 „ 4·0	6·58 „ 7·04
	Chromate (bright red)	2·5 „ 3·0	6·0 „ 6·04
	Molybdate	2·7 „ 3·0	6·7 „ 6·8
Tin.	Oxide of tin	6·0 „ 7·0	6·5 „ 7·1
	Tin pyrites	3·0 „ 4·0	4·79 „ 5·1
Copper:	Sulphide	2·5 „ 3·0	5·5 „ 5·8
	Oxide	3·5 „ 4·0	5·9 „ 6·0
	Carbonate	3·5 „ 4·0	4·0 „ 4·1
	Pyrites	3·5 „ 4·0	4·15 „ 4·16
	Sulphate	2·2	2·21
	Silico-carbonate	2·0 „ 3·0	2·0 „ 2·2
Zinc:	Red oxide	4·0 „ 4·5	5·43 „ 5·52
	Sulphide	3·5 „ 4·0	4·02 „ 4·07
	Carbonate	5·0	4·33 „ 4·44
	Silicate		3·43
Antimony:	Sulphide	2·0	4·51 „ 4·62
	Jamesonite	2·0 „ 2·5	5·5 „ 5·8

Minerals associated with ores.

	Hardness.	Specific gravity.
Wolfram	5·0 „ 5·5	7·1 to 7·4
Iron pyrites (white)	6·0 „ 6·5	4·67 „ 4·84
Mundic	6·0 „ 6·5	4·83 „ 5·01
Sulphate of baryta	2·5 „ 3·5	4·3 „ 4·8
Carbonate of baryta	3·0 „ 3·75	4·29 „ 4·3
Carbonate of iron	3·0 „ 4·5	3·73 „ 3·82
Fluor spar	4·0	3·0 „ 3·33
Quartz or silica	7·0	2·6 „ 2·7
Carbonate of lime	2·5 „ 3·5	2·5 „ 3·8

Ore-bearing rocks.

	Specific gravity.
Hornblende rock	2·8 to 3·2
Syenite	2·7 „ 3·0
Trap or basalt	2·8 „ 3·2
Porphyry, trachyte, and felspar	2·3 „ 2·7
Granite and gneiss	2·4 „ 2·7
Mica slate	2·6 „ 2·9
Clay slate	2·6
Limestone and dolomite	2·5 „ 2·9
Sandstone	2·4 „ 2·7

The following general deductions will also be found serviceable:—

First.— Absolute perfection in separation according to specific gravity cannot be arrived at, chiefly on account of the irregularity of form of the various grains to be operated upon.

Second.— The more finely divided the stuff to be treated, the greater is the amount of labour and care required, and the more imperfect will be the separation.

Third.— That reducing machine may be considered the most perfect which produces the least quantity of stuff finer than that which it is intended to produce.

Fourth.— It is necessary in determining the degree of fineness to which a mineral should be reduced, to consider the metallurgic value of the ore contained in it, and to set against this the value of the loss which will probably be incurred, together with the labour and expense attendant upon the manipulation.

Fifth.—The vein stuff should be reduced to such a degree of fineness that the largest proportion of deads and clean ore should be obtained by the first operation, thus saving the labour and preventing the loss incident to a finer sub-division of the ore and more extended treatment.

Sixth. — That apparatus or plan of dressing may be considered the most efficient which with stuff of a given size allows at an equal cost of the most perfect separation, and of the proper separation of stuff of nearly equal specific gravity.

The average percentage to which the crop is to be brought, and the highest percentage to be allowed in the castaways being determined, it is evident that the more perfect the degree of separation the greater will be the amount of crop and castaways obtained at each operation, and the quantity of middles or stuff to be re-worked will be diminished.

Seventh. — We may further consider as a great improvement in dressing operations such apparatus or plan of working as will allow, without a disproportionate increase in the cost, of the equally perfect separation of fine stuff as that of the coarser, as now practised. This will be of especial benefit in the case of finely disseminated ore, which is necessarily obliged to be reduced to a great degree of fineness.

Washing and Separating Ores.

The vein stuff on arriving at the surface, is not only associated with a large amonnt of gangue, but is frequently much intermixed with clay, rock, and siliceous matter.

In order to get rid of the latter substances, it is usually washed and picked. The washing apparatus ought to be so contrived as to allow the cleansing to be effected both cheaply and expeditiously, and for this purpose a good volume of water is always desirable. If a height or fall can be obtained, it will also be found advantageous. In accordance with the character of the ore the apparatus will have to be varied, but for lead, certain varieties of copper ore, as well as iron, or other abundant ores, the kiln is well adapted. In many mines rectangular grates are fitted to the bottom of the kilns, but a perforated plate would be found to furnish better results, since the former allows of the passage of flat irregular masses of stone, rendering the treatment in the jigging sieves less successful. The holes in the perforated plate should be conical, the largest diameter underneath, so that the stones may have unobstructed passage. In connection with the kiln-plate a sizing trommel should be used, and in order to economise both time and expenditure it would be judicious to introduce the vein stuff, aud discharge the castaways by means of railways.

The picking of the stuff is a highly important operation. As a rule all picked ore should be selected, and the dradge deprived of the largest possible amount of waste before it is sent to the crusher. It is highly fallacious to suppose, because machinery will deal with large quantities expeditiously, that it is cheaper to subject the mass to its action; on the contrary, if correct calculations are made of the losses which will ensue on the initial quantity of ore before the residue is ready for the pile, the cost of the several intricate manipulations requisite to get rid of the castaways, the wear, tear, and maintenance of machinery, it will appear in the majority of cases that the most profitable method is to incur an extra first charge in order to reject the sterile portions by means of hand labour. The ragging hammer should therefore be brought into free requisition, and all worthless stones at once rejected; then in spalling such portions as have been ragged an additional quantity of refuse should be excluded, whilst in the process of cobbing either ragged or spalled work, the greatest care and attention should be given in order to bring the dradge to a maximum degree of richness.

Among the siftings and washings which ores are made to undergo, we would notice those practised on the Continent, *grilles anglaises*, and *step-washings* of Hungary, *laveries à gradins*. These methods of freeing the ores from pulverulent 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 finer 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 of this, 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 *gradins* is represented in *fig.* 1352. There are 5 such systems in the works at Idria for sorting the small fragments 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.

The 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 grates *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 grates. The pieces which remain upon the two grates *b* and *c*, are thrown on the

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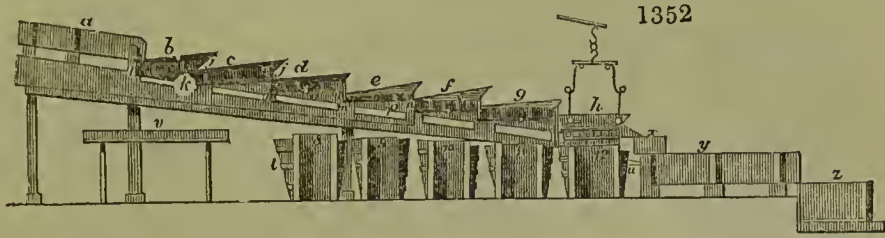

adjoining table *v*, where they undergo a sorting by hand ; there the pieces are classified, 1, into gangue to be thrown away ; 2, into ore for stamping mill ; 3, into ore to be sent directly to the furnace. The pieces which remain on each of the succeeding grates, *d*, *e*, *f*, *g*, *h*, are deposited 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 furnaee.

As to the grains whieh, after traversing the five grates, have arrived at the chest *x*, they are washed in the two chests *y*, which are analogous to the German chests. The upper layer of what is deposited in *y* is sent to the furnace; the rest is treated anew.

The kiln before adverted to is explained by *fig.* 1353.

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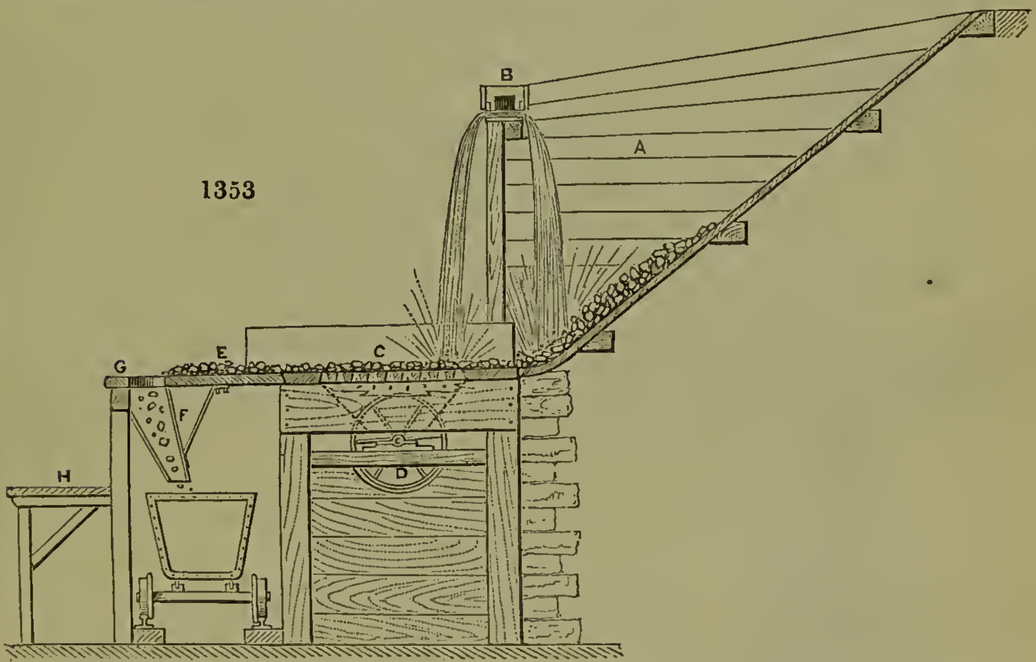

The vein stuff is brought from the shaft by means of tram waggons, into the hopper A; water flows from the launder B, one portion distributing itself at the foot of the hopper, the other upon a east-iron plate perforated with holes $1\frac{1}{4}$ inch diameter at top, $1\frac{1}{2}$-inch diameter at bottom, and 2 inches distant from centre to centre; the plate being 4 feet by 3 feet 6 inches. Between C and E, the washer stands. The fine stuff he rakes through the plate-holes, and that which is too coarse is drawn to E. Children standing on H, select the prill and dradge from the pile E, discharging such stones as are valueless through the shoot F, into the waggon beneath. The trommel D is constructed of perforated plates, having different degrees of fineness, in order to size the stuff whieh passes through into bins or compartments.

Ragging.—It has been remarked that, in breaking the lode underground, numerous rocks are produced throughout which valuable ore is more or less disseminated. After these stones are washed they are ragged. This operation consists simply in reducing the stones to a smaller size, and rejecting as many of the sterile stones as can be readily picked out. The reserved heap is ultimately taken to the spallers and cobbers. The weight of a steel-headed ragging hammer varies from six to eight pounds.

Spalling, *fig.* 1355, is usually performed by women. The object is to break the stones to a proper size for the bucking hammer or crushing mill, and at the same time to

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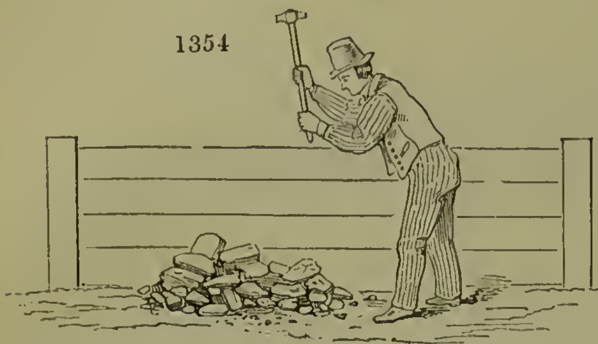

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cast aside such lumps as are destitute of ore. The hammer employed is made of cast steel and is set upon a light pliant handle. Its weight is about sixteen ounces, and its cost eightpence. A practised spaller will produce about one ton of stuff per day, but the quantity must necessarily depend upon the hardness and nature of the stone.

Cobbing, *fig.* 1356.—This work is also generally performed by women or young girls. It consists of picking the best work from the dradge, and with a peculiarly shaped hammer, detaching from each piece the inferior portions, and thus forming either prill or best dradge ore. An expert cobber will manage to pass through her hands about ten hundredweights of tolerably hard stuff per ten hours.

1356

Sizing apparatus.— In the varied processes of dressing, no point is of greater importance than that of correctly sizing the vein stuff, neither is there one demanding the exercise of a more correct judgment. If the particles of ore be reduced below their natural size a source of loss is immediately created, whilst if they are not brought within the limit of their size a portion of waste will probably adhere to each atom, forming a serious difference in the aggregate quantity of castaways, although such waste may afford but a low average percentage. The holes in the sieves or trommels should therefore be proportioned to the nature of the ore, but such apparatus should also be introduced wherever necessary. To the crushing mill, trommels are essential, whilst it will be found highly advantageous to employ them for the purpose of dividing the stuff wherever it may become intermixed. The simplest form of sizing is perhaps by

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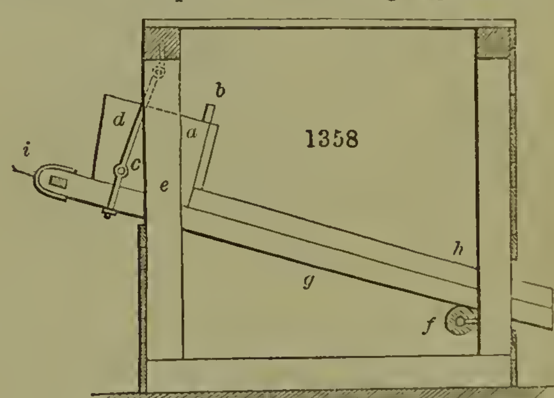

the hand riddle, *fig.* 1357, which is formed of a circular hoop of oak, $\frac{3}{8}$ of an inch thick and six inches deep. Its diameter ranges from eighteen to twenty inches.

The bottom is made of a meshwork of copper or iron wire. The weight of an iron wire riddle is about seven pounds, and its cost 4*s.* 6*d.*

Fig. 1358 represents a swing sieve employed in the mines on the Continent. *a*, box into which the stuff to be sifted is introduced; *b*, regulating door; *c*, pendulating rod attaching the sieve frame to the frame *e*; *f*, friction roller carrying the sieve frame *g*. At *h* springs are fitted to each side of the frame, in order to give it a vibratory action, *i*, rod, giving motion to the apparatus. The width of the sieve frame is about one-third its length, but the sieve bottom only extends from the box *a* two-thirds of the length. The bottom of the sieve frame is subsequently contracted so as to form a shoot. At the extensive mines of Comorn, near Duren, these sizing frames are largely employed in connection with stamping mills.

Fig. 1359 is a swing sieve employed in the Harz, for sifting the small fragments of the ores of argentiferous lead. Such an apparatus is usually set up on the outside of a stamps or washing mill. 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 bears cams or *mentonnets*, placed so as to be pushed down by the driving shaft. 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 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 griddle in the bottom of that chest, are sorted by hand upon a table in front of A, and are classed by the workman, either among the ores to be stamped, whether dry or wet, among the rubbish to be thrown away, or among the ores to be smelted by themselves. As to the small particles which fall through the griddle 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.

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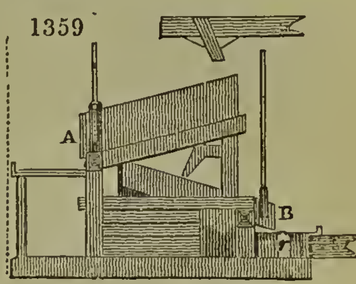

The circular hand-riddle has only recently been introduced into the mines of Cornwall. Although this is in advance of hand riddling, yet it is by no means equal to the large sizing trommels employed in Germany.

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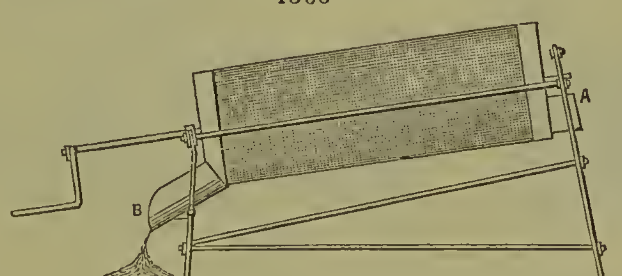

The ore is thrown in it at A, *fig.* 1360, the coarser pieces passing longitudinally through the riddle into the shoot B. The riddle is turned by a hook handle, as shown in the illustration; the meshes of the sieve vary from $\frac{3}{4}$ of an inch to one inch square, according to the character and quality of the vein stuff to be operated upon.

Figs. 1361, 1362 show an elevation and ground plan of a series of flat separating sieves. A A′, B B′ is a strong wooden frame. M M, guides for frame; N N N, basement upon which the sieve frame rests; P, cistern fitted with perforated plate through which clean water is distributed upon the sieves; T, hopper supplying the stuff to be sifted; *s s* bottom of ditto. The sieves are lifted by the rod *l* and make from 40 to 50 beats per minute. The sieves are set about eight inches apart, and discharge the stuff upon the inclines *p p p*.

The holes in No.	1	sieve are $\frac{1}{2}$	inch diameter:
”	2	$\frac{3}{8}$	”
”	3	$\frac{3}{16}$	”
”	4	$\frac{1}{12}$	”

The apparatus is employed in the Clausthal Valley.

Fig. 1363 represents the trommel or sizing sieves in operation at the Devon Great Consols. Although the yield of ore at these mines is extremely large, it may not be generally known that much of it is obtained from stuff yielding no more than from $\frac{3}{4}$ to $1\frac{1}{2}$ per cent. of metal. The product of the lode on arriving at the surface is cobbed and divided into two classes, the first going to market without further elaboration, whilst the dradge or inferior portion is treated by various processes of washing. The whole is however crushed to such a degree of fineness as to pass through the following holes:—

Trommel A, holes $\frac{1}{20}$ inch diameter.
" B, " $\frac{1}{12}$ " "
" C, " $\frac{1}{10}$ " "
" D, " $\frac{1}{8}$ " "

The trommels are each 6 feet long, 24 inches diameter at the large end, and 18 inches

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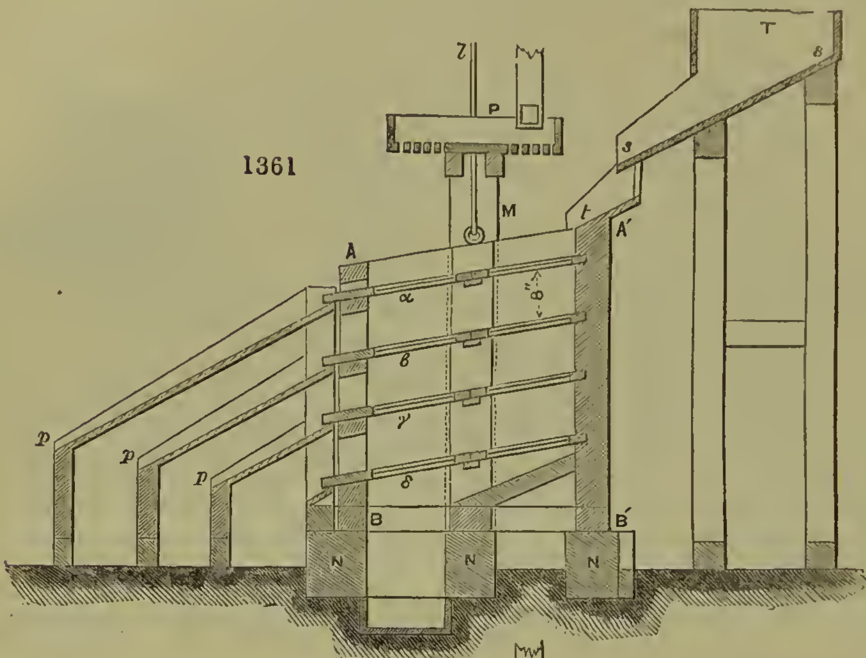

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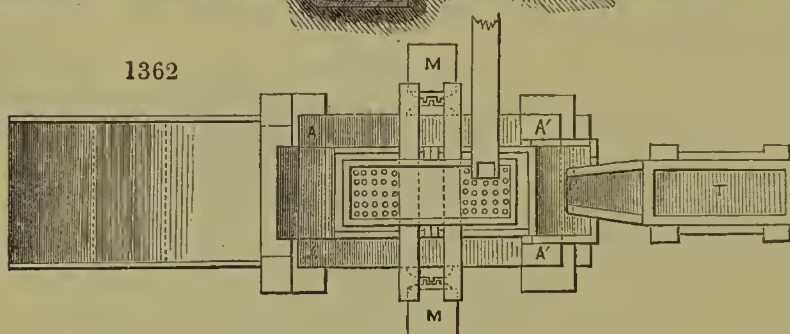

diameter at the smaller, making 20 revolutions per minute, and altogether affording an area of 6,000 square inches.

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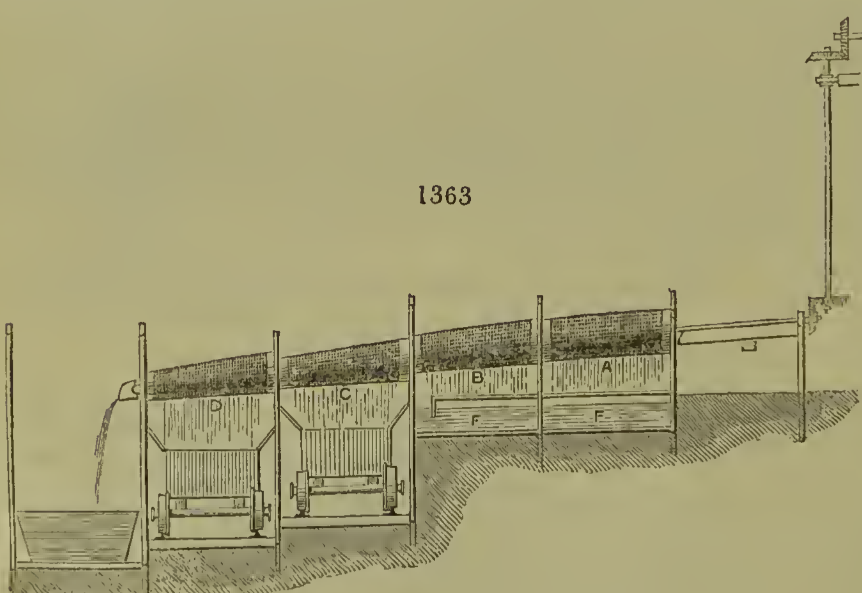


CRUSHING MACHINERY.

Various crushing machines are described and illustrated at page 404, Vol. II.; but it may be observed that this section of the dressing department deserves careful attention, as the results are more or less affected according to the mode of working and adjusting this class of machinery. The crusher is, as it were, the starting or radiating point for treating the dradge work, and if considerable care is not exercised here, not only will there be much loss of power, but also of the initial quantity of ore. In the mining districts of this country it is usual to introduce rough and fine dradge together; no preliminary division of the stuff is attempted; the hopper is continuously charged, and that portion which is not reduced sufficiently fine is returned by the raff wheel to be recrushed.

The consequence is the motion is uneven, strains are inflicted on the machinery, and more time as well as power is necessary for the purpose of realising a given result. Valuable improvements could be effected by first mechanically sorting or dividing the dradge, expediting the speed of the rolls, fitting them with steel faces, setting them so as not to reduce the grain of ore below its normal size, giving them an uniform supply by means of a tilting shoot, and instead of returning the raff to the rolls conveying it to a second series of smaller dimensions, adjusted and managed in a similar way. To each set of rolls there should be fitted sifting trommels, with holes proportioned to the character of the ore, whilst in many instances it would be found judicious to discharge a stream of water on the rolls with a view of expediting the crushing.

In small mines, *bucking*, *fig.* 1364, is resorted to instead of employing the crushing mill. This operation consists of pounding pieces of mixed ore on a slab of iron A, by

1364

1365

means of a hammer or bucker B. The wall on which the plate A is placed, is about 3 feet high. The stuff to be pounded is placed behind the slab, and is drawn upon and swept off the plate by the left hand. In Cornwall it is customary to keep time with the blows and to stand to the bench, but in Derbyshire each operator works independently, and is usually seated.

The bucker, *fig.* 1365, is formed of a wrought-iron steel-faced plate A, 3 inches square, with a socket B, for receiving a wooden handle C. Its cost is about 1*s.* 4*d.*

STAMPS.

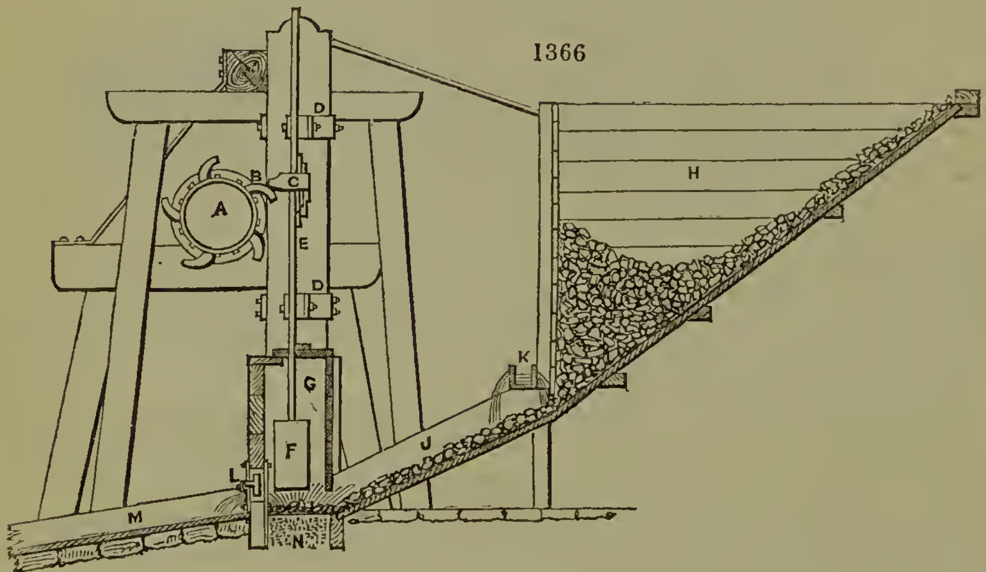
Tin and some other of the more valuable ores are usually associated with and minutely disseminated in a hard crystalline gangue, requiring to be reduced to a fine powder before the valuable portions can be extracted.

Various contrivances have been employed for this purpose, but none of them seem to have entered into competition with the stamping-mill. This apparatus essentially consists of a number of cast-iron pestles, each measuring about 20 inches high, and 6 by 10 inches in the section. These are secured either to a wrought-iron or wooden lifter; a projecting arm is placed towards the top on each lifter, which may be slidden up and down so as to meet the wear of the pestle or any other irregularity. These lifters are retained in their vertical position by suitable metal or wooden supports. Motion is communicated by a revolving shaft in front, fitted with four or five projecting cams, each of which catches the arm, and lifting the pestle from 8 to 10 inches, lets it suddenly fall on the substances which may be underneath. The bottom on which the heads fall is formed by introducing hard stones or other suitable material, and pounding it until it becomes sufficiently solid. In most parts of the Continent of Europe, on the contrary, stamping mills are provided with solid cast-iron bottoms; these are, however, subject to the inconvenience of requiring frequent renewal.

Around the pestles a wooden box or cofer is constructed, and covered in at the top; the back is partly open at the bottom in order to admit the vein stuff. On each side one, and in front two openings are made, 7 or 8 inches square, which are fitted with wrought-iron frames, for the reception of perforated iron, copper, or brass plates, the bur of the punch or drill being towards the inside. As a precaution against the speedy destruction of the cofer from the constant scattering of fragments of stone, the inside is partially lined with sheet-iron. The stuff to be stamped is supplied on an inclined plane, connected with a hopper at the back, in the front of which is a launder for affording a stream of water to the cofer. The stamped stuff passes through the grates into launders and is thus directed to the floors. When water is the motive power, the number of heads is limited by the volume and fall of water available; three heads are the least number used, but a larger number is generally preferred. When steam power is employed, a battery of heads sometimes includes 100 or more pestles. When in action these are elevated from 40 to 80 times per minute, according to the character of the stuff to be reduced. The pulverisation is said to be greatly facilitated by having four heads in the same chest or cofer, about 2½ inches apart. Each head is lifted separately, and the cams by which this is done are so disposed on the axle as to make the blows in regular succession. Great care is also taken whether it be in a large or small battery, to prevent any two pestles falling at the same instant; the object being to secure an equal strain against the power. Practical dressers are not well decided as to the order in which the lifting of four heads in one cofer should take place, whether one of the inner pestles should precede the other, or whether a side pestle should be first lifted. A preference, however, seems to be given to the following method;—supposing a spectator to stand in front of a 4-head stamps, left side pestle first, right side second, right middle third, left middle last.

Fig. 1366 represents the elevation of a steam stamps employed in Cornwall. A, axle; B, cams for lifting heads; C, tongue or projection on lifter; D D, guides for retaining lifter; E, the lifter; F, head or pestle; G, chest or cofer; H, hopper; J, pass connecting cofer and hopper; K, launder discharging water into the cofer; L, stamps grate; M, launder receiving the stuff which has been flushed through the grates; N, the bottom or bed of stamps.

1366



The stamping process is not so simple as it may appear at first sight. Many of its particulars, such as the form of the cofer, mode of exit for the stuff, weight and rapidity of the pestles, and quantity of water employed must be varied to suit the mode of dissemination and the structure and character of the ore, as well as of the matrix. Fineness of reduction is by no means always a desideratum, for if some kinds of stuff be reduced too low, much of the ore contained in it will be wasted, hence considerable judgment is necessary in selecting the grate best adapted to the stuff to be operated upon. Sometimes the grate is replaced by the "flosh," which consists of a small hopper-shaped box, fitted to the front of the grate-hole. This box is provided with a shutter which is raised or lowered according as the ore is required in a fine or rough state. In dry stamping the fineness of the powder depends not on the grate, but on the weight of the pestles, the height of their fall, and the period of their action upon the substances beneath them. The following practical results are derived from the steam stamps at Polberro Tin Mines, Cornwall:—

Cylinder of engine, 36 inches diameter.
Diameter of the fly-wheels, 30 feet.
Weight of dttto, with cranks, shaft, and bolts, $42\frac{1}{2}$ tons.
Power employed, 55 horses.
Reduced in 12 months, 30,201 tons of vein stuff.
Average number of revolutions of stamps axles per minute, $8\frac{1}{2}$.
Number of heads lifted per minute, 72, each 9 inches high.
Weight of each head, 600 lbs.
Average number of blows performed by each head, 45.
Weight of heads collectively, $19\frac{1}{4}$ tons.
Number of grates, 72.
Exposed area of front grates, $9 \times 6 = 54$ inches.
Ditto of end grates, $8 \times 6 = 48$ inches.
Number of holes to the square inch, 140.
Cost of stamping, including maintenance of engine and wear and tear of machinery, 1*s.* $3\frac{1}{2}$*d.* per ton of stuff.

Fig. 1367 is a set of stamping and washing works for the ores of argentiferous galena, as mounted at *Bockwiese*, in the district of Zellerfeld, in the Harz.

A 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; *h h h*, 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. F, G are two German chests. H, J are two percussion tables which are driven by the cams *z z*, fixed upon the main shaft X *y*. K K′ are two sloping sweep tables (*à balai*). The *German chests* are rectangular, being about 3 yards long, $\frac{1}{2}$ a yard broad, with sides 18 inches high; and their inclination is such that the lower end is about 15 inches beneath the level of the upper. At their upper end, usually called the *bolster*, a kind o trough or box, without any edge at the side nxt the chest, is placed containing the o·e 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

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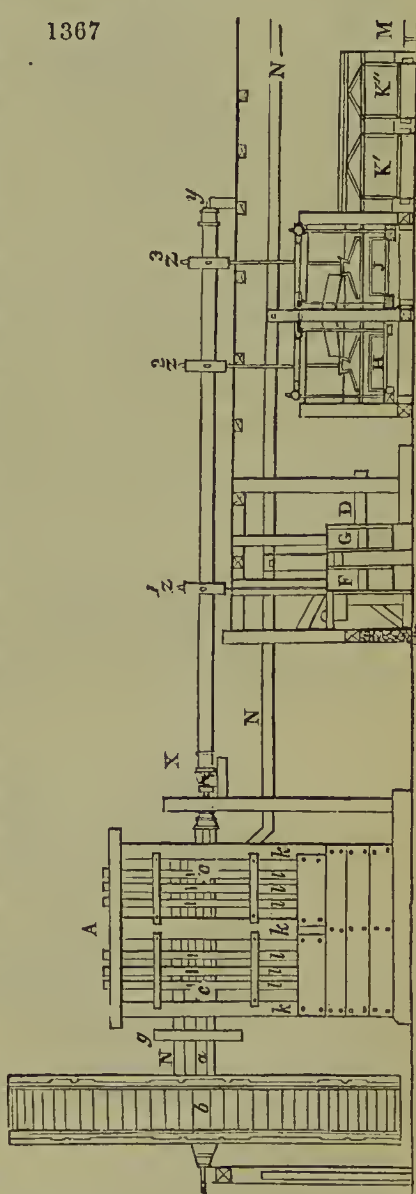

have fully a yard of inclination. The tables are sometimes covered with cloth, particularly in treating ores that contain gold, on a supposition that the woollen or linen fibres would better retain the metallic particles; but this method appears on trial to merit no confidence, for it produces a very impure *schlich.*

Jigging Machinery.

In the jigging sieve only the initial velocity of the substances to be separated is obtained at each stroke. Were, however, the sieve plunged to a depth of, say 20 or 30 feet, the various grains would settle themselves according to their various velocities of fall, one over the other, assuming them to be of a uniform size.

The following table furnished by Mr. Upfield Green, shows the fall of various spheres in water in one second, the depth being in Prussian inches.

Diameter Lines.	Gold. Spec. Grav. 19·2 Prussian inches.	Galena. Spec. Grav. 7·5 Prussian inches.	Blende. Spec. Grav. 4 Prussian inches.	Quartz. Spec. Grav. 2·6 Prussian inches.
8·	100·	60·093	40·825	29·814
5·657	84·090	50·532	34·329	25·071
4·	70·711	42·492	28·868	21·082
2·828	59·460	35·731	24·275	17·728
2·	50·	30·046	20·412	14·907
1·414	42·045	25·266	17·165	12·535
1·	35·355	21·246	14·434	10·541
0·707	29·730	17·866	12·137	8·864
0·5	25·	15·023	10·206	7·454
0·354	21·022	12·633	8·582	6·268
0·25	17·678	10·623	7·217	5·270

Now, instead of assuming the substances to be of a uniform size, let it be supposed that they vary; the foregoing table will show that gold of 8 lines would settle at bottom, and that when gold of 2·9 lines began to settle, the galena of 8 lines would fall also. With galena of 3¾ lines blende of 8 lines would be associated, and so on.

If, secondly, it be assumed that the substances varied between 4 and 8 lines, some time would elapse, after gold of 4 lines had settled, before the galena would begin to deposit itself. With blende, however, of 4 lines and quartz of 8 the latter would almost appear at the bottom at the same time.

The proportion between the maximum and minimum sizes of the stuff to be operated on should be as the specific gravity of one to the other. Thus,

Gold and galena	- - -	7·5 : 19·2 : : 1 = 2·56.
Galena and blende	- - -	4·0 : 7·5 : : 1 = 1·075.
Blende and quartz	- - -	2 6 : 4·0 : : 1 = 1·537.

Hand sieve.—This apparatus, *fig.* 1368, is formed of a circular hoop of oak, ⅜ of an inch thick and 6 inches deep. Its diameter ranges from 18 to 20 inches. The bottom is made of copper or iron wire meshes, of various sizes. Sometimes perforated copper plate is employed, when the sieve is termed a copper bottom. The sieve is shaken with the two hands in a cistern or tub of water, an *ore vat* is however sometimes employed, and either fixed horizontally or in an inclined position. In using this sieve the workman shakes it in the vat with much rapidity and a dexterous toss till he has separated the totally sterile portions from the mingled as well as from the pure ore. He then removes these several qualities with a sheet iron scraper, called a *limp*, and finds beneath them a certain portion of enriched ore.

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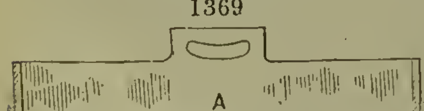
Deluing sieve.—This sieve, A, *fig.* 1369, is either constructed with a hair or canvass bottom; the former is more expensive but more durable. Its peculiar application is chiefly for the final treatment of ores previous to being put to pile, such ores having first passed through the finest jigging sieves, yet still maintaining a certain degree of coarseness and bearing a high specific gravity.

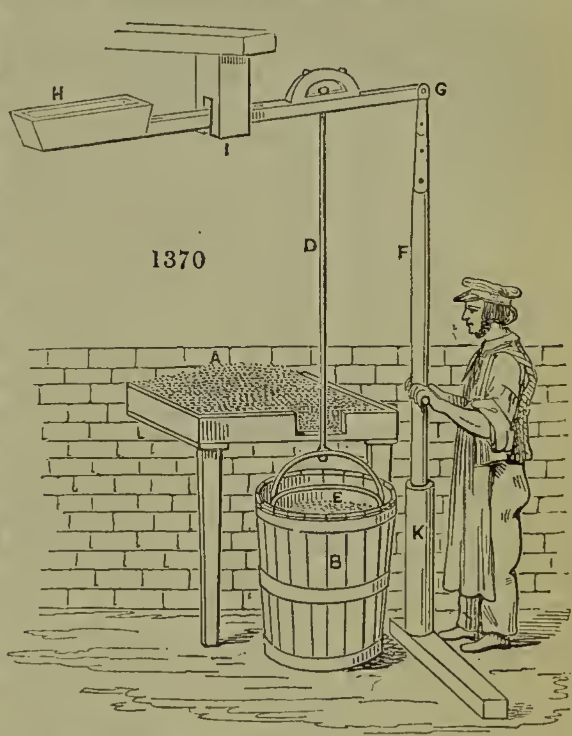
1369



In the separation of ores from light waste, or such minerals as approach one another somewhat closely in their densities, this form of sieve is both good and effective, but to use it properly a considerable amount of dexterity and practice is requisite.

There are two principal methods of using it; by one a motion is given, whereby the waste is being constantly projected and carried over the rim into the kieve by a current of water forced through its bottom. This mode of treatment is adapted for poor ores. In the second case, when the ore is nearly pure but still associated with a heavy gangue, a motion is given to the sieve whereby the water is forced through the ore, and made to traverse the surface of the mineral in concentric circles. This motion collects the waste into the middle of the clean result. By the first method about six tons per day may be passed through by each workman and enriched for the second operation. The weight of the sieve varies from four to five pounds, its diameter is twenty-six inches, depth four inches, and cost from 2*s.* 3*d.* to 2*s.* 6*d.*

1370



A jigging sieve, constructed as shown in *fig.* 1370, is sometimes employed on the Continent. A represents the table on which the mineral is placed; B is a large kieve of water, in which the sieve is suspended by the iron rod D, set in motion by means of the arrangement, F, G, H, suspended at I, and having at the extremity H a box for the reception of small stones, to be used for the purpose of counterpoising the weight of the sieve and several fittings. By moving the rod F, sliding in K, the workman gives the required motion to the sieve, and when its contents have been sufficiently washed he removes them by the same means as when the hand sieve is employed.

Hand jigging or brake sieve.—The brake sieve, *fig.* 1371, is rectangular, as well as the cistern in which it is agitated. A, wooden lever, having its axis at F; B, piece of

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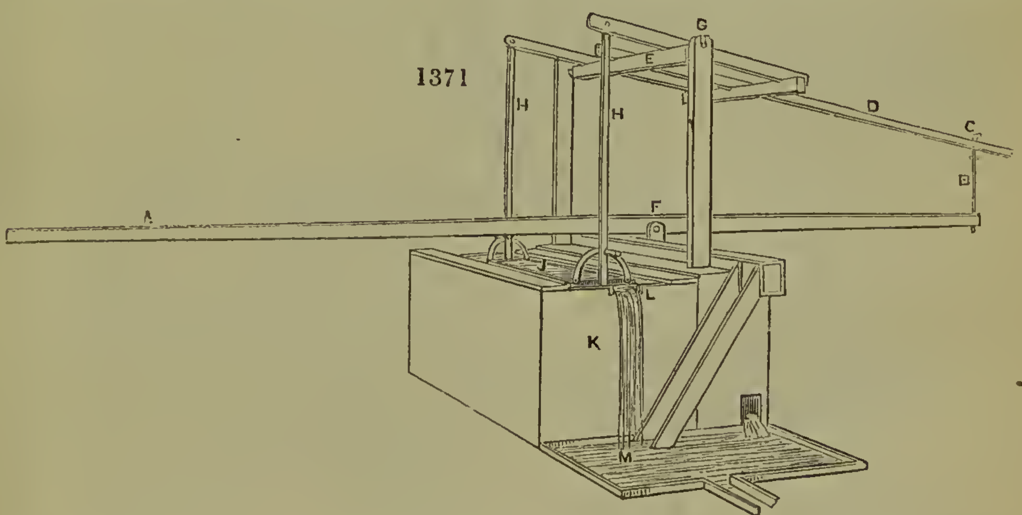
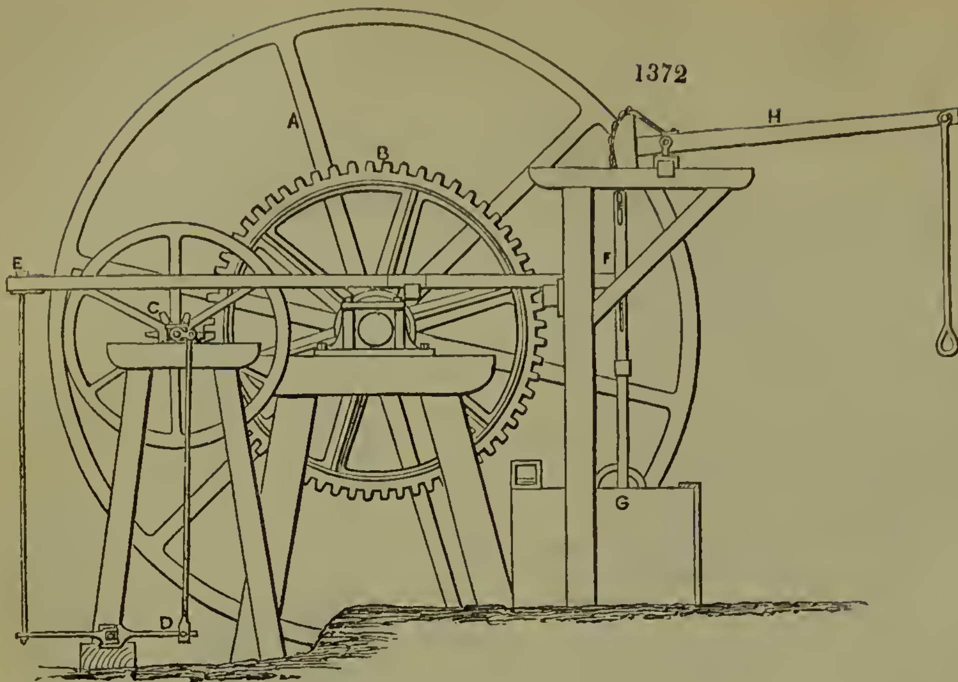


wrought-iron bolted to end of lever A, whilst its upper end passes freely through a slot opening in lever D, and having two shoulder projections C; E, axis of lever D; G, bars connected with lever D, supported on axle E, and from which the iron rods H H depend; J, rectangular sieve; K, under hutch; L, shoot for overflow of water; M receptacle for retaining any fine ore which may escape with the water from L, as well as for receiving the hutchwork. A boy placed near the end of lever A, by the action of leaping, jerks it smartly up and down, so as to shake effectually the sieve J. Each jolt not only makes the fine part pass through the meshes, but changes the

1372



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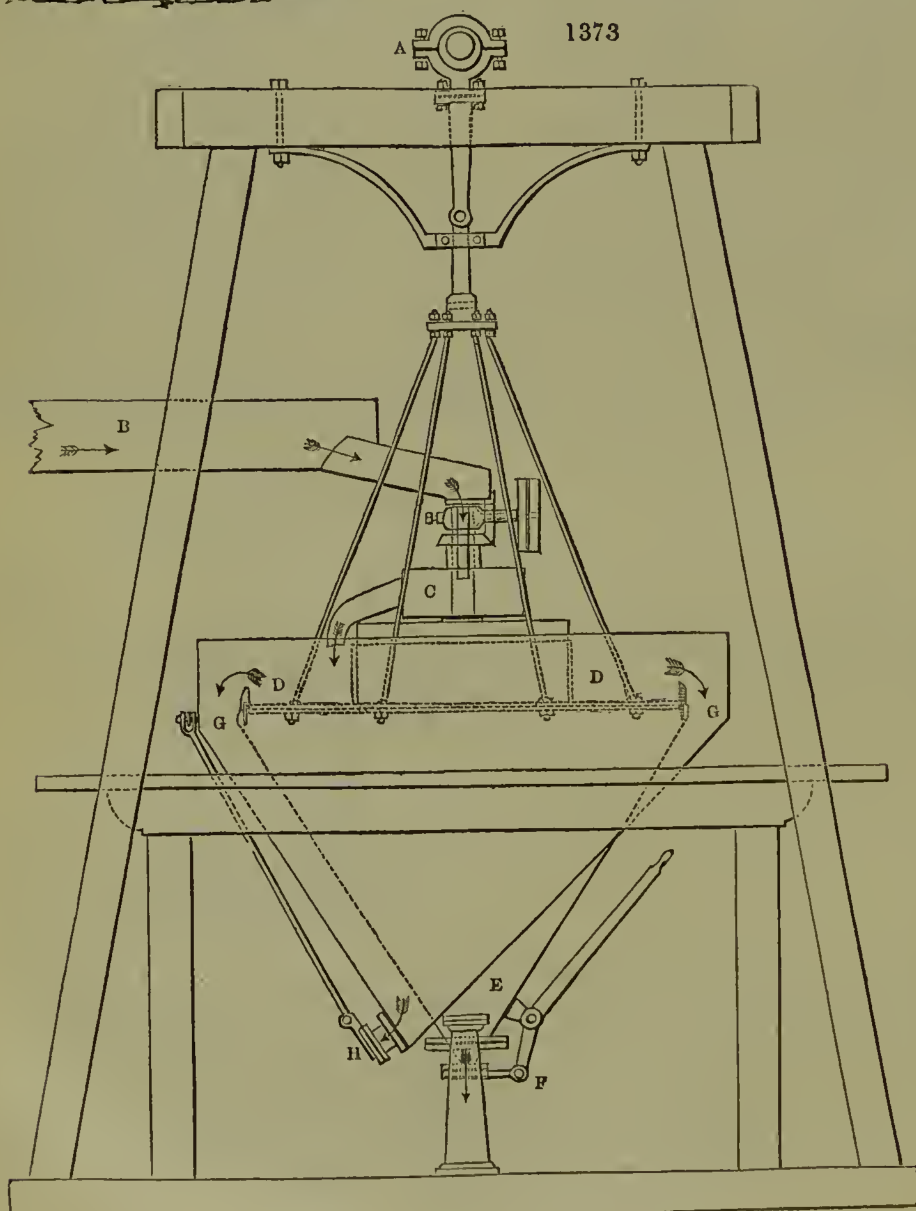


relative position of those which remain in the sieve, bringing the purer and heavier pieces eventually to the bottom. The mingled fragments of ore and stony substances lie above them, while the poor and light pieces are at the top; those are first scraped off by the *limp*, then the mixed portion, and lastly the ore, which is usually carried to the ore heap. The sieve frame may be made 2 × 4 feet inside and 8 to 9 inches deep. The hutch should then be 5 feet long, 3½ feet wide and 4½ feet deep, constructed of good deal boards 2 inches thick. The quantity of stuff which a boy can jig in ten hours will depend upon several circumstances. With a sieve six holes to the square inch and a tolerably light waste, from five to six tons can be operated on.

Machine Jigging.— The machine jigger represented in *fig.* 1372, is constructed on the same principle as the hand apparatus. The hutches are, however, somewhat larger, being six feet long, four feet wide, and four feet deep. A, fly-wheel; B, driving wheel; C, cog wheel receiving motion from B, and giving motion to a crank from which depends a rod attached to lever D. M E, the vertical rod, passes through a slot opening in the wooden lever F, and by these several combinations a vertical movement and jerk is given to the sieve contained in the cistern G.

When it is required to discharge the sieve, the lever H is depressed, and the pin, not seen in the end of lever F, traverses in the slot shown in the bridle rod immediately below the bracket. The sieve measures 4 × 2 feet and 9 inches deep. It is strengthened by iron bands and numerous slips across the bottom.

A jigging apparatus, *fig.* 1373, has been arranged by Mr. Edward Borlase, of St. Just, Cornwall, and introduced by him at Allenheads, with satisfactory results. At these mines it has been worked in conjunction with the machine, *fig.* 1381, and described at page 333. The larger and denser portion of stuff separated by this apparatus is conveyed by suitable launders to a series of sieves, arranged on the top of a conical reservoir, furnished with a feed pipe for the admission of water, and with an outlet pipe at the bottom. This reservoir is placed within another reservoir, also in the form of an inverted cone, and provided with an outlet pipe at the lower part. A, eccentric giving motion to the sieve; B, launder conveying stuff to such sieves; C, distributor, either stationary or revolving as may be required, delivering stuff to the sieves arranged on the top of the conical reservoir; F, valve for discharging the finer portion of the ore; G G, internal cistern furnished with an outlet valve H.

The sieves have a slight outward inclination, and the refuse substances with the waste water are carried over and deposited in the conical cistern, G G.

The sieves should make from 150 to 200 pulsations per minute, according to the quantity and character of the stuff under treatment.

The following is the result of trials made on 160 tons of stuff, one half being delivered to Borlase's machine, the other to the common jigging hutch.

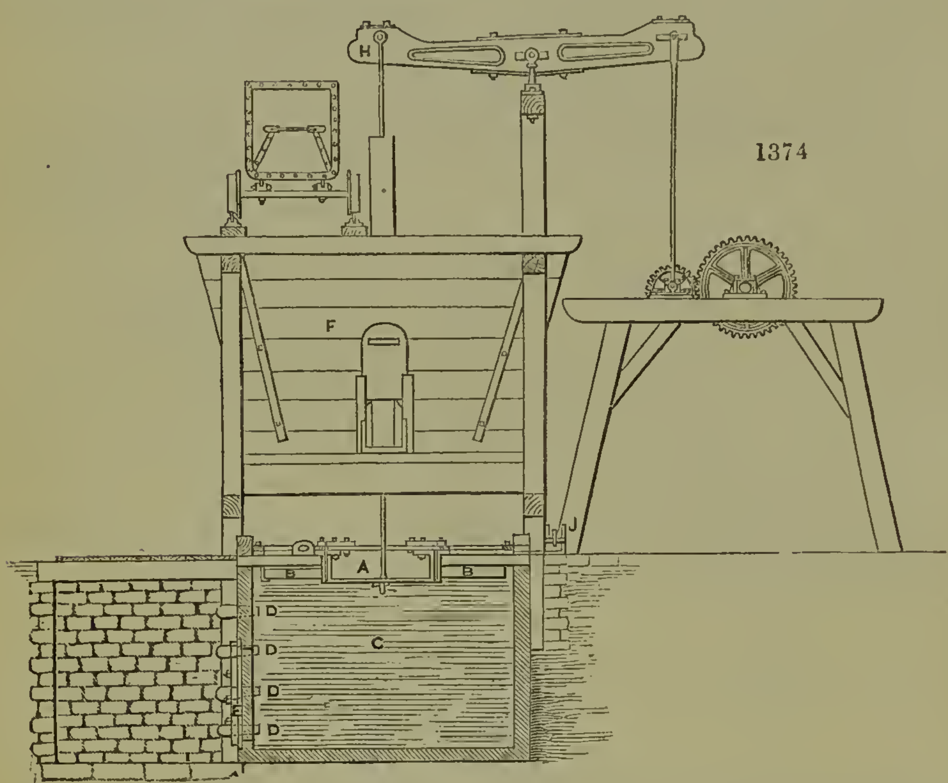
	Borlase's Machine.			Hutchers.			Difference in favour of Borlase's Machine.		
Time:—	Hours.			Hours.			Hours.		
Occupied hutching cuttings - -	50¾			58¼			7½		
Ditto smiddum from do.	5			10½			5½		
Sludge machine, washing sludge and smiddum - - - - - -	21½			} 61½					
Dressing the ore in a trunk - -	29½						10½		
Aggregate number of hours occupied by the lads in doing the work, viz. feeding cuttings and hutching smiddum - - - - - - -	111½			195¾			84¼		
Aggregate number of hours occupied by the lads in washing sludge and smiddum, including the final cleaning in a trunk - - - - -	102			123			21		
Cost:—	£	s.	d.	£	s.	d.	£	s.	d.
Of boys attending machine, wheeling away waste, and preparing ore for the bing-stead - - - - -	1	15	9	2	8	9½	0	13	0½

Produce.

	Sieve and Smiddum Ore.				Sludge Ore.				Total Ore.		Total Lead.	
	St.	lbs.	Assay.	Lead.	St.	lbs.	Assay.	Lead.	St.	lbs.	St.	lbs.
			p. cent.	lbs.			p. cent.	lbs.				
Borlase's machine	19	10	60	165·6	32	5¾	70	317·6	52	1¾	34	7¼
Hutchers - -	17	6½	60	146·7	13		64	116·5	30	6½	18	11¼
Difference in total produce in favour of Borlase's machine - -	-	-	-	-	-	-	-	-	-	-	21	9¼	15	10
Ditto ditto - -	-	-	-	-	-	-	-	-	-	-	71 p. cent.		84 p. cent.	

Petherick's separator. Figs. 1374 & 1375. A, the plunger or force pump; B, receptacles fitted with sieves; C, hutch filled with water; D, discharge holes fitted with

1374



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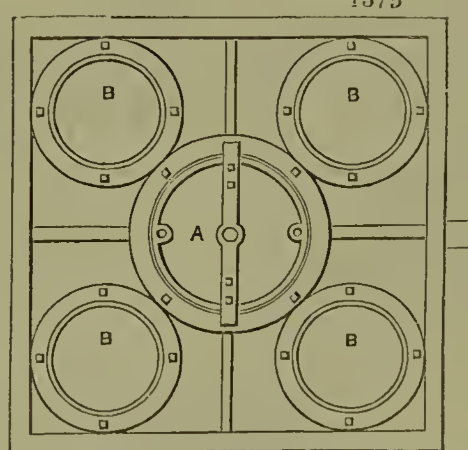


wooden plugs; E, movable plate to admit of withdrawing the ore; F, hopper with shoots for supplying sieves; H, beam for giving motion to plunger piston A; J, launder for delivering water to hutch.

About the year 1831, Mr. Petherick introduced the above machine at the Fowey Consols Mines in Cornwall. It was described in the *Quarterly Mining Review*, January 1832, from which the following is extracted. This machinery is particularly intended to supersede the operation of *jigging* in separating ores from their refuse or waste. * * * In the separators, the sieves containing the ores to be cleaned are placed in suitable apertures in the fixed cover of a vessel filled with water, connected with which is a plunger or piston working in a cylinder. The motion of the plunger causes the water to rise and fall alternately in the sieves, and effects the required separation in a more complete manner than can be performed by jigging. The variety in the extent and quickness of the motion required for the treatment of different descriptions of ores is easily produced by a simple arrangement of the machinery.

A principal advantage in this separator is derived from *the sieves being stationary* (in jigging, the sieve itself is moved) during the process ; thereby avoiding the indiscriminate or premature passing of the contents through the meshes, which necessarily attends the operation of jigging, whether by the brake or hand sieve. Greater uniformity of motion in the action of the water, in producing the required separation, is also obtained ; and superior facility afforded to the deposit in the water vessel (especially in dressing *crop* ores) of the finer and richer particles, which in jigging are principally carried off in the waste water.

The superiority of the patent separators over the ordinary means of cleaning ores will perhaps be best shown by reference to their actual performance. At the Fowey Consols and Lanescot mines in Cornwall, where they are extensively used, seventeen distinct experiments have been made on copper ores of various qualities from different parts of the mines, to ascertain the extent of the advantage of this mode of separation over the operation of jigging. Seventeen lots of ores, amounting together to about 300 tons, were accurately divided, one half was jigged, and the other half cleaned by the separators. A decided advantage was obtained by the latter, in every experiment ; the following are the aggregate results :—

	Quantity of Marketable Ores returned.			Percentage of Metal.	Quantity of Metal.				Value of Ores.		
	Tons.	Cwt.	Qrs.		Tons	cwts.	qrs.	lbs.	£	s.	d.
By jigging - - -	76	19	0	$7\frac{3}{4}$	5	19	2	3	362	15	7
By the separators -	74	19	0	$8\frac{5}{8}$	6	9	0	18	396	6	7

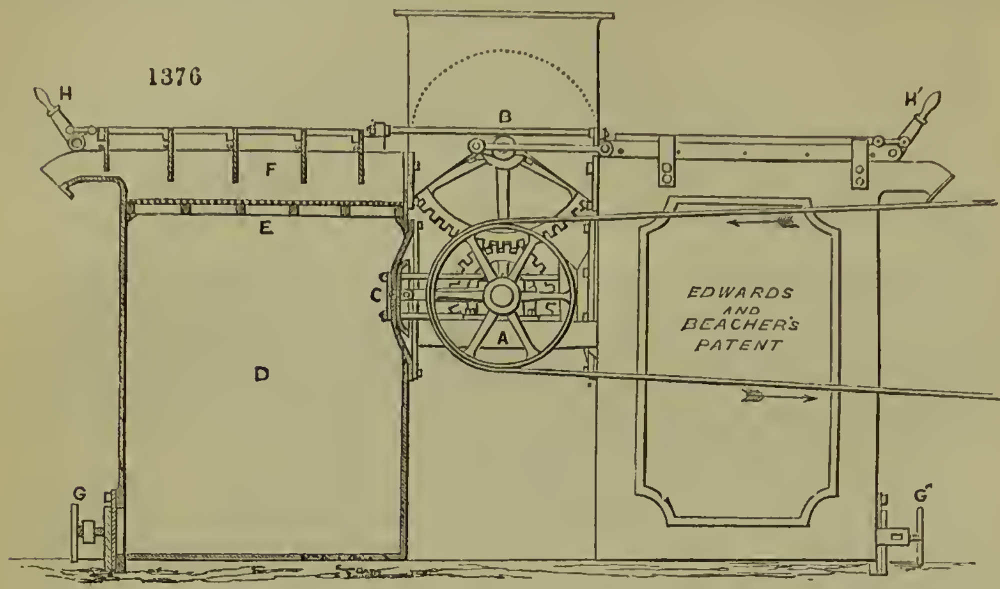
Difference in the Value of Ores.			In the Labor of Cleaning.			Total.			
£	s.	d.	£	s.	d.	£	s.	d.	
33	11	0	2	11	4	36	1	4	Being 9s. 8d. per ton, on 74 tons 19 cwt.

It must be obvious to those who are practically acquainted with the subject, that the poorer the stuff containing the ores, the greater must be the relative value of any improvement in the process of cleaning it. This has been satisfactorily demonstrated by the trials which have been made in the mines before mentioned, in dressing the *tailings*, which are the refuse of the inferior ores, called halvans. It appears that these tailings may be dressed by the separators with more than treble the profit to the proprietors, which could be realised by the ordinary methods ; and there is no doubt that there are vast quantities of surface ores, both copper and lead, in various mines which might be dressed by the same means with considerable advantage.

Edwards and Beacher's Patent Mineral and Coal Washing Machine, consists of two cisterns, rectangular in horizontal section. Within a few inches of the top of these, perforated plates or screens, E, *fig.* 1376, are fixed, upon which the material to be washed is fed through a hopper, which also connects the two cisterns. On the inner sides of the cisterns, are two apertures closed by flexible discs, or diaphragms of leather, C, which, when the machines are filled with water, cause it to rise and fall through a certain space, by means of a horizontal vibratory motion, which they receive from an eccentric on a shaft, which is driven either by a steam engine attached directly to it, or by a driving belt and pulley, A. See WASHING COAL.

The action of the flexible diaphragms is similar to that of cylinders and pistons, which are sometimes substituted for them. Above the driving shaft is a smaller one, B, which is driven at a slower rate by means of toothed wheels, and gives by cranks or eccentrics, a horizontal motion backwards and forwards to sets of scrapers F, above

1376



the cisterns. These are so arranged as to remove the upper stratum of the substance being acted upon, and discharge it into waggons or other convenient receptacles; these upper strata are of course the lightest, the heavier part settling upon the perforated plates below.

When from the action of the machine a considerable quantity of material has accumulated upon these plates, the scrapers are thrown out of gear by means of apparatus attached, H H, and the stuff raked off, the operation being then continued on fresh supplies. Doors, G G, at the bottom of the machines admit of any fine stuff which may pass through the perforated plates being removed from time to time as may be necessary.

These machines are in use for cleansing coal as well as other mineral substances. In such cases the heavier stuff which remains upon the plates consists of shale, pyrites, &c., very injurious substances in the manufacture of coke. One machine of two connected cisterns, is capable of washing about thirty tons per diem of coal, but the quantity of mineral work will depend upon the amount of ore present in proportion to the waste. The size of the perforations in the screens is adapted to the quality of the material acted upon.

A gold washing machine has been arranged by Mr. John Hunt, late of Pont-Pean, France. This gentleman states that it requires but little water, and is so contrived, as to circulate this water for repeated use; also that the principle would be found very successful if employed on a more extended scale; this Mr. Hunt intends to carry into operation at some lead mines in Cornwall.

Separators.

Of late years apparatus of this class has been steadily coming into operation, not only in lead and copper mines, but also in the dressing of tin ores. The prevailing principle is that of directing a pressure of water against the density of the descending material, making the former sufficiently powerful to float off certain minerals with which the ore may happen to be associated. When marked difference of densities exist, and the ore can be readily freed from its gangue, this mode of separation will be found effective. Trommels may be advantageously employed for sizing the stuff previous to its entry into the several separators.

Slime separator.—This apparatus is due to Captain Isaac Richards, of Devon Great Consols, and is employed for removing the slime from the finely-divided ores which have passed through a series of sieves set in motion by the crusher. The finely-divided ores are for this purpose conveyed by means of a launder upon a small water-wheel, thereby imparting to it a slow rotary motion. Whilst this is turning time is allowed for the particles to settle in accordance with their several densities; the result obtained is that the heavier and coarser grains are found at the bottom of the buckets, whilst the lighter and finer matters held in suspension are poured out of the buckets and flow away through a launder provided for that purpose. The stuff remaining in the bottom of the buckets is washed out by means of jets of water obtained from a pressure-column ten feet in height, and passes directly into the funnel, of a round buddle.

The wheel A, *fig.* 1377, is four feet in diameter, two feet six inches in breadth; has

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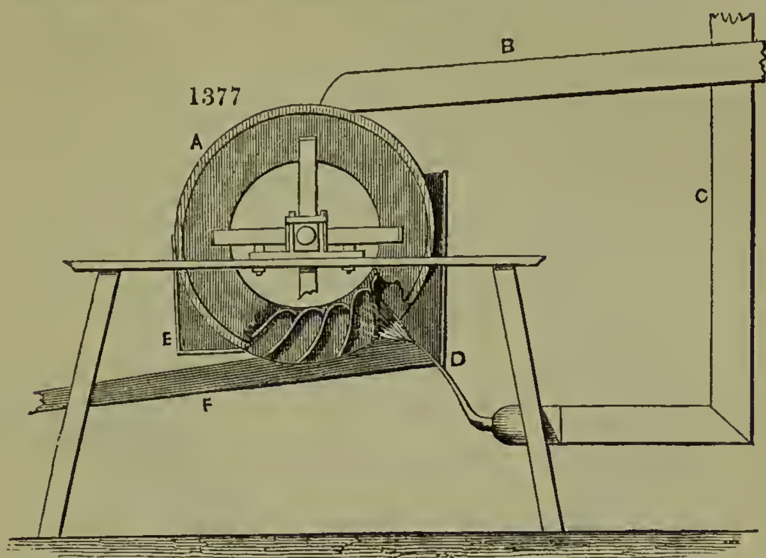

twenty-four buckets, and makes five revolutions per minute; B, launder for supplying the finely-pulverised ore; C, pressure-column; D, jet-piece; E, launder for conveying off the slime overflow of the wheel; F, launder for conveying roughs to round buddle. A modification of this apparatus is employed at the Wildberg mines in Germany, where it has been recently introduced, and is found to succeed admirably for the classification of finely-divided ores.

Sizing cistern.—The tails from round buddles are sometimes passed through this apparatus. It consists, *fig.* 1378, of a wooden box provided with an opening at the bottom, A, which is in communication with a pressure-pipe, B, an outlet, C, and has a small regulating sluice, D. The stuff from the buddles enters at E, and the pressure in the column is so regulated as to allow the heavier particles of the stuff to descend, but at the same time to wash away at F the lighter matters that may be associated with the ore. This is done by having the outlet C of less area than the inlet, and fixing on the extremity D a convenient regulating sluice by which means a greater or less quantity of stuff may be passed over the depression F. Two cisterns of this kind are generally employed, the second being used to collect any rough particles that may have passed off from the first. The depth of the first of these boxes may be eighteen inches, its width thirteen inches, and its length three feet six inches. The dimensions of the second may be considerably less.

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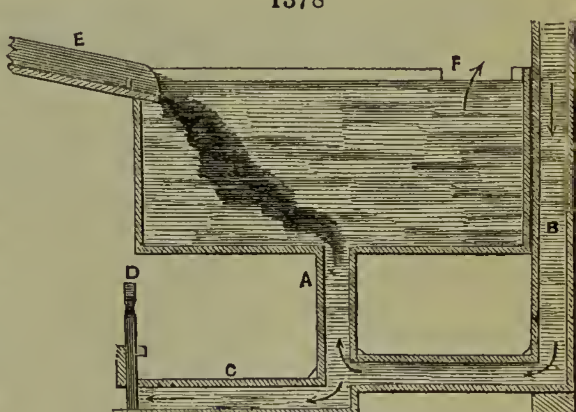
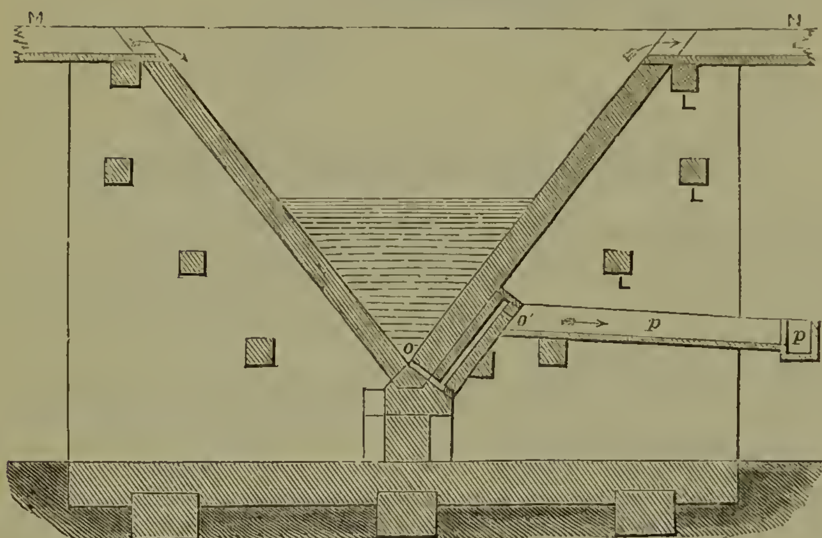


The arrangement of another separating box is shown in *figs.* 1379 and 1380. The slime water flows in at M; and water still holding a considerable portion of slime flows away from the opposite end. It is necessary that pieces of chip, small lumps, or other extraneous matter should be intercepted previous to entering this apparatus, also that the slimes should be evenly sized by means of a trommel or sieve. The heaviest portion of the slime water in which the sand and ore is contained, is discharged at *o*, which is about an inch square. The launders *p p*, are for the purpose of conveying the slime water either to buddles or shaking tables. The dimensions of the cistern No. 1 are, length, six feet; width, one and a half feet; depth, twelve inches. But two other cisterns of similar form are attached. No. 1 cistern will work about ten tons of stuff in twenty-four hours, and by widening the box from eighteen to twenty-seven inches it will get through twenty tons in twenty-four hours. Affixed to one side of the boxes are hammers so contrived as to give thirty blows per minute in the manner of a dolly tub. The sides of the box have an angle of fifty degrees from the horizontal. The chief dimensions of the two cisterns viz. one working ten and the other twenty tons, are subjoined.

No. of Box.	Ten tons.			Twenty tons.		
	Length of Box.	Breadth of Box.	Depth of Box.	Length of Box.	Breadth of Box.	Depth of Box.
	ft.	ft.	ft.	ft.	ft.	ft.
2	9	2	6	9	5	6
3	12	4	8	12	9	8
4	15	8	10	16	15	10

1379



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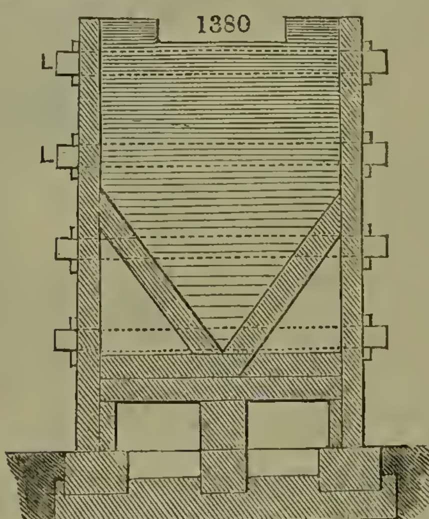
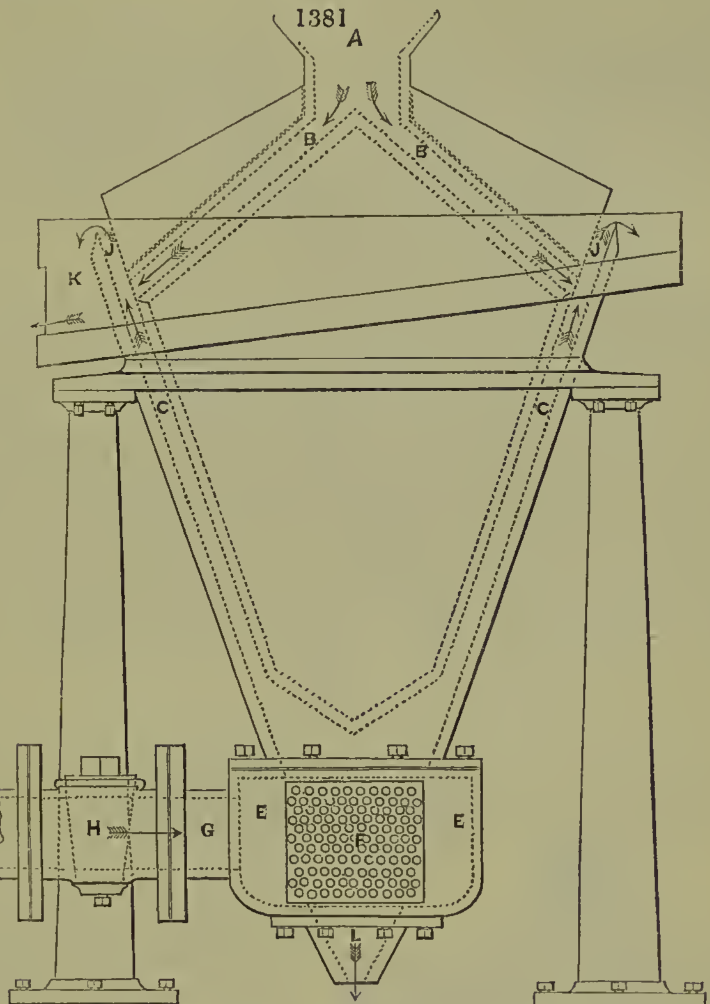


According to experiments made in the Stamping House of Schemnitz, where twelve tons are stamped in twenty-four hours, the first cistern separated from the slimes 40 per cent. of the ore; the 2nd cistern, 22 per cent.; the 3rd cistern, 20 per cent.; the 4th cistern, 12 per cent.; together, 94 per cent., leaving a loss of 6 per cent.

From No. 1 box every cubic foot of water flowing through gave 16 pounds of sandy matter. No. 2 afforded 13 pounds of finer stuff. No. 3, 16 pounds, and No. 4 yielded 12 pounds per cubic foot of water. It should be remarked that the outlet *o* is proportioned to the dimensions of the machine.

Borlase's Machine, fig. 1381, has been recently introduced at the Allenheads Mines, belonging to Mr. Beaumont. The ore and mineral substances, after passing through the crushing apparatus, are introduced at A, and flow through the spaces B B, passing into C C. At the bottom is a circular chamber E E, with a perforated cylindrical plate F. Water under pressure is supplied by the pipe G, and regulated by the cock H.



It will be seen that this apparatus consists of an external and internal cone with a space between them, and that a separation of the orey matter is effected by limiting the power of the water between the density of the stuff to be retained, and that which is to be discharged at J J into the shoot K.

At L the larger and denser portion of the mineral which has fallen through the ascending current of water, is conveyed either to a jigging machine or some other enriching apparatus. Mr. Borlase first erected this apparatus in the United States of America, where it was found to answer remarkably well, and he was induced by this success to attempt its general introduction in this country. In this endeavour he has not however been as yet so entirely successful as could be wished, as the English mines, and particularly those of Cornwall, are for the most part managed by individuals who require to be fully convinced of the utility of any new invention before giving it a trial. This machine has been employed with great success at the mines of Allenheads. The comparative results afforded by Borlase's Trunking Machine and the common Nicking Trunks may be seen from the following statistical statement.

Lead Mines, Allenheads.

Results of trials with Borlase's 4½ feet Circular Lead Ore, Sludge, and Slime Dressing Machine, and the common Nicking Trunks, March, 1859.

Forty-four wheelbarrows full of exactly the same description of slimes were put through each of the respective processes.

Time.

	Borlase's Machine.		Trunks.		Difference.	
	Hours.	Minutes.	Hours.	Minutes.	Hours.	Minutes.
Machine in operation	15	16	0	0	0	0
Occupied in oiling machinery - - - -	0	40	0	0	0	0
Ditto emptying - -	2	37	0	0	0	0
Stirring, nicking, and emptying trunks -	0	0	14	3	0	0
Occupied dollying the the work - - - -	1	19	2	0	0	0
	19	52	16	3	3	49

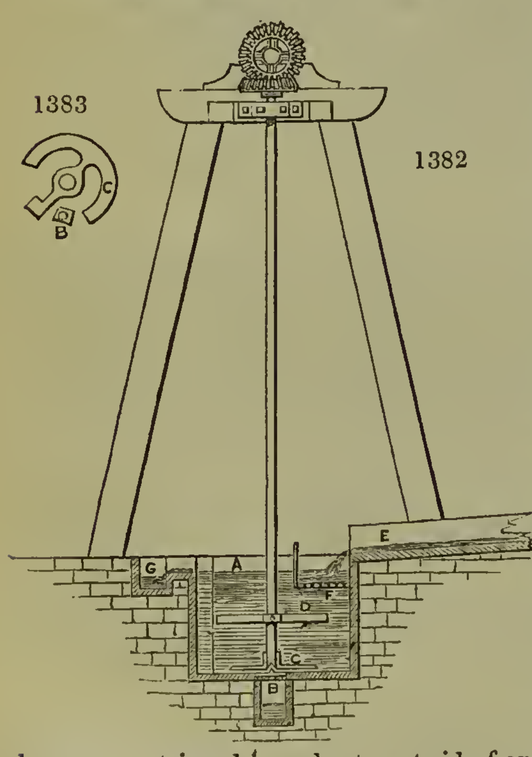
Cost.

	£	s.	d.	£	s.	d.	£	s.	d.
Labour of men and boys employed - -	0	4	3*	0	8	8	0	4	5

Produce.

	Ore.			Lead.	Ore.			Lead.	Ore.		Lead.	
	St.	lbs.	Assay.	lbs.	St.	lbs	Assay.	lbs.	St.	lbs.	St.	lbs
			Per Cent.				Per Cent.					
Best work - - - -	54	$10\frac{5}{8}$	65	498·3	53	$9\frac{1}{4}$	64	480·8				
Seconds - - - - -	10	$3\frac{1}{4}$	46	65·9	11	12	46	76·4				
Thirds - - - - -	21	$9\frac{1}{2}$	30	91·0	34	$2\frac{3}{8}$	12	57·4				
Fourths - - - - -	22	9	8	25·4	0	0	0	0				
	109	$4\frac{3}{8}$		680·6	99	$9\frac{5}{8}$		614·6	9	$8\frac{3}{4}$	4	10

Fig. 1382 represents a wooden cistern A, having an aperture B, at the bottom, about an inch diameter, which is alternately closed and opened by means of an iron plate C, fitted upon the vertical shaft, to which is also fixed an iron paddle D, which revolving horizontally keeps the ore and water in constant agitation. The tails from the various buddles, as well as the stuff from the cofers at the end of the strips, flow in at E, and pass through a perforated sizing plate F, into the cistern. The rougher and heavier portions escape through the hole B into a strip where it is continually stirred, in order that it may be evenly deposited, and at the same time freed from the lighter particles. The overflow containing fine ore passes by the launder G into catch pits, from which heads and middles are taken to be elaborated by means of buddles or other apparatus. When this separator is employed in tin dressing, it is usual to divide the stuff in the strip connected with the bottom of the box, into heads and tails. The first is taken direct to the stamps, and again pulverised with rough tin stuff; but before the tails can be so treated they are re-stripped in order to get rid of extraneous matter.

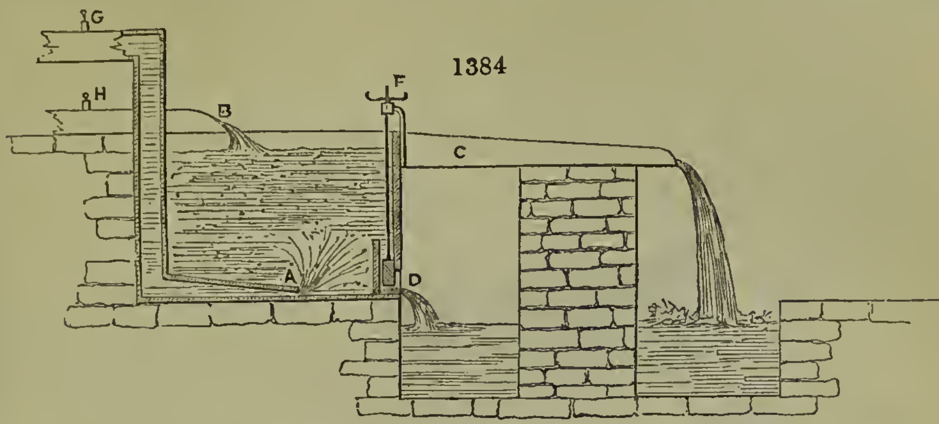


1383 1382

* The cost is unduly heavy, the same value of labour would have maintained three machines.

Wilkin's separator.—This apparatus is the invention of Mr. J. B. Wilkin of Wheal Bassett and Grylls, near Helston. He describes it as a "self-acting tossing

1384



machine, by which the rough particles are separated from the fine and prepared for the inclined plane. The orey matter is carried into a small cistern by a stream of water which enters at the top and passes out at the opposite side bearing the finer particles with it, whilst the rougher and heavier particles escape at the bottom through a rising jet of clean water, which prevents the fine and light particles from passing in the same direction." A, *fig.* 1384, inlet of clean water, B, launder delivering the orey matter, C, outlet of fine and inferior stuff, D, discharge orifice for rough and heavy stuff. This operation must be regulated by a flood-shut. A cistern 10 feet square on the top, and 18 inches deep will pass through about 40 tons in 10 hours. When separating stamps work a smaller cistern is employed, say 14 inches square, 10 inches deep, this will despatch 6 tons in 10 hours.

A valuable form of separator is shown in *fig.* 1385, the peculiarity of which consists

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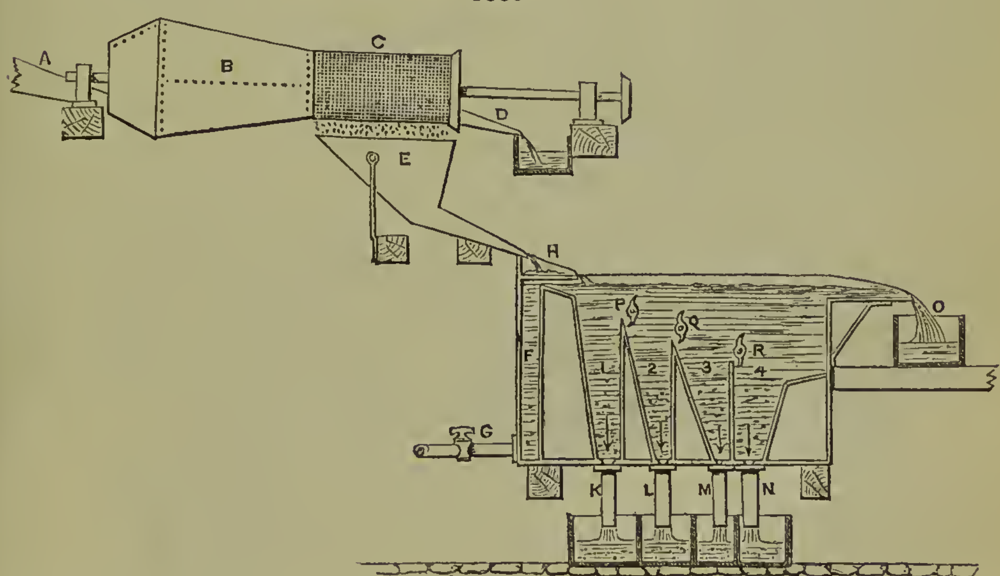
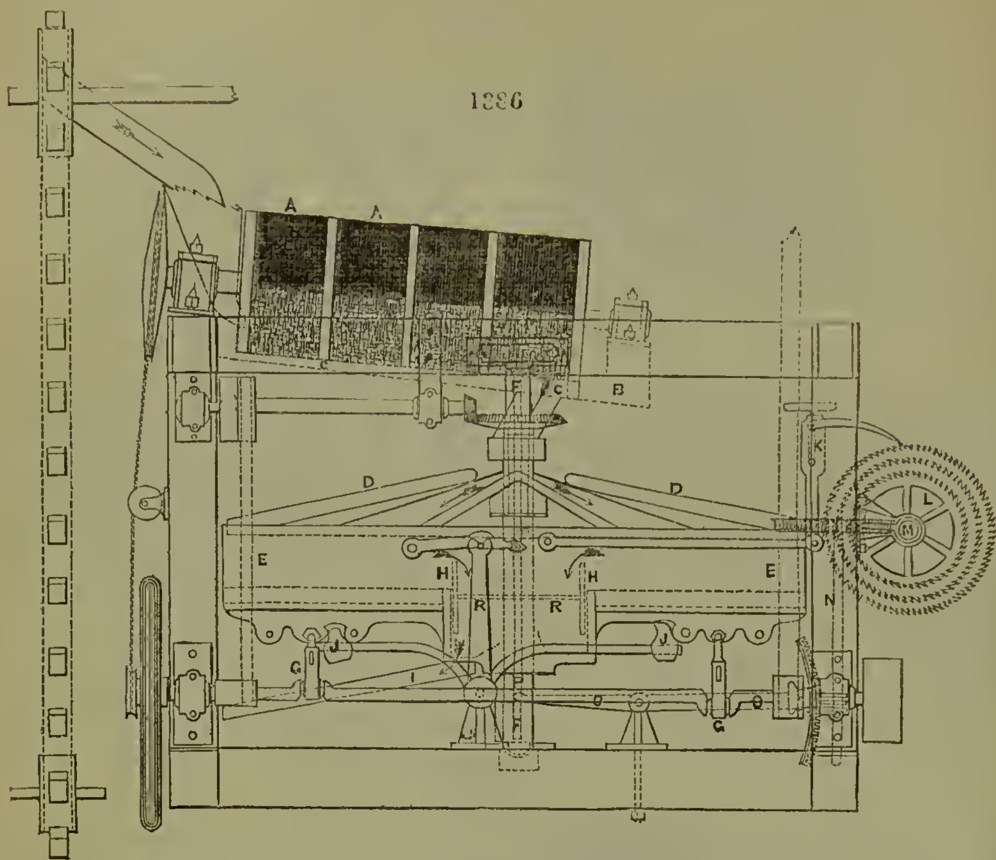
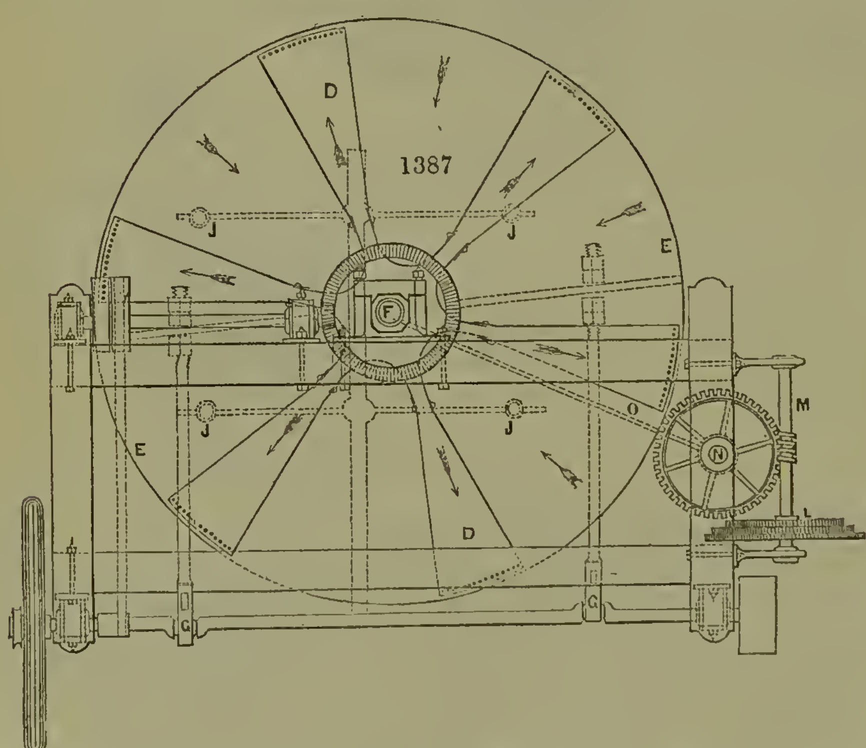


in the manner of introducing the water and slimes. Instead of the latter depending for separation upon the power of an ascending column of water, it here passes into a horizontal flow of greater or less volume and velocity, produced by altering the tap G. Compartments, viz. 1, 2, 3 and 4, are also fitted in the box, for the purpose of receiving mineral of different densities and size, which is discharged and washed in strips set underneath; A, inlet launder to trommel; B, waist of sheet iron; C, trommel either of perforated plate, or wire gauze; D, shoot from trommel serving to convey away the rougher portions; E, hopper for conveying stuff to shoot H, and from thence into the box; F, ascending column of water; G, tap for regulating the flow of water; K, L, M, N, outlet pipes for delivering the separated stuff to strips or buddles; O, launder for receiving overflow from cistern; P, Q, R, valves regulating the width of the compartments, also for the purpose of effecting the disposition of the different minerals with which the ore may be associated.

In addition to the machines already described, a slime or sludge dressing apparatus has been designed by Mr. Borlase, and which he intends to introduce into the mining districts of this country. *Fig.* 1386 represents an elevation, and *fig.* 1387 a plan of this machine.





It is described by the inventor as follows:—The mineral from which it is desired to separate the metallic ore having been crushed or pulverised, is conducted through a pipe or channel into a revolving cylindrical sieve, A A. The larger parts pass into a shoot or launder, B, and from thence into a self-acting jigging machine. The slime or fine portion passes through the meshes of the sieve into a shoot, C, and is discharged into an annular launder, from whence it falls either into a stationary or revolving distributor, D D. From thence it flows through suitable channels into the outer part of the machine, E. The apparatus is fixed on a perpendicular axis, F, and is kept in a continual oscillatory motion by means of cranks and connecting rods, G, the speed of the cranks being adjusted so as to keep the slime in continual motion, and at the same time cause the ore to descend and deposit itself at the bottom, whilst the waste or lighter portion is carried towards the inner part of the machine, where it passes over a movable ring, H, which is raised mechanically, and in proportion as the ore rises in the apparatus. The waste is discharged through the outlet I, and conveyed away in launders, When the machine is filled with ore, it can be settled, as in the dolly machine, by means of percussive hammers, J J. The ore can be collected either by reversing the gear and lowering the ring H, or it may be washed into a receiver as convenient.

Motion is given to the vertical bar K, which is made to vibrate so as to turn by means of a ratchet the wheel L, fitted on a horizontal shaft, M. The ratchet is raised or lowered by a worm screw, in order to increase or decrease the speed rendered necessary by the quality of ore operated upon. On the horizontal shaft M is a worm pinion, that works a wheel on a perpendicular shaft, N, on which is fixed a second worm pinion, raising or lowering the tooth segment on the end of the beam O. This segment can be shifted out of gear. The opposite end of the beam O is attached to the rod P, and connected with the crossbar R, as also with the ring H, which has a reciprocatory motion in the centre of the perpendicular shaft F.

From the foregoing description it would appear that Mr. Borlase has combined in this apparatus the principles of the round buddle with that of the dolly tub.

In the year 1857 Herr Von Sparre, of Eisleben, Prussia, patented four machines for separating substances of different specific gravities, in all of which water is employed, either as a medium through which the said substances fall under the action of gravity, or as an agent for facilitating the motion of portions of the said substances along inclined surfaces. The particulars, together with illustrations, will be found in patent No. 1405 for the year 1857.

The mechanical preparation of tin and copper ores has from time to time been noticed by several writers. In 1758 Borlase described the method employed in the west of Cornwall. Twenty years later, Price, in his *Mineralogia*, added to Borlase's description, and illustrated some of the apparatus then in use. Afterwards Dr. Boase published, in the second volume of the *Transactions of the Geological Society of Cornwall*, an article upon the dressing of tin in St. Just. In volume four Mr. W. Jory Henwood inserted a paper on dressing; and some general remarks will be found on the subject in De la Bèche's *Report on the Geology of Cornwall*. The enrichment of lead ores has been noticed by Forster, in his *Section of Mineral Strata;* also by Warington W. Smyth, in his memoir *On the Mines of Cardiganshire*, in the second volume of the *Memoirs of the Geological Survey of Great Britain*.

In France, Dufrenoy and Elie de Beaumont, Coste, Perdonnet, and Moissenet have treated on the mechanical enrichment of copper and tin ores. The latter gentleman visited this country in 1857, and subsequently gave the results of his observations in a highly interesting memoir, entitled *Préparation du Minerai d'étain dans le Cornwall*. Too much attention cannot be given to this section of mining economics, for with the increasing production of ores, especially of ores of low produce, and the ill-adapted machinery oftentimes employed, the loss in concentrating them is an item of most serious moment, any reduction of which will be so much positive gain to the country.

The following figures give the quantity and value of ores dressed and sold in the United Kingdom in the year 1858.

	Tons.	Value. £
Tin ores	9,960	633,501
Copper "	226,852	1,336,535
Lead "	95,855	1,370,726
Zinc "	11,556	36,199
	344,123	3,376,961

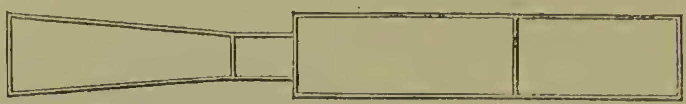
In this paper we have included those machines which have been long employed in our metalliferous mines,—many of them having been proved by experience to be most economical,—together with such of the modern introductions as appear to promise the most advantage, and some suggestions which cannot but be valuable, since the principles involved are founded upon the universal laws of gravitating power, as applied to solids and fluids in motion.

The Strake, Tye, and Strip.

These appliances may be considered modifications of each other. Instead of effecting a separation by relying upon subsidence according to the specific gravity of the substances, they are mechanically impelled against a volume of water so regulated as to carry off the lighter particles.

Fig. 1388 represents a ground plan of a strake employed in the lead mines of Wales.

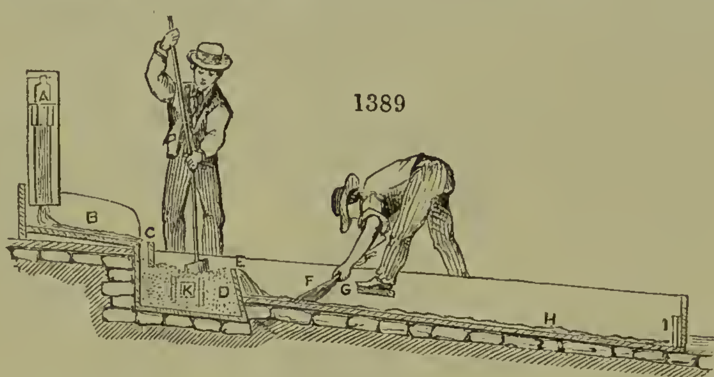
1388



Its extreme length is about 18 feet, width 3 feet. The top increases from 18 inches to 2 feet 9 inches wide. It is constructed of wood, the bottom being covered with sheet iron.

The tye is usually 20 feet long, 2½ feet wide, and is often employed for cleaning hutchwork. In some instances when the ore or dradge is very rich, it is crushed and then tyed into heads, middles, and tails, the first portion going to pile, the middles re-tyed, and the tails treated as refuse or washed in the buddle.

Fig. 1389, A, inflow of water; B, head of tye; C, partition board. The stuff is introduced into the cistern D, flows over the inclined front E, and is broomed at F. Between E and G are the heads, from G to H middles, H to I, tails. At K is an outlet launder regulated with a flood shut. An outline plan of the tye is shown, *fig.* 1390.



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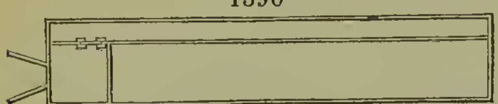
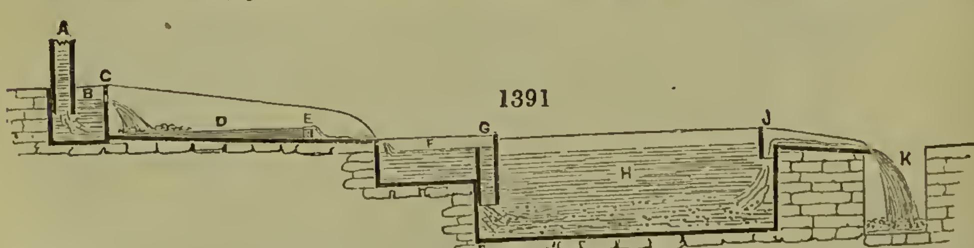


The strip also consists of a wooden box with its bottom inclined at a greater or less angle, in order to suit the character of the stuff to be operated upon. The object of this apparatus is somewhat analogous to the separating box, viz. to deprive the ore of the fine particles with which it may be associated, and thereby to enrich it for subsequent treatment. A rather strong stream of water is employed, against which the mixed mineral is violently projected by means of a shovel. When ores are strong and clean in their grain, but little loss can occur from this process, provided proper care be exercised in conducting it; but if their structure be delicate and the constituents intimately mixed, the wastage must necessarily be great.

The illustration, *fig.* 1391, shows a strip, cofer, and settling cistern, with filtering apparatus contrived for lead ore. A, vertical launder 6 inches square, delivering water into the box B, 9 inches long by 26 inches wide at the point C; D, bottom of strip covered with sheet iron, 6 feet long and 16½ inches wide at E. At this point a ledge



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of wood is sometimes introduced for the purpose of modifying the velocity of the water and forming a kind of shallow reservoir, so as to allow the workman to stir the stuff. At the end of the strip a cofer, F, is fixed, 11 inches deep, 30 inches square; H, settling box, 6 feet long and 30 inches deep; K, outlet for waste water. At G is inserted a filtering launder, 13 inches deep, extending across the cistern. At J a similar launder is placed, about 9 inches deep. The water comes in at A, is lodged in cistern B, flows smoothly over the feather-edged board C, falls into D; here the orey matter is exposed to its action, a portion settles in F, the *florrin* and other light waste then descends through G, depositing itself in the box H; and to retain the valuable products as much as possible it is filtered at J, through a perforated plate covering the bottom of the launder. In stripping care must be taken to regulate the overflow of water at C; rough stuff must be subjected to a stronger current than finer matter, and the bottom of the strip should be constructed with a greater inclination. In some lead mines the buddle and hutch work is stripped to be re-jigged whilst the stuff resulting from the filtering box is hand-buddled until sufficiently enriched for the dolly. When ore is associated with a heavy matrix, and the grain breaks into a lesser size than the other particles, the stripping may be performed by inversion, that is to wash the orey product into the cover and filtering hutch, retaining the worthless portions at D.

The flat buddle, *fig.* 1392, is a modification, peculiar to the Welsh mines, of the inclined plane, and different from all others in its great proportional breadth as well as its very trifling inclination. The stuff is placed in a small heap on one side of the supply of water. and drawn with a hoe partly against and partly across the stream to the other side of the buddle, losing in its passage all the lighter parts. A heap of ore treated in this manner may be deprived of a portion of blende and pyrites, minerals which from their high specific gravity may have resisted previous operations. *a*, platform of boards inclined two and a half inches in seven feet. *b*, catch pit two feet deep. The width of this buddle varies from ten to twelve feet.

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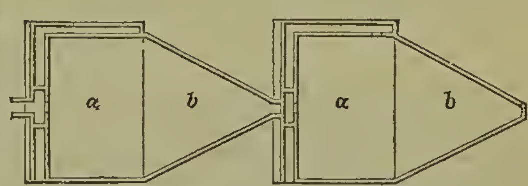

Lisburne machine.—This apparatus was invented by the agents of the Lisburne Mines, Cardiganshire, and has been most successfully employed in separating blende from lead ores. *Fig.* 1393 represents an elevation, and *fig.* 1394 a ground plan of this

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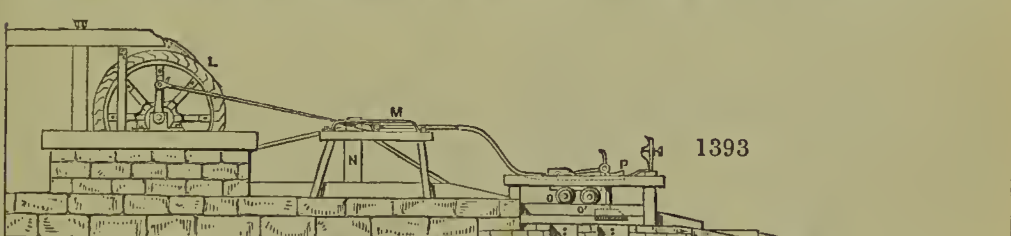

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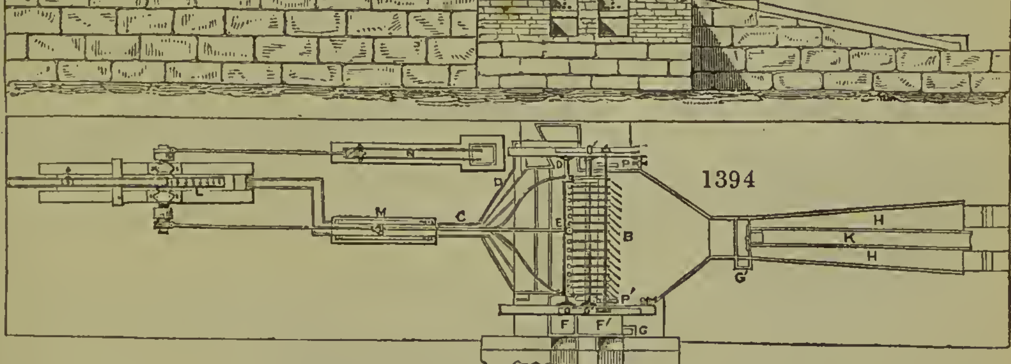

machine. B, rakes or scrapers set at an angle, depending from rods having their axis of motion on the arbor E. This arbor as well as a parallel one, are carried on friction rollers O O′, and so braced together as to form a kind of frame. M, rod attached to frame, and connected with water-wheel L. N, balance beam, counter-poising the frame, and rendered necessary in order to equalise the motion. P P′, balance catches serving to support the third arbor when elevated. This arbor is also parallel to the other two, but has its position on the top of the guide frame shown in the elevation. It passes immediately under the angle of the L shaped rods, and is mounted on friction wheels. Its action is as follows:—When the scrapers have nearly completed their ascending stroke this arbor is elevated by means of the wedge-shaped projection on the top of the frame, and immediately the balance catch acts so as to retain it in this position during the descending stroke, at the termination of which the catch comes in contact with the projecting screw shown in the elevation, thereby dropping the scrapers upon the face of the buddle. Consequently, in the ascending stroke these scrapers plough the vein stuff against the flow of the stream. The orey matter to be operated upon is introduced into the compartment shown on the top of the plan, and by means of the diagonal scrapers it is washed and passed slowly across the table, the heavier portion being delivered into the bin F, and the lighter matter into the box F′, whilst the tails are lodged in the strips H H. The water employed in driving the wheel is also used for the buddle, one portion of it serves to introduce the ore, whilst the other is regularly diffused over the surface of the table, and washes the waste from the stuff. In case the quantity of water is too large for settling the residues flowing into the strips H H, and connected with the bins F F′, discharge launders are provided at G.

The table of the buddle has an inclination towards the bins F F′, and catch pits H H. This machine makes about twelve strokes per minute, and may be furnished with any number of rakes. With twenty-two rakes, forty tons of stuff may be concentrated in ten hours, so as to afford ore for the deluing sieve, whilst the blende will be sufficiently cleaned for the market. The cost of this apparatus complete is about thirty pounds.

Sand and Slime Dressing Machinery.

In most mines a large proportion of the ore is composed of dradge, and has to be brought to a fine state of subdivision either by the crushing mill or stamps. In this condition the ore is freed from sterile matter, and rendered fit for metallurgic treatment. A variety of machines have been invented and applied to this division of dressing, in which the leading principle is to produce a separation by subsidence, according to the density of the substances. In connection with this principle, the stuff is not permitted to have a vertical fall, but is traversed by a flow of water, on a table or bed set at such an angle to the horizontal plane as may be found expedient. With extremely fine stuff apparatus, including both of these features, are sometimes subjected to a mechanical jar or vibration, so as to loosen and eject, as it were, the worthless matter with which it may be charged. In concentrating crushed or stamped ore, a certain quantity will often exist in a very minute state of division, unable to withstand the currents and volume of water necessary for the separation of the larger particles.

The amount and richness must necessarily depend upon the united produce and character of the ore, as well as the mode of treatment observed. A good dresser will form as little slime as possible, since when the ore is brought to this condition it is usually associated with a large mass of worthless matter; and not only so, but the expense of extracting it is materially increased. The loss under the most favourable manipulation is very large, whilst the machinery requisite is probably more complicated and expensive than any other section of the dressing plant. Although several machines are illustrated under this head, and many more might have been added, it does not follow that they may be advantageously employed for every variety of ore.

Thus an apparatus which would enrich slimes by one operation from 1½ to 5 per cent. might be both economical and desirable for treating copper ore, but would not be so important in the case of lead ore of the same tenure; for after deducting the loss of metal incident to the enrichment, charging the manipulative cost on the full quantity of stuff, and estimating the relative value of the two products, it might be found that one would scarcely leave a margin of gain, whilst the other would yield a satisfactory profit.

The proper sizing of slime is as necessary as in the case of coarser work, and for this purpose Captain Isaac Richards, of the Devon Consols Mine, has arranged a peculiar slime pit. The water and stuff from the slime separated, is delivered through a launder into this pit, at the head of which is fixed a slightly inclined plank, divided into channels by slips of wood set in a radial direction from the aperture of the delivery launder. This pit has the form of an inverted cone, and since the water passes through it at a very slow rate, the more valuable and heavier matters will be deposited at the bottom. This apparatus thus becomes not only a slime pit, but also a slime dresser.

The ordinary slime pit has usually vertical sides and a flat bottom; the slime and water enters it at one of its ends by a narrow channel, and leaves from the other by the same means.

A strong central current is thus produced through the pit, which not only carries with it a portion of valuable slime, but also produces eddies and counter-currents towards the sides, which have the effect of retaining matters which from their small density should have been rejected.

The improved pit, *fig.* 1395, receives its slimes from the divided head B, and lets a

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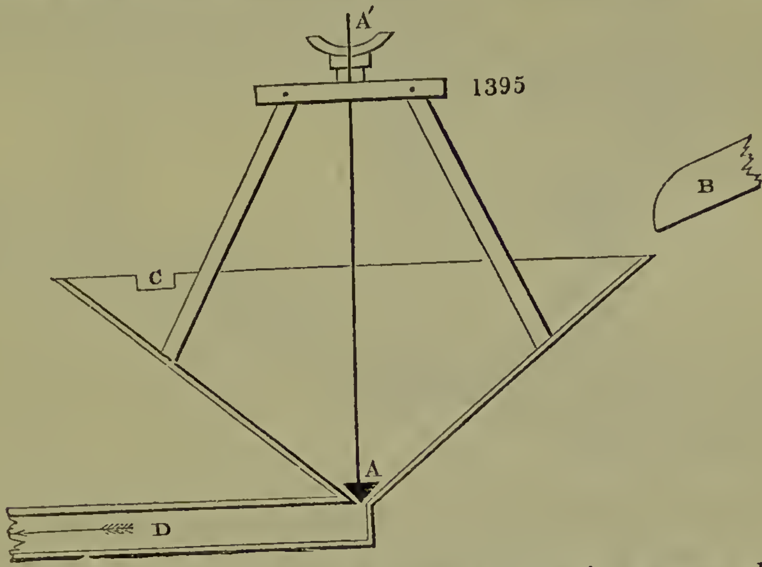

portion of them off again at C, whilst the richer and heavier matters, which fall to the bottom of the arrangement, escape through the launder D, and are regulated by means of the plug A, and the regulating screw A′.

At Devon Consols the slimes flowing from the launder D are directly passed over Brunton's machines, but instead of these sleeping tables may be employed.

In many cases sand and slime stuff are much commingled with clay, and require to be broken and disentegrated before the ore can be extracted. A method for accomplishing this is shown in *fig.* 1396. A is the circumferential line of a round

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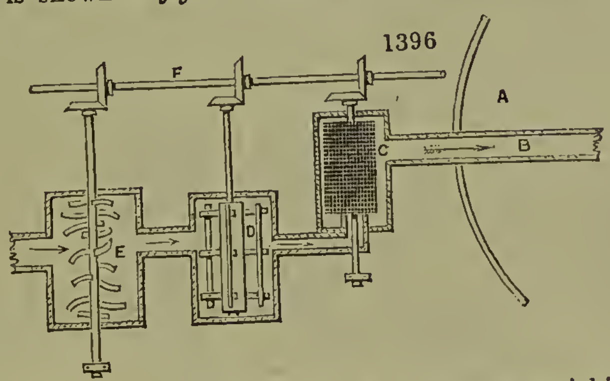

buddle; B, launder leading to such buddle, or any other enriching apparatus; C, sifting trommel; D, rotating paddles; E, tormentor; F, driving shaft.

A modification of this method is found in the slime trommel, *fig.* 1397. A, hopper,

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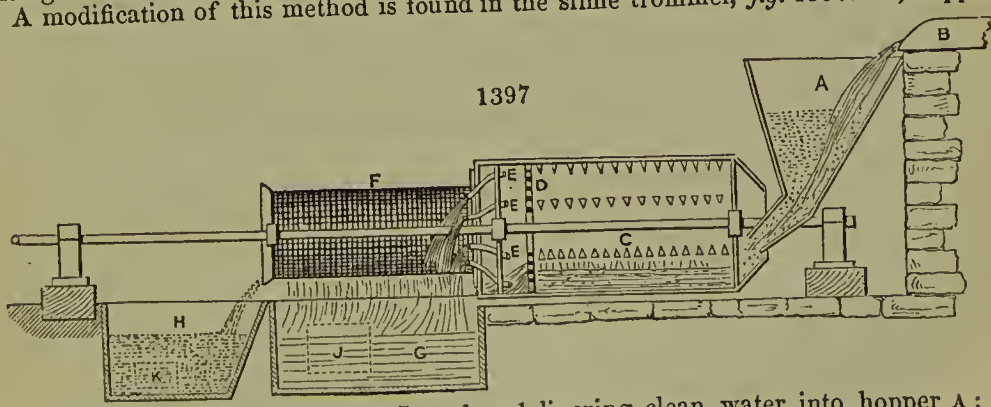

into which slimes are lodged; B, launder, delivering clean water into hopper A; C, trommel of sheet iron, fitted in the interior with spikes for the purpose of dividing the stuff; D, disc, perforated to prevent the passage of pieces of chips or bits of clay and stone; E, Archimedian pipes fitted into a disc of sheet iron, conveying water into gauze or perforated trommel F; G, slime cistern; H, cistern for receiving the rough stuff; J, slime outlet, communicating with round buddle, or other suitable apparatus; K, outlet for trommel raff, which may be delivered to a sizing cistern. The speed of the gauze trommel for fine slimes varies from 80 to 100 feet per minute.

Hand buddle.—This apparatus is somewhat extensively employed in lead mines for the concentration of stuff which contains but a small proportion of ore, such as

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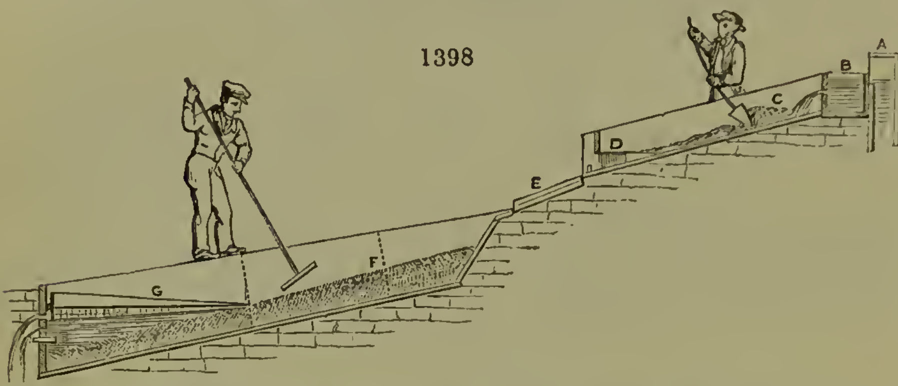

middles and tails resulting from the round buddle, or the tails from strips, &c. A rising column of water is shown at A. This flows into a trough B, and through peg holes into C. Here the stuff to be treated is introduced, and continually agitated by the boy in attendance. The finer portion passes through the perforated plate at D, and is distributed by the fan-shaped incline E in an uniform sheet on the head of the buddles. A boy stands just below the higher line of middles with a light wooden rake; with this instrument he continually directs the descending current to the head of the buddle, and by this means succeeds in separating a larger proportion of the ore than would otherwise be done. Whether the rake or the broom be employed, it is found that some of the fine lead is *florrined* to the extreme tail of the buddle. In order to prevent this the frame G has been introdueed. It is strained with canvass, and always floats on the flooded water. This canvass retains the fine lead, which is from time to time washed off in a cistern of water. The section to the first dotted line shows the heads of the buddle; from this to the second dotted line will be the middles, and from the second dotted line the tails commenee. It must, however, be remarked that the exact line of heads, tails, and middles must depend upon their relative richness. The wooden rake is undoubtedly preferable to the broom, as will appear from the following experiment made at the Swanpool Mines, everything being equal in both trials.

Stuff operated upon; tails from washing strips assayed 13 per cent.

	With Broom.	With Rake.
No. 1. Heads, assayed - -	16% - -	20%
2. Middles, ditto - -	$4\frac{3}{4}$ - -	$5\frac{3}{4}$
3. Tails, ditto - -	$4\frac{1}{4}$ - -	$1\frac{1}{2}$

It would be found a great improvement if these buddles were arranged so as to have their bottoms elevated when it might be necessary. As they are fitted at present the angle at the head is a constantly increasing one. The result is, the heads beeome poorer and the tails richer, provided the fixed inclination of the buddle is correct at starting, as the operation proceeds. In proportion to the poorness of the stuff the buddle should have its width increased, as well as be made shallower. If the stuff be also passed through a trommel before entering the buddle, the result will be found much improved.

The Round Buddle is said to have been first introduced into Cardiganshire, but has now become general in every important mining district. This maehine serves to separate particles of unequal specific gravity in a circular space inclined from the centre towards the circumference. Its construction will be best understood by reference to the annexed engraving, *fig.* 1399, in which A is the conieal floor, formed of wood, and about 18 feet in diameter, on which the stuff is distributed; B is a cone supporting the upper part of the apparatus, and serving to effeet the equal distribution of the orey matter. D is a wheel for giving motion to the arrangement; E, a funnel perforated with four holes and furnished at top with an annular trough; F F are arms carrying two brushes balanced by the weights G G; H is a launder for conducting the stuff from the pit I; K is a receptacle in which the slimes mixed with water are worked up in suspension by the tormentor, which is a wooden

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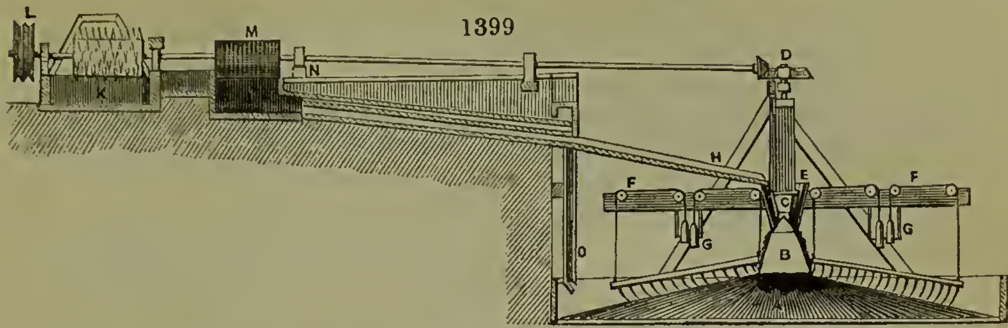
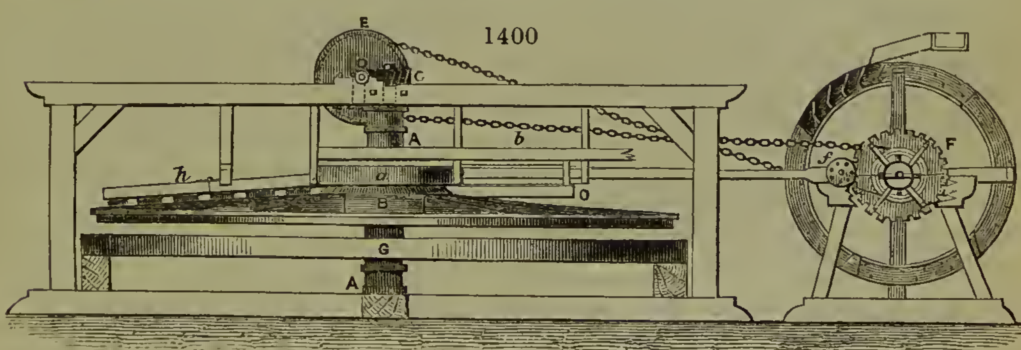


cylinder provided with a number of iron spikes; L is a pulley taking its motion from a water-wheel, and M a circular sieve fixed on the arbor N. The stuff at K is gradually worked over a bridge forming one of the sides of a catch pit between the sieve M and the tormentor, from whence it passes off into the sieve by which the finer particles are strained into the pit I, whilst the coarser together with chips and other extraneous matters are discharged on the inclined floor in connection with the launder O. From the pit I the stuff flows by the launder H into the funnel E, and after passing through the perforations flows over the surface of the fixed cone B, and from thence towards the circumference, leaving in its progress the heavier portions of its constituents, whilst the surface is constantly swept smooth by means of the revolving brushes. By this means the particles of different densities will be found arranged in consecutive circles. The arms usually make from two and a half to four revolutions per minute, and a machine having a bed 18 feet in diameter will work up from 15 to 20 tons of stuff per day of 10 hours.

German rotating buddle. — This machine is said to effect the separation of the earthy matters from finely divided ores more readily than the ordinary round buddle. For this purpose the pulverised ore is introduced near the centre of a large slightly conical rotating table, and flowing down towards its periphery a portion of the upper part or head becomes at once freed from extraneous substances. Beyond this line of separation in the direction of the circumference, the stuff is subjected to the action of a series of brushes or rakes, and by means of a sheet of water flowing over the agitated slimes, clean ore is stated to be produced almost at a single operation.

The illustration, *fig.* 1400, represents this machine as first erected at Clausthal, but

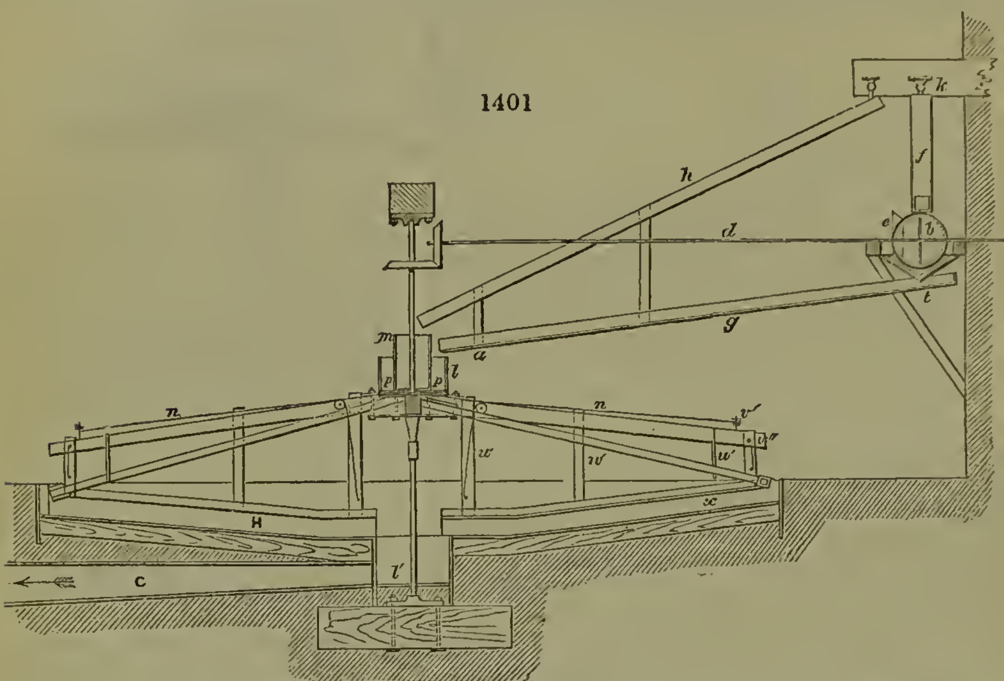
1400



it may be remarked that some of its mechanical details have been since judiciously modified by Mr. Zenner of Newcastle-on-Tyne. A is an axis supporting and giving motion to the table B, 16 feet in diameter, and rising towards the centre 1 inch per foot; C, cast-iron wheel 15 inches in diameter, operated on by the tangential screw D. The tooth-wheel F drives the pinion *f*, the axis of which is provided with a crank giving motion to a rod fitted with brushes; G is an annular receiving box 4½ inches wide, and 6 inches deep; *a*, circular trough of sheet-iron supported on the axis of the table an inch or two above its surface, and so divided that one quarter of it serves for the reception and equal distribution of the slime, whilst the other three quarters supply clear water; *b*, launder for supplying slime ore, behind which is another not shown, for bringing in clear water. O, trough supplying additional water to the stuff agitated by the brushes. One end of this water-trough is fixed about the middle of the table, whilst the other advances in a curved direction nearly to the circumference.

The concave slime buddle.—The object of this apparatus is to concentrate on the periphery of the floor, instead of the centre. This arrangement gives an immense working area for the heads, and at the same time admits of the separation of a greater portion of the waste than can be effected by the ordinary round buddle. After the slimy water has been discharged on the edge, the area over which it has to be distributed is gradually contracting, thereby increasing the velocity of the flow, and enabling it to sweep off a proportionate quantity of the lighter matter associated with the ore. *a* represents the inflow slime launder; *b*, a separating trommel, through

1401



which the slimes pass previous to their entrance into the launder *a*. C, outlet launder, for taking off castaways; *d*, arbor giving motion to the buddle arms and diagonal distributing launders attached thereto held by the braces *w w′*; *e*, bevel wheel on driving arbor; *f*, downright launder, to which is affixed a regulating cock, *k*, for supplying slimes to trommel; *h*, launder for delivering clean water to circular box *m*, and which water passes through slot openings at *p p*, uniting with and thinning the slimy matter previous to its passing into the diagonal delivery launders; *l′*, circular pit for receiving tailings. Attached to the wooden bar *x* is a piece of canvass with corresponding pieces depending in a similar manner from each arm, and which serve to give an even surface to the stuff in their rotation. The slimes flow from four diagonal launders, each having its upper end in communication with box *l*. The speed of the arms and diagonal launders must vary with the nature of the stuff to be operated upon; for rough sands eight revolutions per minute have been found sufficient, but for fine slimes from fourteen to sixteen revolutions in the same time are necessary. The inflow of slime and water should also be proportioned to the speed and density of the stuff to be treated. No precise instructions can be offered on this head, but an experienced dresser would easily determine the proportions after a few trials. The bed is eighteen feet diameter, and has a declination of about six inches from the edge to the point where it unites with the horizontal portion of the floor. The cost of this apparatus complete is about 15*l*. It is employed to a considerable extent in Prussia and affords highly satisfactory results.

Experiment on slime ore, very fine and much intermixed with carbonate of iron:—

Produce before entering buddle - -	6 per cent.
Heads of buddle averaging 3 inches deep and 22 inches wide - - - -	$12\frac{1}{2}$% and 30 oz. of silver per ton of lead.
Middles of buddle averaging $1\frac{3}{4}$ inches deep and 18 inches wide - - -	$6\frac{1}{2}$% and 42 oz. " "
Tails of buddle averaging $\frac{3}{4}$ inch deep -	3% and $55\frac{5}{8}$ oz. of silver per ton of lead.
Castaways - - - - - - -	$\frac{1}{2}$%

Time required to fill buddle, 3 hours; number of arms in buddle, 4; number of revolutions of arms per minute, 8.

Experiment on fine slimes, much associated with carbonate of iron: —

Produce before entering the buddle - - - - - - - - - 3 %
Heads 3 inches deep, 16 inches, wide - - - - - - - - - $7\frac{1}{2}$%
Middles $1\frac{1}{2}$ do. 12 do - - - - - - - - - 1 %
Tails - - - - - - - - - - - - - - traces.

Number of revolutions of arms per minute, 14; time required to fill buddle, 5 hrs. In working this buddle one month upon the fine and rough slimes, indicated in the two foregoing experiments, the results obtained were: —

	Mean.
Assay of stuff before entering the buddle - - - -	5·0%
Heads afforded - - - - - - - - -	12·5
Middles - - - - - - - - - -	5·0
Tails - - - - - - - - - -	0·77

Experiment on slime ore containing $7\frac{1}{2}$ per cent. of lead.

In 12 hours 4 tons were washed, and gave 14 cwts. of crop, 28 cwts. middles, 12 cwts. tails, and 26 cwts. of waste. The 14 cwts. of crop were washed in 3 hours, and afforded $3\frac{1}{2}$ cwts. dressed slime ore, $5\frac{1}{2}$ cwts. of middles, 4 cwts. of tails, and 1 cwts. of castaways The middles resulting from both operations, viz. $33\frac{1}{2}$ cwts., were washed in 8 hours, and gave crop 4 cwts., middles 12 cwts., tails 4 cwts., and waste $13\frac{1}{2}$ cwts. The tails were now washed in 3 hours, and afforded 4 cwts. of middles and 12 cwts. of castaways. 16 cwts. of middles were also washed in 3 hours, and furnished 2 cwts. crop, 6 cwts. middles, and 8 cwts. of castaways. In addition, 10 cwts. of crop ore were washed during 3 hours, and gave $1\frac{8}{10}$ cwt. of slime ore, crop, 1 cwt., middles, 6 cwts., castaways, 1 cwt.

The results, therefore, show that 4 tons of rough slimes were washed in 32 hours, and afforded $5\frac{1}{2}$ cwts. slime ore at $43\frac{1}{2}$ per cent., leaving 1 cwt. of crop at 31 per cent., and 12 cwts. of middles yielding $4\frac{1}{4}$ per cent. A comparison was also made with the shaking table; 5 tons of the same slimes were washed in 48 hours, and gave 7 cwts. of dressed ore, 1 cwt. of heads, and 8 cwts. of middles.

The following are the results of an experiment made between the concave buddle and the ordinary round buddle, time occupied, 24 hours: —

	Pounds.	Water. Weight per cent.	Dry Weight.	Lead.		Blende.	
				Assay per cent.	Total.	Assay per cent.	Total.
Quantity of slimes to each buddle -	4262	$23\frac{1}{2}$	3268	8·7	284·5	34·33	1121·5
Obtained from concave buddle: —							
Crops - -	505	15·4	427	23·6	100·8	36·65	155·6
Middles - -	1350	25·7	1003	7·6	77·7	37·0	371·0
Total -			1430		178·5		526·6
Obtained from round buddle: —							
Crops - -	510	24·8	383·5	10·2	39·	34·64	133·4
Middles - -	2530	39·9	1521·0	7·86	119·5	27·59	419·6
Total - -			1904·5		158·5		553·0
Loss by concave buddle - - - - - - -					106·	- -	594·0
do. round do. - - - - - - -					125·9	- -	568·5

The tails lying upon the horizontal part of concave buddle contained $27\frac{1}{2}$ per cent. of zinc and $2\frac{1}{2}$ per cent. of lead.

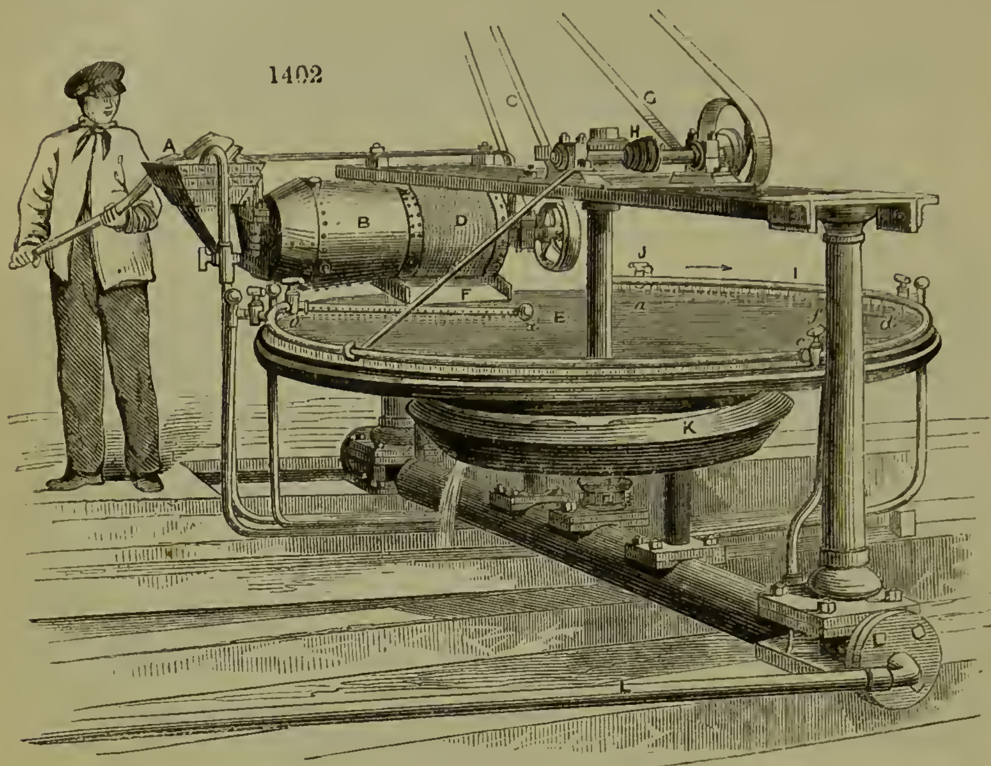
It will be perceived that the much larger crop from the concave buddle was more than twice as rich for lead, whilst it was only 2 per cent. richer for zinc.

Quartzose ore without blende was then tried, and a similar weight gave 1570 lbs. of crop, affording $56\frac{1}{2}$ per cent. or $888\frac{1}{2}$ lbs. of lead, and 3450 lbs. of middles, of 14 per cent. produce, equal to 483 lbs. of lead, or together 5020 lbs. of stuff, containing 1372 lbs.

of lead. The round buddle, on the contrary, gave 455 lbs. of crop ore, of 63½ per cent., equal to 290 lbs. of lead, 2910 lbs. of middles, of 18½ per cent., representing 541 lbs. of lead, or a total of 3365 lbs. of stuff, containing 831 lbs. of lead.

Fig. 1402 represents a buddle arranged for the treatment of fine slimes, and which

1402

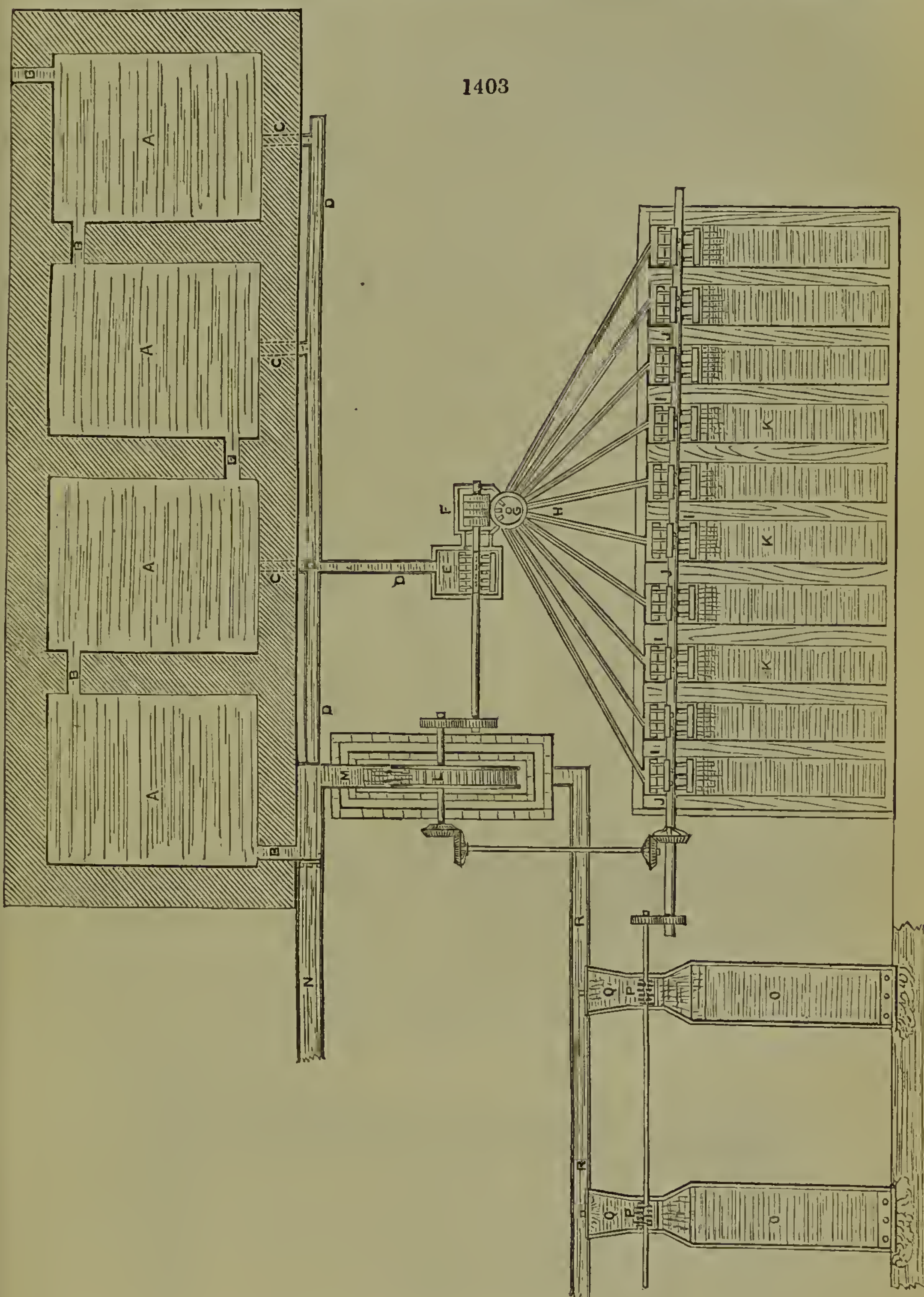


has been found to yield highly satisfactory results at several mining establishments in Prussia where it has recently been introduced. It is entirely constructed of metal, and every part is carefully fitted in order to secure an even and delicate action. The stuff is introduced into the hopper A, from whence it passes into the trommel B, turned by the band C. The fine stuff passing through the perforated cylinder D, falls upon the shoot F, and flows upon the concave table E. This table revolves in the direction of the arrow and acquires its motion by means of the strap G driving the tangent wheel and screw shown at H. Concentric with the table a wrought iron pipe, I, is fixed, which is pierced with numerous small holes. The quantity of water to this pipe is adjusted by the regulating cocks J J′ J″. Beneath the table is a circular receptacle or bottom, K, having three compartments for receiving the washed stuff. From *a* to *d* the jets of water are comparatively light; from *d* to *c* the force of water is increased, and still further augmented in that portion of the circle extending from *c* to *o*, whilst from *o* to *x* it is sufficiently powerful to clean the buddle. In each of the sections a portion of waste along with a little light ore is washed into the receptacles underneath, from whence it may flow into strips or buddles for further separation, or is otherwise manipulated upon a second buddle. The water is supplied to the machine under pressure by the pipe L. This apparatus will wash from 80 to 100 cubic feet of free slimes in ten hours, or from 60 to 80 cubic feet of tough slimes in the same period. Lead stuff affording 4% with a light waste has been enriched to 40% in a second revolution, and in a third and fourth rotation 40% slime has been enriched so as to yield 60% of ore. The buddle table makes two revolutions per minute; its diameter varies from 8 to 10 feet, and the power required is about one-tenth of a horse power. One boy can serve four buddles.

Slime trunking apparatus. — The illustration *fig.* 1403 shows the apparatus employed in some of the lead mines of Cardiganshire. The slimes are lodged in the several settling pools marked A, and flow through the channels B. At C the slimes pass into the launder D to the box E, where they are comminuted, and from thence progress into the trommel F. From the circular cistern G, V-shaped launders diverge to the trunks K, which are divided by partitions I. Upon the axis J in each buddle head, paddles rotate, and flush the slimes over a head board, where a partial separation is effected. The wheel L is driven by water from the pools A, and any excess is carried off by the launder N. At O O two hand buddles are shown; these are intended for the concentration of the heads and middles produced in the trunks K. The axis at P is furnished with spikes for the purpose of breaking up the slimes. After the water has passed over the wheel L, it flows into the launder R, and from thence into Q.

At the Minera lead mines, where the ore produced is very massive and capable of a high degree of enrichment, the slimes average 9 per cent., and are concentrated,

1403

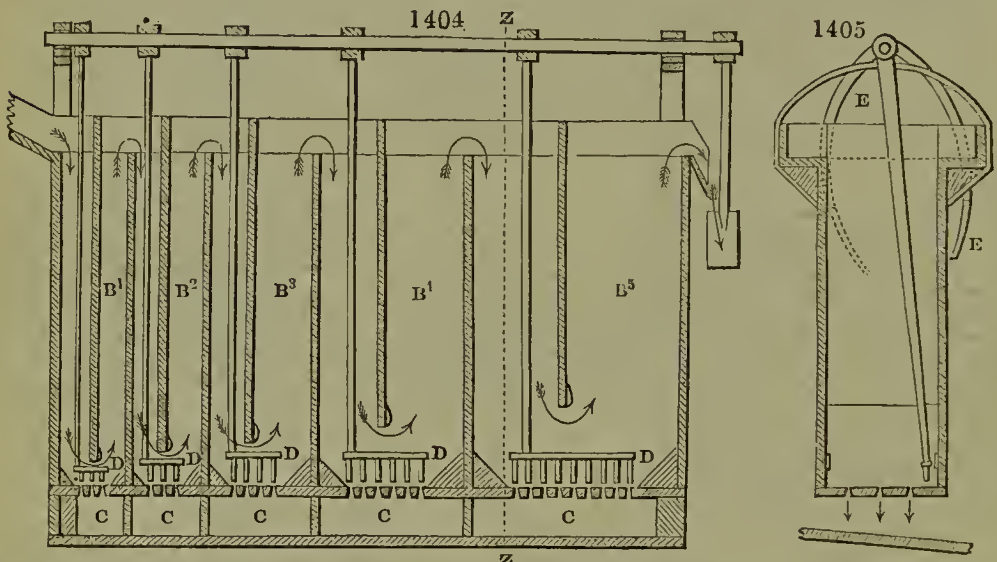


by means of this apparatus, together with a round buddle and dolly tub, to 75 per cent. of metal. With six trunks, one round buddle, one man, and four boys, about nine tons of clean ore is obtained monthly.

Attempts have been made by Brunton and others to separate metalliferous ores of different specific gravities by allowing them to descend at regulated intervals in still water. By reversing the operation and causing the current to ascend uniformly, the particles may be much more conveniently and accurately classified. This has been done in a machine designed by the late Mr. Herbert Mackworth. Suppose a funnel-shaped tube, larger at the top; with a current of considerable velocity flowing upwards through it, grains of equal size of galena, pyrites, and quartz, when thrown in, will be suspended at different heights depending on the velocity of the current at each height. Thus cubical grains of galena, iron, pyrites, and quartz, of $\frac{1}{12}$ inch diameter, will be just suspended by vertical currents moving at velocities of 12 inches, 7 inches, and 5 inches linear per second; flat or oblong particles require rather less velocities to support them, inasmuch as they descend more slowly in still water than the cubical or spherical particles.

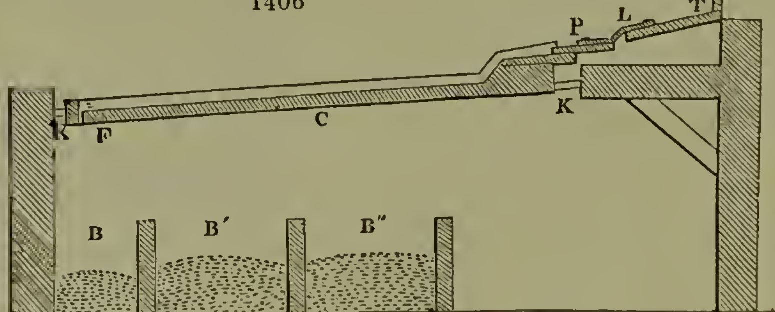
A simple form of applying this principle is presented by the vertical trunks shown in *figs.* 1404 and 1405. Metalliferous ore, after being classified by sifting, or tin ore as it comes from the stamps, may be allowed to flow mixed with water down the shoot A. The supply of water should be taken from a head so as to be perfectly uniform in quantity. The water mixed with the ore flows in the direction of the arrows down and then up the divisions B^1, B^2, B^3, B^4, and B^5, each of which increasing in area, the velocity of the ascending current diminishes in the same proportion. The particles of greatest specific gravity will be deposited in the bottom of B^1. In the bottom of B^2 will be found small particles of great specific gravity and large particles of small specific gravity. The same relation will exist in B^3, B^4 and B^5, only the particles of each will be smaller in succession. The plugs in the holes C C C being opened as is found necessary, allow the accumulations in the bottom of each trunk to discharge themselves into separate troughs. The rocking frame and rakes D D constantly stir up the sediment so as to bring it under the action of the water. To produce the

1404 1405



oscillation of the rakes, two spade-shaped plates E E are exposed to the action of the falling water discharged from the end of the box which rocks the frame to and fro.

1406



The ore in the first trunks is fit for smelting; the ore passing off from the bottom of the other trunks is in a very favourable condition for framing, or it may be sifted to remove the larger particles of less specific gravity.

The rack or hand-frame. — This is composed of a frame C, *fig.* 1406, which carries a sloping board or table susceptible of turning to the right or left upon two pivots K K. The head of the table is the inclined plane T. A small board P, which is attached by a band of leather L, forms a 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 pulverised.

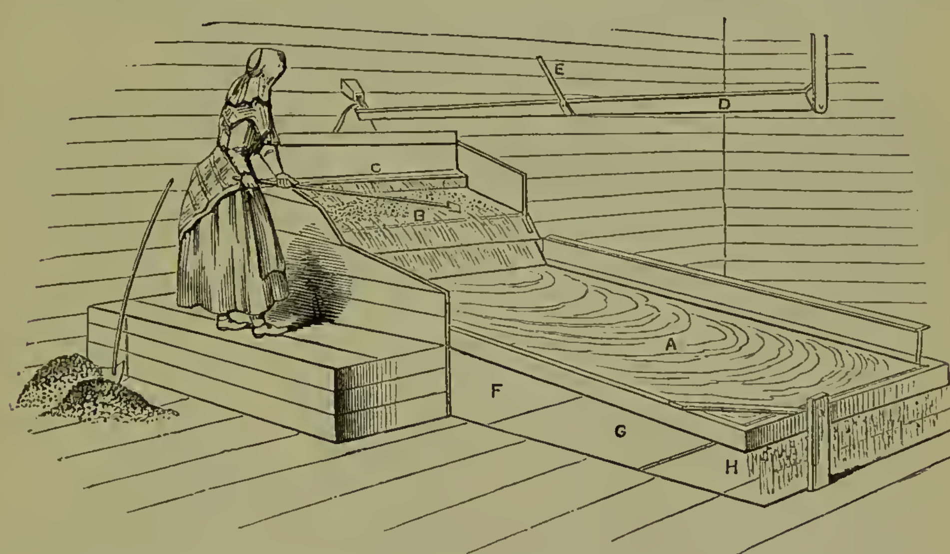
In operating with the table, the slimy ore, to the extent of 15 or 20 pounds, is placed on the head T, and washed over L and P on to the table; then the operator with a toothless rake distributes it equally over the head, the richest particles remain on the highest part of the table by virtue of their greater specific gravity, whilst the muddy water falls through a cross slit at the bottom into a receptacle B. When the charge of ore has been thoroughly racked, the table is turned on its axes K K until it is brought into a vertical position, and the deposit on its surface is washed into boxes B′ B″. The box B′ will contain an impure schlich which must be again framed, whilst B″ will probably contain a slime sufficiently enriched to be finished by the dolly tub.

The slope of the rack table for washing tin stuff is 7¾ inches in 9 feet. The width is about 4 feet.

The average quantity of lead slime which can be washed per day of ten hours, is about 30 cwt., and the water necessary, say 600 gallons.

The general appearance of the rack is shown in the illustration, *fig.* 1407. A, table;

1407

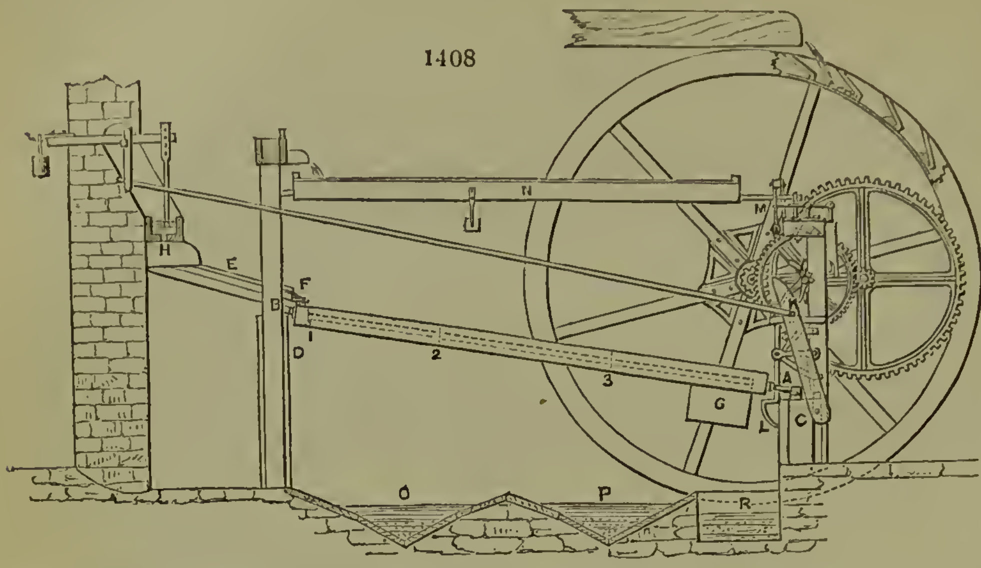


B, inclined plane upon which the stuff is lodged. Clean water flows over the ledge C. When the table A is turned in a vertical position, the racking girl washes it by depressing the lever E attached to the V-shaped launder D, thereby discharging the water which it may contain. The heads, middles, and tails are lodged in the compartments F, G, and H, respectively.

The machine frame, *fig.* 1408, consists of an inclined table, about 8 feet long, and 5 feet wide, with sides 5 inches high. At each end are fixed axles of iron, A B, which are centred in two vertical pieces of timber C D, and admit of the frame being turned perpendicularly. At the head of the frame is a ledge E, on which numerous lozenge-shaped pieces of wood are fixed in order to distribute the liquid stuff on the entire width of the frame.

From the frame head, the stuff falls on a sloping board F, which admits of being turned, as it is hung by leathern hinges, when the frame assumes an upright position. At one of the bottom corners of the frame is a box G, into which the chief part of the water from the table flows. In operating with this machine, the liquid matter is admitted to the frame head E, through the hole H, and flowing in a thin sheet on the table I, deposits the vein stuff according to its varying specific gravity, the best quality being heads from 1 to 2, the middles from 2 to 3, whilst the tails are lodged at the end of the apparatus. To the water wheel is attached a horizontal axle fitted at given distances with cams, which disengage at the proper time parts of the machinery connected with the frame. The first cam acts on the rod K, and stops the flow of tin stuff; the second cam disengages a catch beneath the displacing box G, containing the frame water, and immediately the frame assumes a vertical position striking in its movement a catch at M, which upsets the V-shaped launder N, containing pure water, in such a way as to wash the ore on the table into two cofers O and P. The frame then returns to its horizontal position, and the orey matter is again admitted through H. One boy can manage twenty of these frames. When employed in cleaning tin stuff, the two cofers O and P are discharged into separate pits about 15 feet long, 6

1408

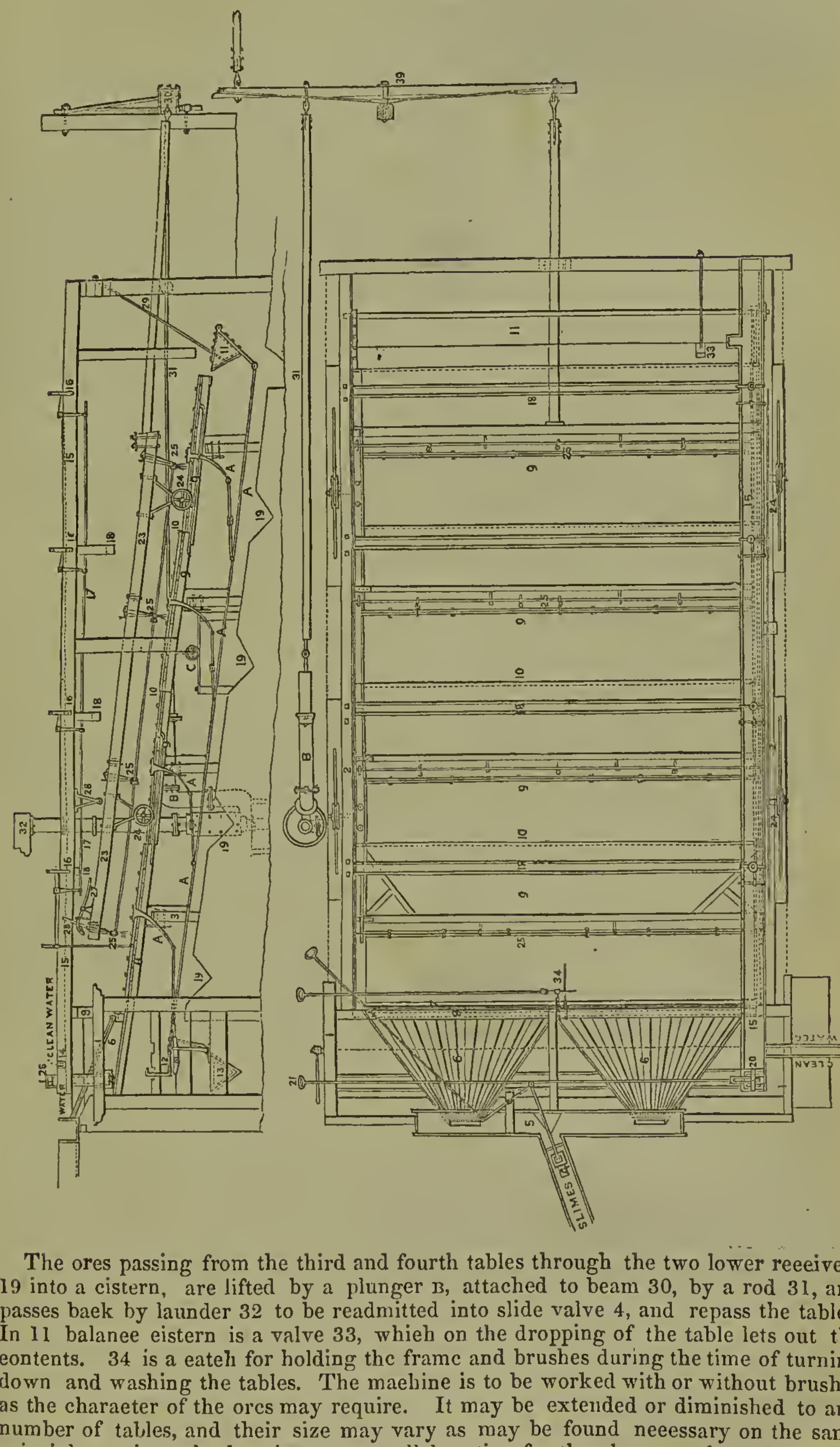


feet wide, and 12 or 15 inches deep. The refuse from the end of the frames as well as the slimy water from the displacing box, is either thrown away or subjected to further treatment; the cover O is usually taken to the hand frames, after which it is tossed and packed, whilst the stuff from cover P is again submitted to machine framing.

Hancock's slime frame. — The ores and accompanying waste are brought into a state of suspension by water, and are then by adjustment made to pass over a slight fall, so as to produce the greatest regularity in its flow over tables fixed upon a given incline, each table having a sufficient drop from the table above. When the tables are sufficiently charged, clean water is introduced to pass over the charged table. The surfaces of the tables are subject to the action of brushes or brooms during a part or the whole time of both operations until the ores are sufficiently cleaned. In some cases the use of such brushes or brooms are dispensed with. The ores (on the tables) thus cleaned are washed off into cisterns by the action of water passing over the surfaces of the tables after they are raised to nearly perpendicular positions.

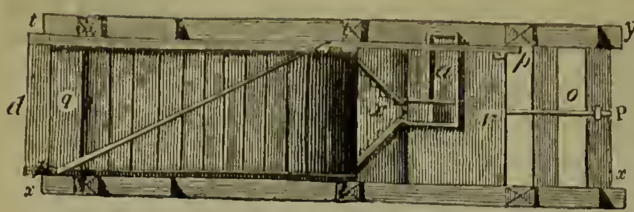
Fig. 1409 represents, 1, framework to carry the gear on each side of the machine; 2, the stretcher or pivot piece on which all the tables are resting; 3, centre bearings of the tables, to which is attached an adjusting screw for raising or falling them; 4, a slide valve, which admits or shuts off, as required, the ores, which are previously brought into a thin consistency with water; 5, launder through which the ores pass to the heads, which are divided into sections and numbered; 6, the ores, &c., dropping from the heads into a launder, 7, the working edge of which is made level by an adjusting screw at each end for the ores to pass over; 8 is a stretcher, passing over the heads in both ends, bolted to 1, from which 6 and 7 are supported by three drop adjusting screws; 9 are four tables over which the ores have to pass, first receiving the deposit of the cleanest or best ores, and the rest in gradation; 10, the drop or fall from one table to another; 11, the balance cistern, into which the refuse from the tables passes, and when full, by lifting the catch 12 it forms a balance for turning up the tables to be washed down, each table being connected with rods and lever A; this done, such catch is lifted up, and 13 forms a returning balance for the tables; at 14 a stream of water is introduced, passing into 15 as a receiver; on the turning up of the tables, valves 16 are lifted by lever and rod 17, and admit the water into perforated launders 18 to wash off the ores into receivers 19, through which it passes out into deposit hutches. The slide valve 4 having admitted a sufficient quantity of ore, which has been deposited on the tables, is now closed, and the valve 20 is opened by the conductor's hand at rod handle 21, through which a supply of water passes into launder 22, and flows over the tables for the purpose of cleaning the ores. The framework for the brushes 23 is carried on four wheels 24, each table being supplied with a brush 25, which brushes its respective table upwards, and on arriving at the heads of the tables, the brushes being all connected, are lifted by lever and 26 slips into the catch 27, and the brushes pass back over the tables without touching until the lever of the catch is struck out by 28, and the brushes drop again on the tables. Each brush is adjusted by serews and carried on arbors running aeross the frame. This frame with its appendages is propelled by a rod 29, attached to a beam 30, that ean be worked by any sufficient power that may be applied.

1409

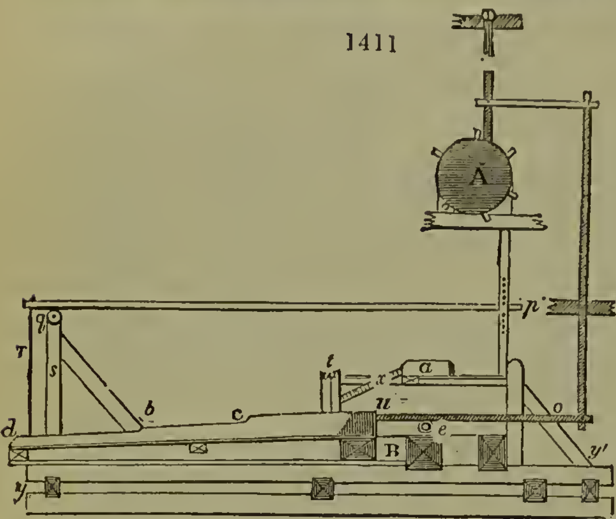


The ores passing from the third and fourth tables through the two lower reeeivers 19 into a cistern, are lifted by a plunger B, attached to beam 30, by a rod 31, and passes baek by launder 32 to be readmitted into slide valve 4, and repass the tables. In 11 balanee eistern is a valve 33, whieh on the dropping of the table lets out the eontents. 34 is a eateh for holding the frame and brushes during the time of turning down and washing the tables. The maehine is to be worked with or without brushes as the charaeter of the orcs may require. It may be extended or diminished to any number of tables, and their size may vary as may be found neeessary on the same principle. C is a wheel aeting as a parallel motion for the plunger pole and running on a bar of iron.

1410



1411



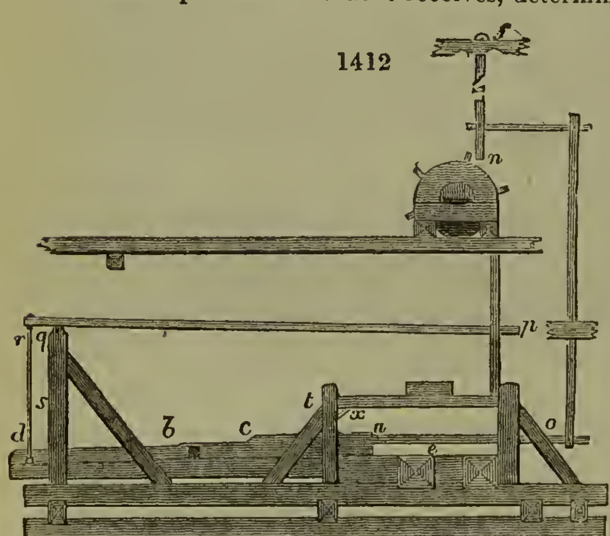
This machine was in constant use at the Great Polgooth Mine for some time, and it is said effected a saving of 30 per cent. in the dressing of slime ore. It is not so well adapted for rough as for the treatment of fine slimes; the apparatus may be managed by a boy at 8*d.* per day, and the cost of the machine complete is about 60*l.*

Percussion table or Stossheerd. — The diagrams, *figs.* 1410, 1411, and 1412, exhibit a plan, vertical section, and elevation of one of these tables, used in the Harz. The *arbor* or great shaft, is shown in section perpendicularly to its axis, at A. The *cams* or wipers are shown round its circumference, one of them having just acted on *n.*

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 B. A lever *p, q,* serves to adjust the inclination of the movable table, the pivots *q* being points of suspension.

The stuff 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 small sloping 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 rake. 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

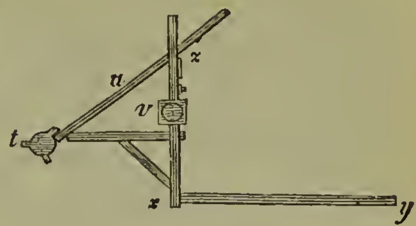
1412



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 launders, whence they are removed to undergo a new manipulation.

Fig. 1413 is a profile of a plan which has been advantageously substituted, in the Harz, 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; thus the adjustment is produced.

1413



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 following remarks on the Freiberg *shaking table*, are by Mr. Upfield Green, of the Wildberg Mines, Prussia. The bed of the table is about fourteen feet long, by six feet wide, and is formed of double one-inch boards, fastened to a stout frame. The table is hung by four chains, the two hindermost are generally two feet long with an inclination of 2 to 4 inches. The two front ones, which are attached to a roller for the purpose of altering the inclination of the table, are five feet six inches long, and hang perpendicularly when the table is at rest.

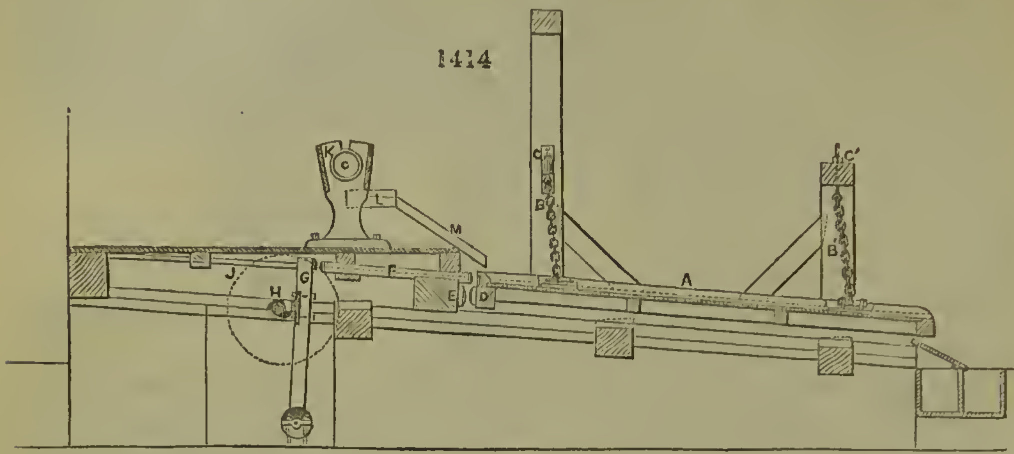
The table receives its action from cams inserted in the axle of a water-wheel, acting on the knee of a bent lever. The slimes after being thoroughly stirred up by a tormentor, are conveyed by a launder in a box, where they are still further diluted with clean water, and passing through a sieve with apertures corresponding to the size of the grain to be dressed, flow upon an inclined plane furnished with diffusing buttons, and from thence drip on to the shaking table.

In treating rough slimes the two hindermost chains are set at an inclination of 5 to 6 inches, and the table with an inclination of 4 to 6 inches on its length, makes 36 to 39 pulsations of 5 to 6 inches in length per minute. About 2½ cubic feet of diluted slimes, twelve of clean to one of slime-water, enter the table per minute.

Before commencing the percussive action, the table is covered with a thin layer of rough slimes, and during the first few minutes only clean water is admitted. In consequence of the quantity of water and violent motion employed, the smaller and lighter particles of ore are likely to drift down the table, and a rake is therefore employed at intervals to reconvey such particles towards the head of the table. Care must, however, be taken not to allow the water to wear furrows in the deposit. From two to three hours are usually required for the roughest sand-slimes to deposit four to five inches on the head of the table. The crops are twice more passed over the shaking table and afterwards dollied. The rapidity of movement and quantity of clean water increase with each operation. The tails of the first operation, which are considerably poorer than the original stuff, may be either thrown away, or once more passed over the table, when the crop will be fit for treatment along with a fresh quantity of original slime. The treatment of fine slimes is similar to that of the rough, with the exception that the inclination of the table, quantity of slime-water, proportion of clean water, and length of stroke, constantly decrease with the degree of fineness of the slime; and the number of strokes increase in proportion. In fact, for the finest slimes, the table has no greater inclination than one inch on its whole length, while the stroke, of which 35 to 45 per minute are made, is no longer than ¼ to ½ an inch. The time required for dressing varies with the nature of the slime operated on, five tons of rough slimes occupies sixty-eight hours, whilst the same quantity of very fine slimes requires no less than four times that period.

The Stossheerde.—To the kindness of Mr. Charles Remfry, of Stolberg, I am indebted for the elevation of a stossheerd erected at the Breinigerberg Mines, under his management. It has the merit of being extremely light, requiring little power, and of performing its work in a highly satisfactory manner. *Fig.* 1414, A, table swung

1414



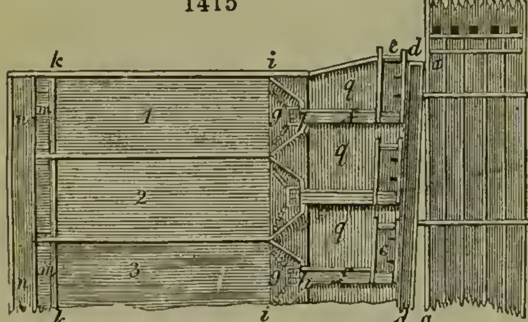
by chains, B B′, its width being 3 feet and length 12 feet. A greater or less inclination is given to the table by raising or lowering the screws C C′. At the upper end of the table is a buffer, D, which acts against a counter buffer, E. A sliding bar, F, is also fitted between the table and percussion lever G. This lever is struck by cams fitted on the axis H, driven by the runner J. The slimes to be treated flow into the cistern K, 30 inches long. 13 inches wide, and 18 inches deep. Into this box a tormentor is introduced for the purpose of breaking up the slimes. The bottom is fitted with a launder, L, 7 inches long, and 5 inches wide. From this launder proceeds a head-board, M, expanded to the width of the table, and fitted with buttons, for the purpose of dispersing the slimes equally on the head of the table.

At the Breinigerberg mines the slimes are very fine and tough, and not rich in metal. With the round buddle unimportant results were obtained; but the stossheerd concentrated them satisfactorily. About five tons of rough slime are enriched per day on four tables, whilst from nine to ten tons of the enriched slime are despatched in a similar period.

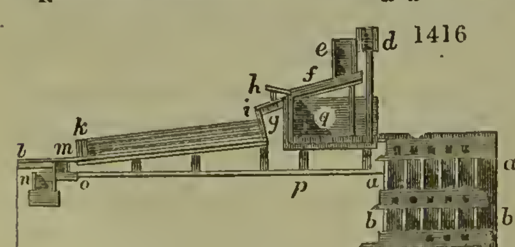
The four tables are managed by two boys, at a cost of 1*s.* 2*d.* per day. The cost of these machines complete, including water-wheel, 9 feet diameter, and 3 feet in breast, was 114*l.*

Sleeping tables. — *Figs.* 1415, 1416, represent a complete system of *sleeping tables, tables dormantes*, such as are mounted at Idria. *Fig.* 1415 is the plan, and *fig.* 1416 a vertical section. The ores, reduced to a sand by stamps, 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 stop-cocks for each trough. The sand thus diffused upon each table, runs off with the water by a groove *f*, comes upon a sieve *h*, and spreads itself upon the board *q*, 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 the chest. A general conduit *n*, passes across at the foot of all the chests, *i k*, and receives the refuse of the washing operations.

1415



1416



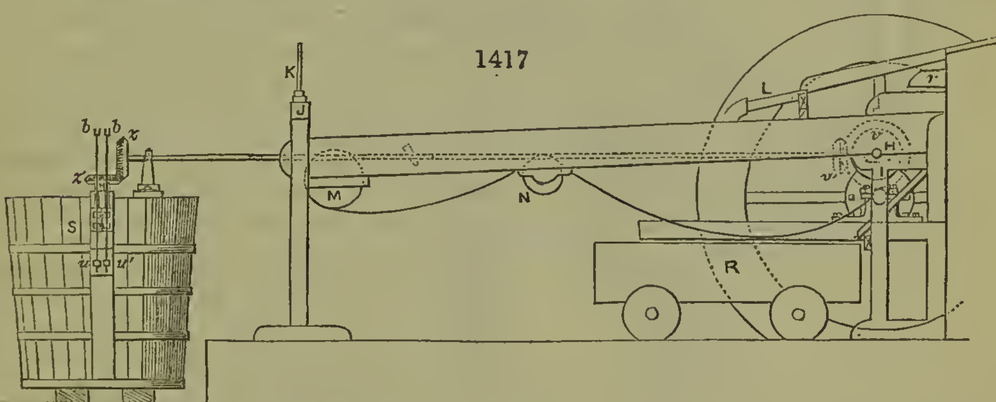
In certain mines of the Harz, tables called *à balai*, or *sweeping tables*, are employed. The whole of the process consists in letting flow, over the sloping table, in successive currents, water charged with the ore, which is deposited at a less or greater distance, as also pure water for the purpose of washing the deposited ore, afterwards carried off by means of this operation.

At the upper end of these *sweeping-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.

Brunton's machine.—This apparatus appears to be well adapted for the utilisation of the ore contained in very fine slimes. At Devon Great Consols it is extensively employed, not only to concentrate the viscid kind of slime sometimes found at the periphery of the round buddle, but also to dress the tops and middles resulting from the dollying operation.

The small water-wheel, shown in *fig.* 1417, is sufficient to drive six of these

1417



machines, viz. three on each side. Before the stuff is permitted to enter upon the rotating cloth, it is disintegrated by tormentors, and passed through a sizing trommel; it then flows over the head or dispersing board L, on to the cloth. This cloth rotates towards the stream on two axles, H and M, and is supported by a third roller N. It is also stiffened in its width by numerous laths of wood. Clean water is introduced behind the entrance of the slime, in order to give it the proper consistency. Different degrees of inclination are given to the cloth by raising or lowering the roller M, by means of the screw K. The heavier particles lodged on the cloth are caught in the waggon R, whilst the lighter matter is floated over the roller M. The following particulars are furnished by Captain Isaac Richards, of Devon Great Consols :—

One revolution of the cloth is made in $4\frac{1}{2}$ minutes; its length is about $29\frac{1}{2}$ feet, so that it travels say $6\frac{1}{2}$ feet per minute. Its width is four feet two inches.

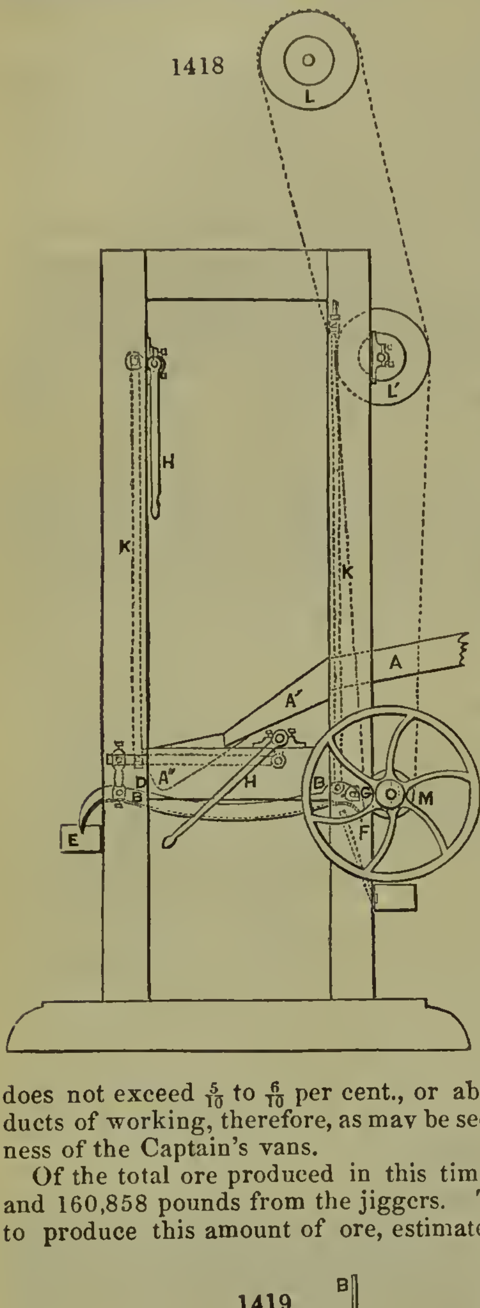
Before the slime comes upon the cloth it is reduced to a size of $\frac{1}{60}$ of an inch, and yields an average of $1\frac{1}{2}$ of copper; but by means of this machine the stuff is concentrated so as to afford 5 per cent. In ten hours it will clean $1\frac{1}{2}$ tons, at a cost of 1*s.* per ton. The speed of the cloth must, however, be varied with the condition of the stuff; if it be very poor the cloth must travel very much slower, since the enrichment requires a longer period of time.

At the end of the machine, and worked by the same water-wheel, is a dolly tub; but the dimensions and mode of working this apparatus are fully stated page 356.

Bradford's slime apparatus, *fig.* 1418, has been extensively employed at the Bristol Mines, situated in Connecticut, United States.

Its action is intended to imitate that of the vanning shovel. The slime enters by the launder A, about 5 inches wide, and descends on the inclined head A′, which expands from the width of the launder to within a few inches of the width of the table frame B. The slime box A″ is perforated at D with numerous holes, each of which is fitted with small regulating pins.

1418



The table B B is 2 feet 2 inches wide, and 2 feet 10 inches long, with a bottom formed of copper gauze. It is suspended by the vertical rods K K, and varying degrees of inclination are given to the table by altering the levers H H. For the purpose of quickening or decreasing the action of the table two cones are employed, L L′, upon which the driving band is shifted as may be necessary. A band from a runner, fitted on the axis of the cone L, communicates motion to a pulley wheel, M, upon the shaft of which are cranks attached to connecting rods G, giving motion to the table.

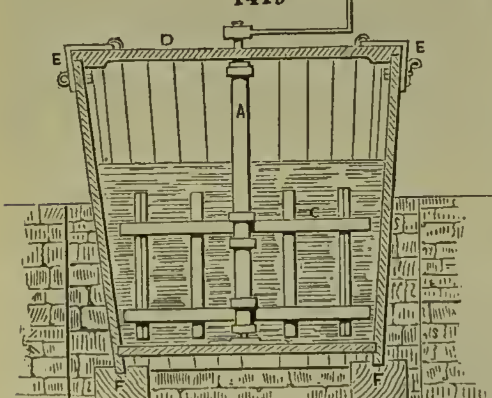
When the machine is in operation, the ore flows over at F, into the launder beneath it, whilst the waste is carried over the opposite end into the trough E.

Professor B. Silliman, jun., and Mr. J. D. Whitney give the following particulars of results realised by this machine:—The total weight of ore stuff dressed during 122 days was 11,948,900 pounds of rock stamped and crushed, or 5,080 tons miners' weight.

The total ore sold from this quantity of stuff was 128 gross tons (2352 lbs.), or $2\frac{51}{100}$ per cent. of the stuff worked over. By the Captain's vans the average richness of the stamp work (forming much the larger part of what goes to the separators) for 22 weeks was 2·32 per cent. The humid assay of the average work from the stamps for five weeks in July and August, gave for the richness of the stuff dressed on the separators 3·28 per cent. of ore, or ·984 per cent. of metallic copper. There is, therefore, an apparent loss in the tailings of $\frac{77}{100}$ per cent. of 30 per cent. ore, or $\frac{23}{100}$ of copper. The amount of ore, however, lost in the tailings does not exceed $\frac{5}{10}$ to $\frac{6}{10}$ per cent., or about $\frac{15}{100}$ per cent. of copper. The actual products of working, therefore, as may be seen, exceed for the machines the average richness of the Captain's vans.

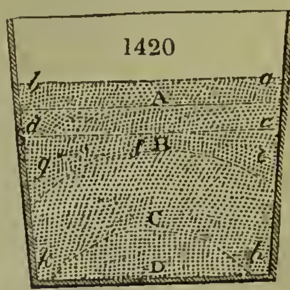
Of the total ore produced in this time, 181,126 pounds came from the separators, and 160,858 pounds from the jiggers. The whole amount of stuff therefore required to produce this amount of ore, estimated from the above ratio (1·15 : 1) is 768,680 pounds. This may be taken approximately as the actual quantity which passed over the separators, and if calculated on the Captain's vans, it should have produced 177,961 pounds of ore, while in fact it did produce 181,126 pounds, or a variation in excess for the machines of only 3,210 pounds. Each of the separators therefore dresses about $1\frac{1}{2}$ tons of rock daily, of stuff yielding an average of 2·5 per cent. of 30 per cent. ore.

1419



Dolly tub or packing kieve.—This apparatus is employed for the purpose of excluding fine refuse from slime ore, which has been rendered nearly pure by previous mechanical treatment. In using it the workmen proceed thus:—The kieve, *fig.* 1419, is filled to a certain height with water, and the dolly A introduced. A couple of men then take hold of the handle B, and turning it rapidly cause the water to assume a circular motion. The tossing is then commenced by shovelling in the slime until the water is rendered somewhat thick. After continuing the stirring for a short period, the hasps E E are loosened, and the bar D with the dolly are suddenly withdrawn. The tub is then packed by striking its outside with heavy wooden mallets. When this operation is terminated, the water is poured off through plug-holes in the side of the tub.

1420

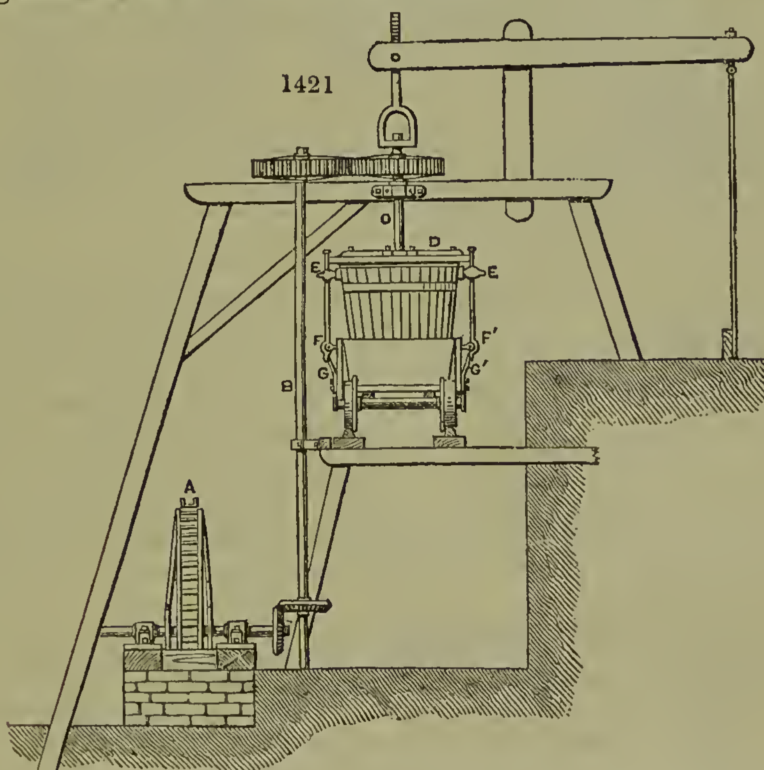


The object of the rotary motion created by the dolly is to scour off clayey or other matter adhering to the ore, whilst the packing hastens the subsidence of the denser portions. In one operation of this kind four distinct strata may be procured, as indicated by the lines *a b*, *c d*, *e f g*, *h c k*, in *fig.* 1420.

The upper portion, viz. from A to B, will probably have to be set aside for further washing, whilst the schlich C should be fit for market. The conical nucleus in the centre of the tub generally consists of coarse sand, and is usually further enriched on a copper bottom sieve, or else submitted to the action of a tye, or other suitable apparatus.

Machine dolly tub. — This kieve is packed by machinery represented in the accompanying woodcut, in which A is a small water-wheel working a vertical shaft B, and driving another shaft O. At the bottom of this is fixed a notched wheel D, which

1421



presses outwardly the hammers E E; these are mounted upon iron bars F F′, and violently driven upon the side of the kieve by means of springs G G′.

The degree to which ore can be concentrated by dollying must evidently depend upon several conditions: — 1st. The initial percentage of the ore. 2nd. The condition to which it is reduced. 3rd. The matrix with which it is associated. 4th. The proportion of water employed. And lastly, if the rotation and packing have been judiciously performed. An experiment upon some sandschlich lead ore, much intermixed with fine carbonate of iron, gave the following results: —

Introduced into dolly tub, 17 cwt., assayed, 48%.

Time required to introduce stuff	6	minutes.
Dolly rotated	5	„
Dolly withdrawn —		
Tub packed	5	„
Running off water	6	„
Skimming and cleaning out tub	20	„
Total	42	

Top skimmings	4 cwt., assayed		20%
Second „	$1\frac{1}{4}$	„	45
Clean ore, middles	$5\frac{1}{2}$	„	65
„ bottom	$4\frac{1}{2}$	„	$67\frac{1}{4}$
	$15\frac{1}{4}$		
Fine schlich	$1\frac{3}{4}$		
Total	17		

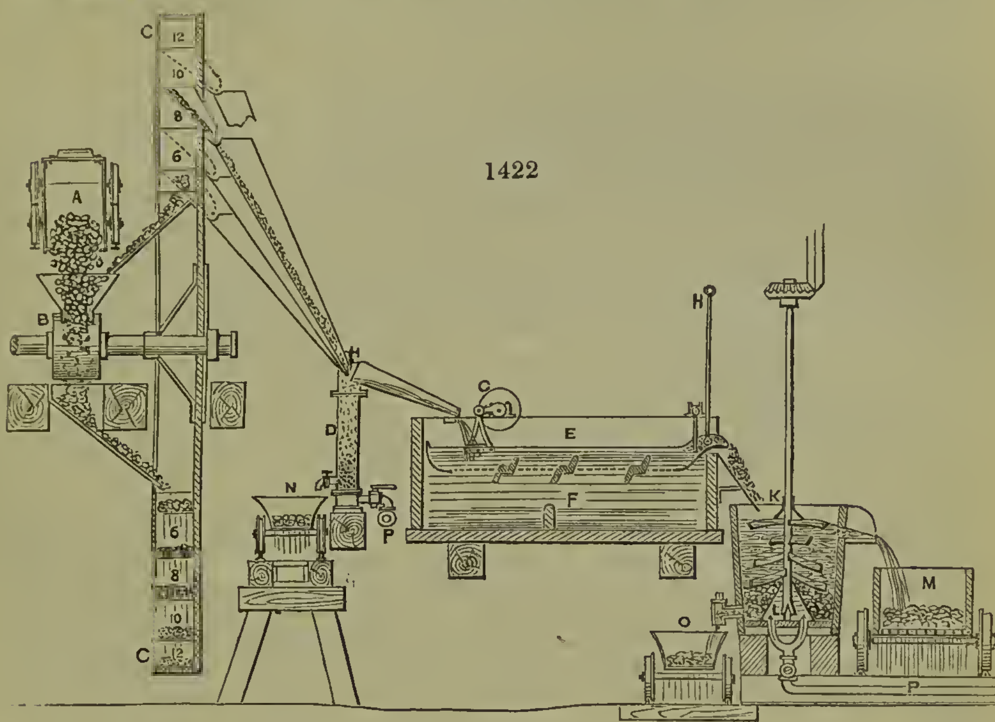
It may be remarked, that none of the various processes of dressing is more satisfactory than that of dollying, since, if carefully conducted, little or no loss of the total quantity of ore can occur.

Jordan's System of continuous Dressing.

We have now to notice a method of separating mineral sands of varying specific gravity, which was first used by Mr. T. B. Jordan at the Colonial Gold Works, in separating gold from quartz and other gangues with which it was associated. The plan was successfully practised for its original object during the years 1853 and 1854, and has since been elaborated for general application to dressing minerals.

The principle on which the system is founded, is the fact that bodies having the same bulk and various gravities, will fall through a column of water in the order of their densities, and hence that water moving upwards, at a rate greater than that at which any given body would descend through still water, will not allow such a body to descend through it, but will carry it up, and deliver it over the top of the containing vessel; therefore, granting that it is possible to reduce metalliferous ores to grains of uniform bulk, and taking the most simple case for our illustration, such as galena and carbonate of lime, or quartz, it becomes at once obvious that an upward stream of water, may be so regulated as to throw over all the lime or quartz, and allow all the galena to pass through it; but as we seldom find the associated material so simple, and as there is considerable difficulty in reducing minerals to grains of absolute identity of bulk, we must be content to complicate our machinery a little, and to put up with a somewhat less perfect or more laborious result than this argument seems to promise; nevertheless the author of this system contends, that the introduction of *this element of washing by the up current*, greatly facilitates the arrangement of dressing machinery of continuous action; and, further, that if perfectly continuous action can be secured, so that each machine shall deliver its products to the next in succession which is to be employed on them, a very great improvement will have been effected, and a great saving made on the present cost of dressing; for it would not be difficult to show that nine-tenths of the labour consists of putting down, picking up, and transferring the material to the various processes through which it passes.

Our figure (1422) must be taken as a diagram illustrative of Mr. Jordan's views. In actual practice, the construction is varied to meet the peculiarities of each case, while the general principle here illustrated is strictly adhered to. A, is a tram bringing the rough material to the crushing rollers B; C C, is a sort of raff wheel so arranged as not only to serve the usual purpose of returning the stuff not sufficiently crushed to the rollers, but also to separate that which is crushed into four or more sizes by the concentric rings of wire-work which divide the wheel into the compartments 6, 8, 10, 12. These numbers may be taken to denote the mesh in holes per lineal inch, and if so, all the materials from the crushing rolls being conveyed into the centre opening of the wheel will be sharply rolled over a six-hole sieve of great area, that part of it which is fine enough will pass through the mesh, that which is not will be carried up by the partition or bucket which returns it to the mill for further grinding. In the stuff which has passed the 6-hole sieve, and reached the compartment marked 6, there will be a large proportion which will pass the next or 8-hole sieve, and again from the 8 to the 10 and 12, so that this wheel separates the ground stuff into four lots of approximately uniform grain. To secure the greatest effect from this separator, the stuff must be either perfectly dry, or ground with a good stream of water passing between the rolls and through the wheel. Each compartment of the wheel is furnished with one stop-bucket and spout, which, when it arrives at the top, delivers the contents of the compartment collected during the revolution into separate launders which carry it to as many different tubes, one of which is shown at D. These tubes are supplied with water from a main P, which is in connection with a reservoir some 12 or 14 feet above the level of the dressing floor; a few inches above the true bottom of the vessels D, there is a false bottom or diaphragm of wire-gauze, through which the water rises. Under the conditions described, the superintendent will have the power of regulating exactly the quantity of water which shall rie through each tube in a given time, and therefore the rate of



the upward flow of the water; or, in other words, he will be able so to adjust each stream as to throw over the waste, and allow the valuable part of each sand to fall on the wire bottom of its tube. It is of course admitted that the sizing effected in the wheel C, although better than by the usual methods, is still but an approximation to perfect sizing; and even if in the wheel it were perfect, still the rush through the launders would inevitably produce some dust ore if dry, or slime ore if wet, so that it would not do to throw away all that is washed over the top of the tubes, it therefore passes forward to the hutch E, where it falls on a fine gauze bottom sieve, parted longitudinally into as many divisions as there are tubes or sizes of sand to be worked, the bottom of each of these divisions is composed of a wire gauze, somewhat finer than that of the compartment of the parting wheel from which the sand came, and therefore none of the waste can find its way into the hutch; the action of this sieve is widely different from that of a jigging machine, inasmuch as the back and fore part of it, have a different kind of motion, and it is a machine of continuous action, not requiring the constant attention of skilled labour. The crank G, by its constant rotation, dips the back of the sieve a few inches under water, and at the same time draws it back through the water at every revolution, and on rising and passing over the upper half of its revolution, it frees the sieve forwards, while all its contents are above the surface of the water in the hutch. The front of the sieve is suspended by a pendulous rod from the point H, so that it has very little elevation and depression, while it has the same lateral motion as the back, and this enables the simple hanging scraper, which can move freely outwards but cannot pass inwards beyond the perpendicular, to throw over a portion of the waste at every stroke, this being much assisted by the stream constantly flowing over it. There are cleets placed across the bottom of these sieves both above and below, the tendency of which in giving direction to the waste, and stopping the rich slimes, will be readily understood on reference to the figure. The dolly tub K is intended to meet the case of secondary products, such as "Jack," or other ore of zinc, frequently associated with lead. The peculiarities of its construction are such as are requisite to avoid the necessity for stopping and taking the machine apart in order to dig out its contents; it is accomplished partly by the direction given to the revolving arms which tend to lift the stuff, but principally by an up current of water of sufficient rate to throw over the lightest of the two materials now associated; as in the former case, the original sizing is not abandoned, but a separate dolly tub is used for each size, so that the up current may still be adjusted to its work with the greatest precision; the step or bearing in the bottom of the tub is protected from the sand by a sheet-iron cone attached to the shaft, into which the clean water from the main is supplied, so that the stream of water constantly running from under the edges of this cone, keeps the step at all times perfectly clean and free from sand ; P, is the main for supplying to the tub, and there is a tap on the communicating pipe which regulates its force ; M, is the waste waggon, having a riddled bottom for drawing off the water ; O, is the "Jack" waggon into which the clean stuff from the tub is occasionally discharged by the sluice valve ; and N is the lead waggon for carrying away the clean ore from the tubes, this waggon, like the others, is furnished with a riddled bottom covered with some material which is too fine in the mesh to allow any of the ore to pass ; the ore is drawn off from the washing tubs from time to time in small quantities ; each waggon remains under its own tube until it has received a full load, and is then wheeled off to the ore house : by this system, the inventor says, nothing is left to clean up but the hutch F, and its sieve, which latter may require looking to two or three times a day, and the bottom of hutch about once in three days.

Vanning is a method commonly practised by the dressers of Cornwall and Devonshire, by which they ascertain approximately the richness and properties of the ore to be treated. If the object be to determine the value of a pile of stuff, it is carefully divided, then sampled, and a portion, say a couple of ounces, given to the vanner. If the stuff thus given should be rough, it is reduced to the tenure of fine sand, and in this state put upon the vanning shovel. The operator now resorts to a cistern or stream of water, and by frequently dipping the shovel into it, and imparting to the shovel when withdrawn a kind of irregular circular motion, he succeeds in getting rid of a greater or less portion of the waste : that which remains on the shovel is then considered equal to dressed work and assayed. So accurately is this operation performed by many of the tinners, that parcels containing only fifteen pounds of tin ore per ton of stuff, are sold by it to the mutual satisfaction of both buyer and seller.

The vanning process is also well adapted for determining the properties of an ore. If, by this method, vein stuff should withstand concentration, no machinery is likely to dress it. If also the loss of ore is found great, then the apparatus to be employed for effecting the enrichment will have to be carefully considered and constructed.

Fig. 1423. The vanning shovel A, is 14 inches long, and 13 inches wide at the

1423

top, the edge of which is slightly turned up. The shovel is also formed with a hollow or depression. The handle is about 4 feet long. The vanning cistern is shown at B.

Hushing.— It often occurs, that the water employed on the dressing floors makes its escape below the refuse or waste heaps. This may be used for the purpose of hushing, which operation is performed in the following manner. The husher diverts the escape water into a rivulet and introduces a given quantity of waste. He then builds a dam or reservoir, with a door or trap valve at the high end, in order to collect the necessary water for hushing, and puts aside all the large stones lying in the middle of the hush gutter in order to form them into a wall. After this, he starts his hush by lifting the door of the dam, which slides in a wooden frame adapted for that purpose.

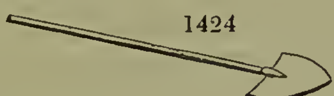
This allows the water to rush out, and displaces the waste to a certain depth, at the same time driving it forward.

If the hush has bared or uncovered a further quantity of large stones in the middle of the gutter, they are again removed to one side, since they would retard the force and action of the water. When these impediments are removed, the water is repeatedly discharged from the reservoir until the waste is hushed off the ore, which is found lying in holes, and around earth and fast stones, in the bed of the rivulet. A clay bottom is found to be most favourable for hushing, and the velocity and power of the stream should be proportioned to the size and density of the waste to be treated.

Forwarding and Lifting Apparatus.

Besides the machinery required for the enrichment of ores, it is a matter of great importance to introduce such auxiliary arrangements as shall not only facilitate actual dressing, but also be in themselves somewhat inexpensive. In this division, as in every other, the means should be strictly adapted to the end, and ought not to bear a cost disproportionate either to the circumstances or prospective advantages of an undertaking.

The shovel. *fig.* 1424, usually employed in British mines is of triangular shape, and made of good hammered iron pointed with steel. The dimensions vary, but one of an average size is about 11 inches wide at the top, and 13 inches from the point to


1424

1425


the shank, weight 4 pounds, and costs one shilling; to which must be added, five pence for the hilt, or handle. The hilt should be of ash, free from knots and slightly curved.

Picking boxes, *fig.* 1425, are employed for the purpose of collecting the prill and dradge ore from the stuff with which it may be mechanically intermixed. These boxes or trays, are handled by children. They are made of deal, 1 inch thick, of the following dimensions. Length, 16 inches; depth. 7 inches; width at bottom, 7 inches; width at top, 10 inches; and cost about 1*s.* 3*d* each. A ledge of wood to serve as a handle is sometimes nailed to the ends of the box.

Wheelbarrow. — The sides, ends, and bottom, are composed of deal $1\frac{1}{4}$ inch thick. The ends are mortised to the sides, whilst the bottom is generally fastened by means of nails, and bound with slips of hoop iron at the angles. Hoop iron is also employed to protect the upper edges of the barrow. The wheel is often made of wrought iron, ($\frac{5}{8}$ round) and 14 inches diameter. Its axes rotate in wrought iron ears. The extreme length of the sides of a well-proportioned barrow is 60 inches, depth at centre 9 inches; the ends are inclined as shown in the *fig.* 1426. The cost of a barrow with wrought iron wheel complete, will vary from 6*s.* 6*d.* to 7*s.*

1426


Hand barrow. — When large quantities of stuff have to be removed from place to place on the surface, and where it would be inconvenient to use the wheel-barrow, a barrow having handles at both ends is employed. It is made of deal plank $1\frac{1}{4}$ inch thick; the length of the sides is 5 feet 6 inches; depth in centre, 9 inches; width, 18 inches at top and 10 inches at bottom; length, 24 inches at top and 18 inches at bottom; cost complete about 4*s.* 6*d.*

1427

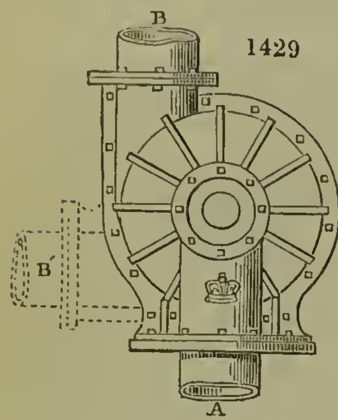

Railroads. — The gauge of surface roads varies from 2 feet 4 to 2 feet 6 inches within the rails. Instead of manufactured rails, common flat wrought-iron, $2\frac{1}{2}$ inches wide and $\frac{1}{2}$ inch thick, is oftentimes employed. An extremely serviceable rail is formed of a strip of timber 2 inches square, upon which is laid wrought-iron, $1\frac{1}{4}$ inches wide and $\frac{1}{4}$ inch thick, fastened by means of nails or screws.

Tram waggon and turn table. — A good tram waggon and turn table is shown *fig.* 1428. The waggon is built of wrought-iron, with cast-iron wheels. The latter are usually 12 inches diameter, with flanges 1 inch deep and tires from 2 to 3 inches wide. The turn table is of cast-iron. It does not rotate, but the waggon is easily directed to either line of rail by means of the circular ring; the elliptical loops in advance serving to guide and place the wheels on the rails.

1428


Lifting apparatus. — It sometimes happens that the surface is nearly level, and affords very little natural fall. In such case the enrichment of ores becomes more expensive from the necessity of shifting some of the various products by manual labour, and of introducing lifting appliances in order to procure the requisite elevations for carrying out the various elaborative processes. It is, moreover, scarcely practicable from the conformation of the ground to form useful reservoirs of water within a reasonable distance; neither does it commonly occur in such cases that a free supply can be obtained for washing.

The pumping engine is therefore required to furnish the requisite quantity of water. This is generally conveyed over the floors by wood launders, often interfering with each other and obstructing the direct circulation of carts, railways, &c. Now if a stand-pipe or pressure column were erected at the engine, and a main judiciously laid throughout the floors, it is obvious that it would not only remedy this evil, but also afford water for the several washing purposes, as well as motive power for common, dash, or other wheels, together with turbines, flap jacks, &c.



1429

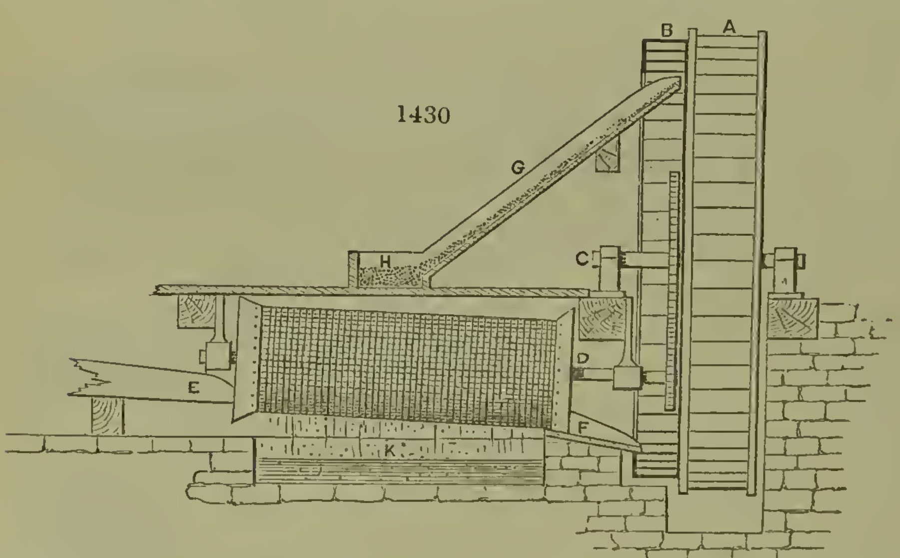
When an inconsiderable proportion of water has only to be raised to a higher level the common shoe or chain-pump will be found to render effective service; but when a larger stream is requisite it would be better to employ the rotary pump. This pump, *fig.* 1429, has been brought to great perfection by Messrs. Gwynne; A is the suction-pipe, and B the discharge, the dotted lines showing the discharge B, horizontal when required.

Pumps of the following dimensions are stated to raise and discharge per minute for medium lifts, say from 10 to 70 feet high:—

Diameter of discharge-pipe.	Diameter of suction-pipe.	Gallons of water per minute.
$1\frac{1}{2}$ inches.	2 inches.	25
3 ,,	4 ,,	70
4 ,,	5 ,,	150
5 ,,	6 ,,	300
6 ,,	7 ,,	500
7 ,,	8 ,,	1400

Stuff consisting of slimes and sand may be readily elevated by means of a Jacob's ladder or the Archimedean screw, illustrated at page 437, Vol. I. *fig.* 269. For short elevations combined water and raff wheels devised by Mr. Charles Remfry of Stolberg, Prussia, may be advantageously employed.

Fig. 1430, A, water-wheel; B, raff or inverted wheel; C, axis of both raff and water wheels, carrying a tooth driving wheel; D, sizing trommel; E, launder for inlet of stuff;

1430


F, discharge launder; G, shoot delivering water and raff to launder H; K, cistern receiving slime from trommel.

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 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 of various dimensions, 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 2*s.* 6*d.*, or 3*s.* the bing; while others are worth at least 10*s.* The richness of the ore varies from 2 to 20 bings of galena per *shift* of ore; the shift corresponding to 8 waggon loads.

It is not essential to describe the dressing routine observable in any particular mine, since it is scarcely possible to observe the same system in any two distinct concerns. In the various modes of treatment, however, it may be remarked that the two leading features will always be *reduction* to a proper size and *separation* of the ore from the refuse. Until the vein stuff arrives at the crusher or stamps, the labour is chiefly one of picking and selecting, but from these machines usually commence a long series of divisions, sub-divisions, selections, and rejections. To follow these out in their various ramifications would not only exceed the limits of this paper, but would perhaps be misunderstood by those not intimately acquainted with the subject.—J. D.

OREIDE, a new brass, is the name given by MM. Meurier and Valient, of Paris, to an alloy which has a golden brilliancy.

Copper	100	Sal ammonia	3·6
Zinc	17	Quicklime	1·80
Magnesia	6	Tartar of commerce	9

The copper is first melted and then the other things are added, by small portions at a time, skimming and keeping in fusion for about half an hour.

The oreide has a fine grain, malleable, takes a most brilliant polish, and has its complexion restored by the use of acidulated water. This brass melts at a comparatively low temperature. The zinc replaced by tin gives an alloy of greater brilliancy.

ORIENTAL AMETHYST. The name given to the violet or lilac-blue variety of sapphire. It forms the passage between that gem and the ruby.

ORIENTAL EMERALD. The name given to green sapphire.

ORIENTAL TOPAZ. The name given to yellow sapphire.

OR-MOLU. A brass in which there is less zinc and more copper than in the ordinary brass; the object being to obtain a nearer imitation of gold than ordinary brass affords. In many of its applications the colour is heightened by means of a gold lacquer, but in some cases, and as we think with very great advantage, the true colour of the alloy is preserved after it has been properly developed by means of dilute sulphuric acid.

ORPIMENT (Eng. and Fr.; *Yellow sulphide of arsenic; Operment; Rauschgelb*, Germ.) is found native in many parts of the world; in Hungary, Turkey, China, &c.; the finest specimens being brought from Persia, in brilliant yellow masses, of a lamellar texture, called golden orpiment.

Native orpiment is the *auripigmentum*, or *paint of gold*, of the ancients. It was so called in allusion to its use and its colour, and also because it was supposed to contain gold. From this term, the common name of "*orpiment*," or "*gold paint*," has been derived.

In nature it is found most generally in amorphous masses of a bright yellow colour, but sometimes in crystals, which are oblique rhombic prisms; these crystals are flexible, of a yellow colour, and possess a brilliant lustre.

Native orpiment has a specific gravity of about 3·48. Orpiment is also prepared artificially, 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. As thus obtained, it is in yellow compact opaque masses, of a glassy aspect; yielding a powder of a pale yellow colour.

Artificial orpiment seems to be a substance of uncertain composition, it containing sometimes, according to Guibourt, 94 per cent. of arsenious acid, and only 6 per cent. of the tersulphide of arsenic. On this account it is much more soluble in water than the native orpiment, and consequently a much more powerful poison. It has been administered several times with criminal intentions, and in many of the cases proved fatal. Orpiment is the colouring matter of the pigment called king's yellow, which is a mixture of arsenious with a little tersulphide of arsenic, just as the sample analysed by Guibourt.

A proper tersulphide of arsenic may be obtained by passing a stream of sulphuretted hydrogen gas through a solution of arsenious acid in hydrochloric acid. It falls as a brilliant yellow amorphous powder.

Tersulphide of arsenic is insoluble in water and dilute acids, but is decomposed by nitric acid and aqua regia. It fuses easily, and when heated in air burns with a pale blue flame, generating arsenious and sulphurous acids. In close vessels it sublimes unchanged. It is dissolved by ammonia, and the caustic fixed alkalies forming colourless solutions, from which it is again precipitated by the addition of an acid. The alkaline sulphides also dissolve it, forming double salts, from which solutions it is precipitated even more completely than from the former, by the addition of an acid.

According to Dr. Paris, Delcroix's depilatory, called *poudre subtile*, consists of quicklime, orpiment, and some vegetable powder.

Orpiment is used by pyrotechnists, and as a pigment, the best kinds of native orpiment being reserved for artists. It was formerly used in medicine, but at the present time it is never employed.—H. K. B.

ORTHOCLASE (*Orthoklas*, Germ.), or potash felspar, enters into the composition of many rocks, and is the common ingredient of granite, of which it ordinarily constitutes about 45 per cent. It consists of silica, 64·8 ; alumina, 18·4 ; and potash, 16·8 ; but the latter is frequently replaced by small quantities of lime, soda, and magnesia, as appears from the following analysis, from Baveno, by Abich : silica, 65·72; alumina, 18·57; potash, 14·02 ; soda, 1·25 ; lime, 0·34 ; magnesia, 0·10 = 100. Specific gravity = 3·5 to 3·6.

Orthoclase is colourless, or pale flesh-coloured, or yellow, with a vitreous lustre, or pearly on the faces of cleavage. The name is generally restricted to the subtranslucent varieties, there being many sub-varieties (founded on variations of lustre, colour, and other differences), of which the following are some of the principal, viz. : Adularia, a transparent or translucent felspar, met with in granitic rocks (frequently in large crystals) ; moonstone ; sunstone ; Murchisonite ; erythrite ; glassy felspar or lanadine, a transparent variety found in volcanic rocks, and containing four per cent. of soda, or upwards, &c. &c.

Before the blow-pipe, orthoclase fuses with great difficulty to a blistered turbid glass : in borax it dissolves slowly, forming a transparent glass. It is not acted on by acids.

Fine crystals of orthoclase are found at Baveno, on Lago Maggiore, in Piedmont ; at Lomnitz in Silesia ; Carlsbad and Elnbogen in Bohemia ; in many parts of the Ural ; in Brazil ; the United States ; in granite near the Land's End, and elsewhere in Cornwall ; Mourne Mountains in Ireland ; Rubislaw, Aberdeenshire, in Scotland ; &c. &c.

In the process of decomposition, to which some varieties of this mineral are liable, the potash combines with a portion of the silica, and is removed in a soluble form: the residue, consisting of a white earth, is composed of silicate of alumina.—H. W. B.

ORYCTNOGNOSY. A name given by Werner to the knowledge of minerals ; and is therefore synonymous with the English term Mineralogy. It is never used.

OSMIUM is one of the rare metals, most generally found in the ores of platinum, in which it was discovered by Mr. Tennant in 1803. These ores generally contain the metals palladium, rhodium, osmium, ruthenium, and iridium, mixed with the platinum.

The process for obtaining osmium from these ores has been much simplified by M. Fremy. After the exhaustion of the ores by aqua regia there remains a residue, which often contains titaniferous iron and chrome iron ; but the most important constituent is an alloy existing in flat plates or scales, of a white colour, and metallic lustre, and which was formerly thought to contain only osmium and iridium, but later experiments have proved the presence of ruthenium, and a little rhodium. Fremy takes advantage of the oxidability of osmium and of the volatility of its peroxide. His process consists in roasting the alloy in a current of dry air; for this purpose the residue above mentioned is placed in a porcelain or platinum tube, and heated to redness.

In the portion of the tube beyond the fire is placed some fragments of porcelain, and the tube is connected to a series of glass flasks, in which the osmic acid condenses as it distils over ; in the last flask is placed some caustic potassa solution, in order to retain any osmic acid which might have escaped condensation ; this flask is connected with an aspirator, by which a constant current of air is maintained through the apparatus ; the air is dried and purified before entering the heated tube, by passing through tubes filled with pumice stone moistened with sulphuric acid. During the operation the osmium and ruthenium become oxidised ; the osmic acid which is formed volatilises, carrying with it the oxide of ruthenium, which is deposited upon the fragments of porcelain in regular crystals ; the osmic acid passes on and is condensed in the flasks in beautiful needles. The metal osmium may be obtained by several processes, but the most simple is by treating this osmic acid with hydrochloric acid and mercury. Suboxide of mercury is first formed at the expense of the oxygen of the osmic acid, and is then decomposed by the hydrochloric acid, subchloride of mercury being formed.

$$OsO^4 + 8Hg + 4HCl = Os + 4Hg^2Cl + 4HO.$$

The water and excess of acid are driven off by evaporating to dryness, and on heating the residue in a small porcelain retort the excess of mercury and subchloride are driven off, leaving pure osmium in the state of a fine powder. In this finely divided state it takes fire if heated in air, and is dissolved by nitric acid or aqua regia, being converted into osmic acid. In the most compact state in which this metal has been obtained it has a bluish-white colour, and although somewhat flexible in thin plates, is nevertheless easily powdered. Its specific gravity is 10; it is not fusible, but according to the recent investigations of Daville and Debray it volatilises at the heat at which iridium fuses. (*Ann. de Chimie et Physique.*) When fused with nitre, osmate of potash is formed.

The equivalent of osmium is 99·6; and its symbol, Os.

Five compounds of osmium and oxygen exist, viz. *Protoxide*, OsO. It is a dark green powder, slowly soluble in acids. *Sesquioxide*, Os^2O^3, has never been obtained pure; it is formed by heating a solution of osmate of ammonia, when a brown powder falls which is this compound mixed with some ammonia, which explodes feebly when heated. *Binoxide*, OsO^2, is a black powder, insoluble in acids, and burning to osmic acid when heated in the air. *Osmious acid*, OsO^3; this only exists in combination; it forms a rose-red crystalline powder with potassa ($KO,OsO^3,2HO$); this salt is obtained by adding alcohol to a solution of osmate of potassa, the osmic acid is reduced by the alcohol, and this salt is precipitated. On attempting to separate this acid it is decomposed into binoxide and osmic acid. *Osmic acid*, OsO^4; the preparation of this compound has already been described, it melts and even boils below 212°; its vapour is irritating and deleterious, and has a peculiarly offensive odour, hence the name of the metal from οσμη, an odour. Three combinations of osmium and chlorine are known; protochloride, Os,Cl; sesquichloride, Os^2Cl^3,—this only exists in solution; bichloride, Os,Cl^2,—this exists only in a double salt, with chloride of potassium, $OsCl^2 + KCl$. Osmium combines also with phosphorus and sulphur. — H. K. B.

OSMIUM-IRIDIUM. *Iridosmine; Native iridium.* This alloy is found with platinum in the province of Choco, in South America, and in the Ural Mountains. It was first discovered by Mr. Smithson Tennant in the black scales which remain when native platinum is dissolved in aqua regia. It is rather abundant with the alluvial gold of California, occurring in small bright lead-coloured scales, sometimes six-sided (*Dana*). The following are analyses of this alloy by (1) Berzelius; (2) Rose; (3) Thomson.

Iridium - - - -	46·77	19·86	72·9
Osmium - - - -	49·35	80·14	24·5
Iron - - - -	0·74		
Rhodium - - - -	3·15		

See IRIDIUM.

OSTEOCOLLA. A name given to 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. See GELATINE.

OTTO, OTTAR, or ATTAR OF ROSES (from an Arabic word signifying *aroma*), is a volatile oil too well-known to require description as to its odour and uses. It is obtained by distilling roses with water. It is manufactured extensively at Ghazipoor, in Hindostan, as well as at Shiraz in Persia. Polier says that, to obtain a little less than three drachms of otto from 100 lbs. of rose petals in India, it requires a most favourable season, and the operation to be carefully performed. According to Donald Monro the otto is procured without distillation, merely by macerating the petals in water; and in India it is sometimes thus prepared: the roses macerating in water are exposed to the sun, when the oil separates and floats on the water. It has also been said to be obtained at Damascus, and other parts of Asia Minor, by the dry distillation of the rose at the temperature of a salt-water bath.

Otto of roses is imported from India, Constantinople, and Smyrna. The duty on it is 1*s.* 4*d.* per lb., and in 1838, 973 lbs., and in 1859, 745 lbs., paid duty.

Below 80° F. otto of roses is a crystalline solid. It has little colour. It is combustible, and its vapour forms with oxygen an explosive mixture.

It fuses between 84° F. and 86° F. Its specific gravity at 90° F. is ·832. At 57° F. 1000 parts of alcohol (sp. gr. ·806) dissolve 7 parts, and at 72° F. 33 parts of otto.

Otto of roses consists of two volatile oils; one solid and the other liquid at ordinary temperatures, in the proportion of about one of the former to two of the latter. To separate them, the otto must be frozen and compressed between folds of blotting paper, which absorb the liquid, and leave the solid oil. They may also be separated by alcohol (of sp. gr. ·8), which dissolves the liquid and scarcely any of the solid oil. The solid oil, according to Saussure, contains only carbon and hydrogen, and these in equal number of atoms, and is therefore isomeric with oil of turpentine; it occurs in crystalline plates, fusible at 95° F. The liquid oil has not been carefully examined; it is uncertain whether it contains nitrogen, or only carbon, hydrogen, and oxygen.

Otto of roses is sometimes adulterated with some essential or fixed oils and spermaceti. The purity of the otto is determined by the following test: put a drop or two of the oil to be tested in a watch-glass, and then add as many drops of concentrated sulphuric acid as of the oil, mix with a glass rod. All the oils are rendered more or less dark-coloured by this process, while the otto of roses retains its purity of colour; the oil of geranium if present acquires a strong disagreeable odour, which is very characteristic. — H. K. B.

OUT-CROP. A geological and mining term, to signify that the edge of any inclined stratum, bed of coal, or mineral vein, comes to the surface.

OXALATES are saline compounds of the bases with oxalic acid.

OXALIC ACID (*Acide oxalique*, Fr.; *Sauerkleesaüre*, Germ.) is now the object of a considerable chemical manufacture. It is usually prepared, upon the small scale, by the following process: — One part of sugar is gently heated in a retort with five parts of nitric acid, of sp. gr. 1·42, diluted with twice its weight of water; copious red fumes are disengaged, and the oxidation of the sugar proceeds rapidly. When the action slackens heat may be again applied to the vessel, and the liquid concentrated, by distilling off the excess of nitric acid until it deposits crystals on cooling. These crystals are purified by redissolving in a small quantity of water and recrystallisation.

Oxalic acid occurs in aggregated prisms when it crystallises rapidly, but in tables of greater or less thickness when slowly formed. They lose their water of crystallisation 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.

The effloresced acid may be sublimed in a great measure without decomposition, whereas the ordinary crystallised acid, containing the three equivalents of water, is decomposed by a high temperature into carbonic and formic acids and carbonic oxide. The crystals of oxalic acid dissolve in eight parts of water at 60° F., and in their own weight, or less, of boiling water; they are also soluble in spirit. The aqueous solution has an intensely sour taste and most powerful acid reaction, and is highly poisonous. In cases of poisoning with this acid the proper antidote is chalk or magnesia, as these substances form with oxalic acid compounds almost insoluble in water, the lime compound being much less soluble than the magnesian. This acid differs from all other organic acids in not containing any hydrogen in its composition, the formula for it being, anhydrous oxalic acid, or oxalic acid in combination with bases, C^2O^3; the crystallised acid, $C^2O^3,HO + 2HO$; the effloresced acid, C^2O^3,HO. Oxalic acid is decomposed by hot sulphuric acid into a mixture of carbonic oxide and carbonic acid. The binoxides of lead and manganese effect the same change, becoming reduced to protoxides, which combine with the unaltered acid.

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 crystallise, 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 sawdust, 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 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 $2\frac{1}{2}$ 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 lined with lead, 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 loug as the carbonic acid is present, the mixture may be mingled with its own bulk of oxygen gas, for several minutes, without any diminution of volume, 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 economise 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 peroxidised 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 to that previously employed is thrown in, and the solution is boiled for a few minutes; and then it is set aside to crystallise. The crystals, after being drained and dried, are fit for the market.

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 binoxalate of potash, is often used for removing ink or iron-mould stains from linen.

On the large scale leaden vessels, or wood vessels lined with lead, are employed in the manufacture of oxalic acid. For this purpose square open vessels, 8 feet square and 3 feet 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 feet 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 siphon, 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.

A process for the conversion of formic acid into oxalic acid has been patented by Mr. Jullion. And also a process for obtaining oxalic acid from uric acid, this latter being produced from guano, patented by Dr. Wilson Turner. But owing to the cheapness of sugar these processes are of no commercial value. The patents taken out of late years for the manufacture of oxalic acid have been chiefly confined to the saving of nitric acid, by reconverting the red fumes of nitrous and hyponitric acids into nitric acid. Among these the following may be particularly 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 Woulfes' 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. The part in the furnace is a little enlarged, and is heated from 600° to 900° Fahr., and 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 avoided, 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 crystallised.

Messrs. M'Dougall 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 is 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 hyponitric acid ($3NO^4$) being passed into water of the temperature of 100° Fahr., or upwards, nitric acid and binoxide of nitrogen ($2NO^5 + NO^2$) result, the $2NO^5$, two atoms of nitric acid, remain in solution, whilst the NO^2, 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 NO^4, which passing through the liquid becomes nitric acid and binoxide of nitrogen, as before, and thus nearly the whole of the nitrous fumes or gas are reconverted into nitric acid.

In Ecarnot'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.

Instead of cane sugar or treacle, the saccharine substance obtained by the action of an acid on potato starch is employed (as in Mr. Nylen's process). 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 (oxalic acid acts more rapidly) 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.

OXFORD CLAY. An argillaceous or clayey deposit which is well developed in the neighbourhood of Oxford. It forms the base of the Coral Rag or Coralline Oolite, and extends across England in a north easterly direction from Weymouth in Dorsetshire, to the river Humber. Its general character is that of a tough brown or bluish-black clay, sometimes attaining a thickness of five or six hundred feet. Although not generally adapted for arable land, it furnishes admirable pasture; a favourable example of which is afforded by the vale of Blackmoor, in Dorsetshire, so famous for its dairy produce.—H. W. B.

OXIDE OF TIN. See Putty Powder.

OXIDES are compounds containing oxygen in definite proportions.

They are usually divided into *basic oxides*, which unite with acids; *acid oxides*, which neutralise basic oxides, combining with them; and *neutral oxides*, which do not unite with either bases or acids. In addition to these are *saline oxides*, or compounds which are produced by the union of two oxides of the same metal.

OXIDES for polishing. *Oxides of iron.* — The finest *crocus* and *rouge* are thus prepared. Crystals of sulphate of iron are taken from the pans in which they have crystallised, and are put at once into crucibles, or cast-iron pots, and exposed to a high temperature; the greatest care being taken to avoid the presence of dust.

The least calcined portions are of a scarlet colour, and form the jeweller's rouge for polishing gold or silver articles. The more calcined portions are of a purple or bluish purple colour, and these form crocus for polishing brass or steel. It is found that the blue particles, which are those which have been exposed to the greatest heat, are the hardest. It will, of course, be understood that the result of the action of heat is to drive off the sulphuric acid from the protoxide of iron, which becomes peroxidised in the process.

Lord Rosse, in the *Philosophical Transactions*, thus describes his process of preparing his polishing powder.

"I prepare the peroxide of iron by precipitation with water of ammonia, from a pure dilute solution of sulphate of iron. The precipitate is washed, pressed in a screw-press till nearly dry, and exposed to a heat, which in the dark appears a dull low red. The only points of importance are, that the sulphate of iron should be pure—and the water of ammonia should be decidedly in excess, and that the heat should not exceed that I have described. The colour will be a bright crimson, inclining to yellow. I have tried both potash and soda pure, instead of water of ammonia, but after washing with some degree of care, a trace of the alkali still remained, and the peroxide was of an ochrey colour, and did not polish properly."

Jeweller's rouge is, however, frequently prepared in London by precipitating sulphate of iron with potash, well working the yellow oxide, and calcining it until it acquires a scarlet colour.

Crocus is sometimes prepared after the manner recommended by Mr. Heath. Chloride of sodium and sulphate of iron are well mixed in a mortar; the mixture is then put into a shallow crucible and exposed to a red heat. Vapour escapes and the mass fuses. When no more vapour escapes, remove the crucible and let it cool. The colour of the oxide of iron produced, if the fire has been properly regulated, is a fine violet—if the heat has been too high it becomes black. The mass when cold is to be powdered and washed, to separate the sulphate of soda. The powder of crocus, is then to be submitted to a process of careful elutriation, and the finer particles reserved for the more delicate work.

OXIDES OF IRON. Four definite combinations of iron and oxygen are known namely:—

Protoxide	FeO.
Peroxide or sesquioxide	Fe^2O^3.
Black or magnetic oxide	$Fe^3O^4 = FeO,Fe^2O^3$.
Ferric acid	FeO^3.

Protoxide, FeO. — Owing to the rapidity with which this oxide attracts oxygen from the atmosphere it is almost unknown in a separate state. When a solution of a salt of this oxide is mixed with a solution of caustic alkali, or ammonia, a bulky white precipitate is formed, which almost immediately begins to change colour, becoming first green, then red brown, and when exposed freely to the air, as in the process of collecting and drying, it is entirely converted into the red brown sesquioxide.

It is a powerful base, neutralising acids completely, forming salts which generally possess, when pure, a pale green colour, and a nauseous styptic taste. This oxide is isomorphous with lime, magnesia, oxide of zinc, &c.

Sesquioxide, Fe^2O^3 — This oxide is known in several different forms. It is found native, beautifully crystallised, as *specular iron ore*, the finest specimens of which are brought from the Island of Elba; also as brown and red hæmatites, the former being a hydrate. Rust of iron is also a sesquioxide, containing variable quantities of protoxide.

It is prepared artificially, in the anhydrous state, by the ignition of ordinary sulphate of iron, or green vitriol, till no more acid fumes are given off, and is the residue left in the retorts in the manufacture of Nordhausen oil of vitriol (see SULPHURIC ACID). After the ignition, it is reduced to powder and treated with water, when, after the coarser portions have subsided, the water is poured off, and allowed to stand for the finer portions to deposit. It is generally of a bright red colour, but the colour varies with the degree of heat to which it has been subjected. It is known in commerce under various names, as *colcothar*, *trip*, *brown-red*, *rouge*, and *crocus martis*. That which has the brightest colour is called *rouge*, and the brighter the colour the more is it valued, if it is also fine. It is extensively used in the steel manufactures for giving a finished lustre to fine articles; it is also employed by silversmiths, under the name of plate powder and rouge; and by the opticians for polishing the specula of reflecting telescopes.

The hydrated oxide, prepared by precipitation with ammonia, is valuable in cases of poisoning by arsenic, for it is found to render the arsenic insoluble and therefore inert. For this purpose it should always be prepared by precipitating with ammonia, as it only requires about a quarter the quantity thus prepared to what would be required if precipitated by potash or soda. It has been found that twelve parts of the moist ammoniacal oxide is required for every part of arsenic to insure its full antidotal effects. Dr. A. Taylor says, that when the arsenic is in powder there is scarcely any effect produced; but, nevertheless, it has proved beneficial in most cases of arsenical poisoning, if given in time. The arsenious acid combines with the hydrated oxide and forms an insoluble subarsenite of iron, on the composition of which there are several opinions.

In the copperas and alum works, a very large quantity of ochrey sediment is obtained; which is a sesquioxide 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 described under *white lead*, forms a cheap pigment in very considerable demand in the French market, called *English red*.

An excellent powder for applying to razor-strops is made by igniting together in a crucible equal parts of well-dried green vitriol and common salt. The heat must be slowly raised and well-regulated, otherwise the materials will boil over in a pasty state, and the product in a great measure be 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 olegiste*, 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 hogs'-lard or tallow into a stiff cerate.

An extremely fine rouge, which will not scratch the most delicate article, may be obtained by, first precipitating the protoxalate of iron from a solution of a protosalt of iron by oxalate of potash; this, when washed and dried, is gradually heated on a sheet of iron, when it is entirely converted into rouge, which, although not of a very bright colour, is very fine.

The sesquioxide is a feeble base, isomorphous with alumina.

Black or magnetic oxide, $Fe^3O^4 = FeO,Fe^2O^3$. — This oxide is also found native, as *magnetic iron ore*, which in the massive form is called *native loadstone*. It is found in Cornwall, Devonshire, Sweden, &c. This iron ore occurs in different forms, as earthy, compact, lamelliform, and crystallised in the form of the regular octahedron. It may be prepared artificially in the hydrated state, by adding an excess of ammonia *instantly*, to a mixed solution of a persalt and protosalt of iron in due proportions; it is obtained as a greyish black powder, which is strongly attracted by the magnet.

Ferric acid, FeO^3. — This is only known in combination with a base, and the only salt of it which is permanent seems to be the ferrate of baryta, which is a deep crimson powder, and is formed by adding a solution of a salt of barium to the solution of ferrate of potash. The ferrate of potash is formed by heating to full redness, for an hour, in a covered crucible, a mixture of one part of pure sesquioxide of iron and four parts of dry nitre. By treating the brown, porous, deliquescent mass thus formed with ice-cold water, a deep amethystine red solution of ferrate of potash is obtained, which gradually decomposes even in the cold, evolving oxygen and depositing sesquioxide; by heat it is rapidly decomposed.— H. K. B.

OXYGEN (*Oxigène*, Fr.; *Sauerstoff*, Germ.) is a permanent gas, and is best obtained by heating a mixture of chlorate of potash and binoxide of manganese, when the chlorate is decomposed into oxygen and chloride of potassium, $KClO^6 = KCl + O^6$. Oxygen may be obtained from binoxide of managanese alone by the action of heat; but in this case, when used with chlorate of potash, the binoxide seems only to act in moderating the evolution of oxygen from the chlorate. When chlorate of potash alone is used the evolution of gas does not commence so soon, and often is given off rather suddenly at first, and may cause the fracture of the glass vessel.

Oxygen was first discovered by Dr. Priestley in England, and Scheele in Sweden, in 1774, about the same time, but independently of each other. Dr. Priestley called it *dephlogisticated air*, and Scheele *empyreal air*. It was Lavoisier who gave it the name of *oxygen*, from the idea that it was the acidifying principle in all acids (from ὀξὺς, acid, and γεννάω, I beget, or give rise to); but this name has of late years been shown to be a false one. Oxygen may be obtained from several substances, viz. by heating red oxide of mercury, $HgO = Hg + O$; by heating three parts of bichromate of potash with four parts of oil of vitriol in a glass retort. The products are sulphate of potash, sulphate of chromium, water, and oxygen:

$$KCrO^4,HCrO^4 + 4HSO^4 = KSO^4 + Cr^2 3SO^4 + O^3.$$

Oxygen is colourless, odourless, tasteless, incombustible, but the most powerful supporter of combustion. According to Regnault, 100 cubic inches of this gas weigh, at 60° F. and barometer at 30 inches, 34·19 grains, and its specific gravity is 1·1056. According to Berzelius and Dulong its sp. gr. is 1·1026.

Of all known substances oxygen is the most abundant in nature, for it constitutes at least three-fourths of the known terraqueous globe. Water contains eight-ninths of its weight of oxygen; and the solid crust of our globe probably consists of at least one-third part by weight of this principle; for silica, carbonate of lime, and alumina, —the three most abundant constituents of the earth's strata,—contain each about one-half their weight of oxygen. Oxygen also constitutes about twenty per cent. by volume, or about twenty-three per cent. by weight, of the atmosphere; and it is an essential constituent of all living beings. Plants, in the sunlight, absorb carbonic acid, decompose it—keeping the carbon and liberating the oxygen; while animals on the other hand, absorb oxygen and give off carbonic acid. Oxygen is *the* great supporter of combustion; substances which burn in air burn with greatly increased brilliancy in pure oxygen. Several propositions have been made to produce intense light by the use of pure oxygen gas, in the plaee of atmospheric air, as the active agent of combustion. The Drummond Light, the Bude Light, Fitzmaurice's Light, and others, employ oxygen in combination with carburetted hydrogen at the moment of entering into combustion; and some of these bring in the additional aid of a solid incandescent body, as lime, to increase the intensity of the illuminating power. The employment of any of these plans generally appears to depend upon the production of oxygen by some cheaper process than any at present employed.—H. K. B.

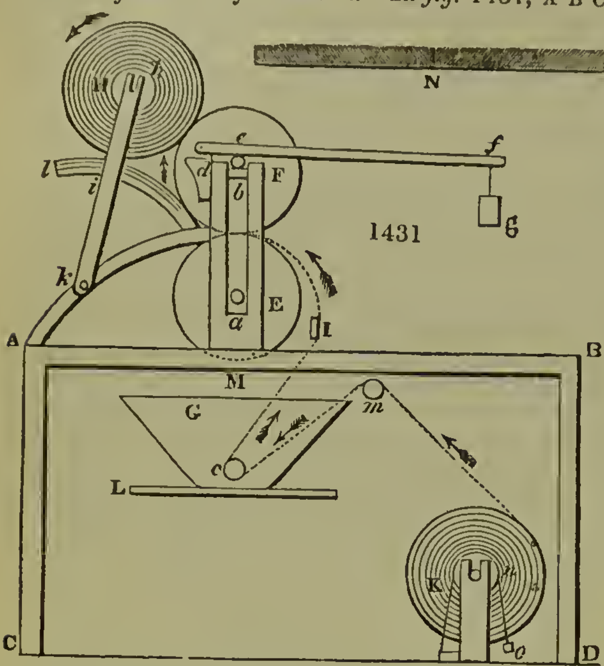
OZOKERITE or OZOCERITE. A mineral resin found in the Urpeth Colliery, Newcastle-on-Tyne, at Uphall in Linlithgowshire, and in one or two of the collieries in South Wales. Its composition is usually hydrogen 13·79, carbon 86·20. *Hatchefine* may be regarded as the same substance; the composition of a specimen from Merthyr-Tydvil, analysed by Johnston, being, hydrogen 14·62, carbon 85·91.

P.

PACKFONG. An East Indian alloy, forming a white metal like German silver. It appears to contain copper, zinc, and nickel.

PACO, or PACOS, is the Peruvian name of an earthy-looking ore, which consists of brown oxide of iron, with almost imperceptible particles of native silver disseminated through it.

PADDING MACHINE (*Machine à plaquer*, Fr.; *Klatsch*, or *Grundirmaschine*, Germ.), in calico-printing, is the apparatus for imbuing a piece of cotton cloth uniformly with any mordant. In *fig.* 1431, 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 E F run; the gudgeons of E turn upon fixed brasses or plummer blocks; but the superior cylinder F 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 F. K 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 K. The trough G, 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 I, 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 E, F. These are lapped round 6 or 7 times with cotton cloth, to soften and equalise their pressure. The piece of goods glides obliquely upwards, in contact with one third of the cylinder F, and is finally wound about the uppermost roller H. The gudgeon of H revolves in the end of the radius *h k*, which is jointed at *k*, and movable by a mortise at *i* along the quadrantal arc towards *l*, as the roller K becomes enlarged by the convolutions of the web. The under cylinder E 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 connection with the driving mechanism is given under HOT FLUE. See CALICO PRINTING.

PAGING MACHINE. A self-acting machine for paging books and numbering documents, by Messrs. Waterlow and Sons, is of a very ingenious character. 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 disc 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 figure 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 re-ascending 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 and Co. have introduced 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.

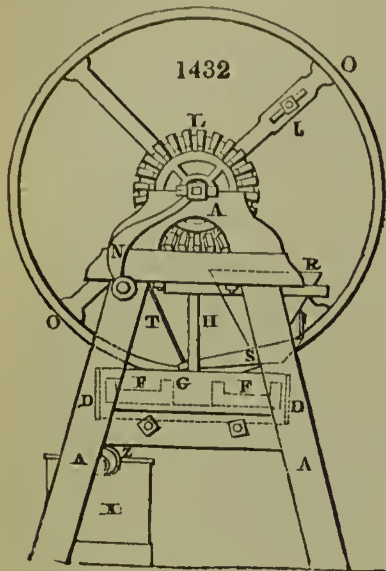
The machine is caused to print the figures in duplicate by drawing the spring catch out of action at every alternate descent of the frame, and thereby preventing any change of the figures taking place until after the next impression.

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.

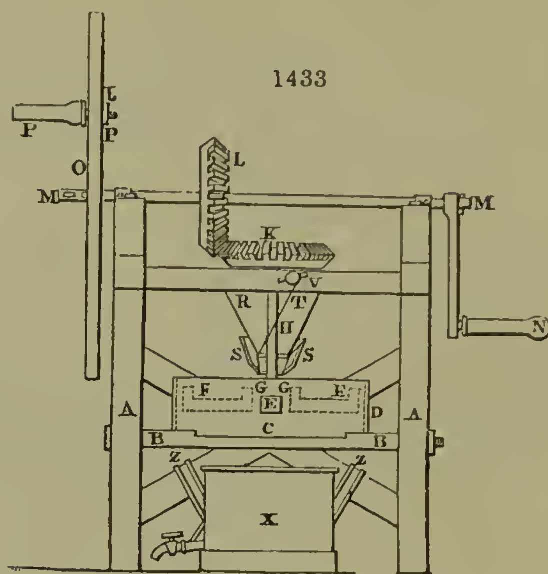
PAINTS are colouring matters in combination with oil. In most cases for the ordinary paints the basis is white lead, with the colouring agents derived from the mineral or vegetable kingdom mixed with it. This does not apply to artists' colours (see COLOURS). The advantages of lead are that its carbonate (or white lead) actually combines with the oil, whereas white lime is merely mechanically suspended in it. In the one case we have a plaster spread over the wood or canvas to which the paint is applied, in the other we have only a fine powder held by the oil so long as it continues permanent, but which washes out when the oily coating begins to give way. See LEAD, OXICHLORIDE; and WHITE LEAD.

PAINTS, GRINDING OF. There are many pigments, such as common orpiment, 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.

1432

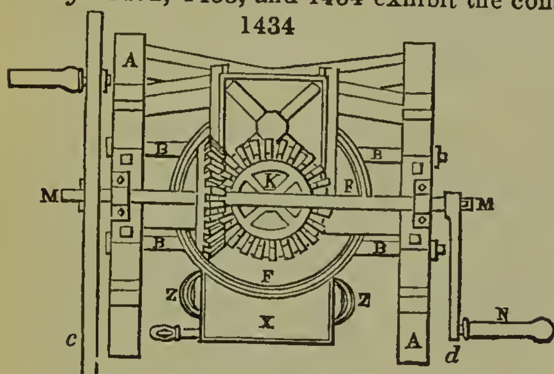


1433

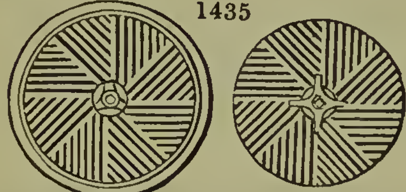


Figs. 1432, 1433, and 1434 exhibit the construction of a good colour-mill in three views; *fig.* 1432 being an elevation shown upon the side of the handle, or where the power is applied to the shaft; *fig.* 1433 a second elevation, taken upon the side of the line *c d* of the plan or bird's-eye view, *fig.* 1434.

1434



1435



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.* 1435 is a plan of the millstones. The lying or nether millstone C, *fig.* 1433, is of cast iron, and is channelled on its upper face by 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-consistenced colour from running over the edge. It can escape only by the sluice hole E, *fig.* 1433, formed in the hoop; and is then received in the tub X placed beneath.

The upper or moving millstone F 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, K, *figs.* 1433, 1434, 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 K. This horizontal axis, M M, bears at one of its ends a handle or winch, N, by which the workman may turn the millstone F; 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 P, 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 R, below which the bucket S is suspended, for supplying the colour uniformly through the orifice in the millstone G. 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 Y, without removing the tub. For many purposes, as for colour printing, it is highly important that the paint used should be in the finest possible state. To effect this at Messrs. De la Rue's and some other large establishments the colours are passed between finely polished steel rollers which are by screws brought very closely together.

PAINTS, VITRIFIABLE. See PORCELAIN, POTTERY, and STAINED GLASS.

PALISANDER WOOD, a name employed on the Continent for rosewood. *Holtzapffel* has the following remarks on this wood:—"There is considerable irregularity in the employment of this name; in the work of Bergeron a kind of striped ebony is figured as *bois de Palixandre*; in other French works this name is considered a synonym of *bois violet*, and stated as a wood brought by the Dutch from their South American colonies, and much esteemed."

PALLADIUM, a 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-grey 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. It is also found in many varieties of native gold. 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 sp. gr. 1·3. The solution containing the silver palladium, for the gold does not dissolve, being treated with chloride of sodium or with hydrochloric acid, will part with all its silver in the shape of a chloride. The supernatant liquor being concentrated and neutralised 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 then ignited will yield 40 per per cent. of metal.

Palladium is one of the hardest of the metals; its colour is not so bright as that of silver; it is malleable, ductile, and capable of being welded. This metal is more oxidisable than silver, for it tarnishes in air at the ordinary temperature; when heated in air it becomes blue at first from partial oxidation; but if the temperature be increased, this colour disappears and its brightness returns.

Palladium is sometimes substituted for silver in the manufacture of mathematical instruments. The commoner metals may be plated with palladium by the electrotype process. Palladium is sometimes used in the construction of accurate balances, and for some of the works of chronometers. An alloy of palladium and silver is employed by the dentists from the circumstance that it does not tarnish. The influence of palladium in protecting silver from tarnishing is a remarkable and valuable property. The Wollaston medal given by the Geological Society is, in honour of its discoverer, made of palladium.

PALMITIC ACID. $C^{32}H^{32}O^4$. This acid was first discovered in palm oil, from which it derived its name; it has since been found in many other natural productions and may also be manufactured artificially from some other substances. It is contained, for instance, in bees'-wax, and that in considerable quantities; the portion of the wax insoluble in boiling alcohol is called *myricine*, and is a palmitate of *myricyle*. This *myricine* requires a *strong* solution of potash to saponify it, and then the palmitic acid is obtained as palmitate of potash, from which it may be separated by adding an acid.

Spermaceti consists principally of a fat into which this acid enters, viz., a palmitate of cetyle. The palmitic acid may be obtained from this by dry distillation. It has also been proved to be contained in human fat.

It may be obtained artificially from different substances; one of which will be sufficient to mention here, viz. by fusing caustic potash with oleic acid, avoiding of course too high a temperature, and for this purpose a few drops of water are added from time to time to it.

$$\underset{\text{Oleic acid.}}{C^{36}H^{34}O^4} + \underset{\text{Caustic potash.}}{2(KO,HO)} = \underset{\text{Palmitate of potash.}}{C^{32}H^{31}KO^4} + \underset{\text{Acetate of potash.}}{C^4H^3KO^4} + \underset{\text{Hydrogen.}}{H^2}.$$

The easiest and cheapest way of obtaining palmitic acid is by using palm oil. Palm oil, *when fresh*, consists principally of palmitin (palmitate of glycerine) and oleine; but by the action of the air and moisture it speedily changes. The fats become decomposed into the fatty acids (palmitic and oleic), with the liberation of glycerine, which is itself afterwards converted into sebacic acid. The palm oil is first subjected to pressure to separate as much as possible the liquid portions; the solid residue is then boiled with an alkali, and the soap thus formed decomposed by an acid; the palmitic acid, which thus separates, is then collected and purified by several crystallisations from alcohol.

None of these processes are employed commercially for obtaining palmitic acid, which is largely used in making candles. When thus required it is obtained in the same manner as stearic acid, by distilling with high pressure steam. See CANDLES.

When pure, palmitic acid is a colourless solid substance, without smell, lighter than water. It is quite insoluble in water, but freely soluble in boiling alcohol or ether. These solutions have an acid reaction, and when concentrated become almost solid on cooling; but if more dilute, the palmitic acid separates in groups of fine needles. It fuses at 143·6° Fahr., and becomes on cooling a mass of brilliant pearly scales. It may be distilled without decomposition, even without the presence of steam. It unites with bases to form salts, most of which are insoluble in water. It may also be made to unite with glycerine to form *palmitin*, in which state it previously existed in palm oil.

PALMITIN. As above stated, this is the principal constituent of fresh palm oil. It may be obtained from it by the following process:—The palm oil is subjected to pressure to remove the liquid portions, the solid portion is then boiled with alcohol, which dissolves the free fatty acids which may be present. The residue is then crude palmitin, and it is purified by repeated crystallisations from ether. When thus obtained it is in small crystals; these fuse and become, on cooling, a semi-transparent mass, which may be easily reduced to powder. It is almost entirely insoluble in cold alcohol, and only slightly soluble in boiling alcohol, from which it again separates, on cooling, in flakes. It is soluble in all proportions in boiling ether.

M. Duffy states that there are three modifications of palmitin, differing in their melting point, the first melting at 115° F., the second melting at 142° F., and the third at 145·2° F.

According to Dr. Stenhouse, palmitin has the following composition:—

$$C^{70}H^{66}O^{8};$$

which by saponification yields glycerine and palmitic acid.

$$\underbrace{C^{70}H^{66}O^{8}}_{\text{Palmitin.}} + 6HO = \underbrace{C^{6}H^{8}O^{6}}_{\text{Glycerine.}} + \underbrace{2C^{32}H^{32}O^{4}}_{\text{Palmitic Acid.}}$$

H. K. B.

PALM OIL. See OILS.

PALM TREE. The woods obtained from the various palms of the tropics pass under different names in commerce, according to the patterns they present. The only two varieties much used are—the Betel-nut palm, or *Areca catechu*, which yields a wood of a light yellow-brown colour; and the cocoa-nut palm, *Cocos nucifera*. This wood is of a chestnut-brown colour. It is much employed for joists, water troughs, &c., in small quantities for marquetry, and other ornamental works. We receive this wood under the various names of palm, palmetto, palmyra, nutmeg, leopard, and porcupine woods. The two last receive their names accordingly as the section is made in one direction or another.

If the wood is cut horizontally, it exhibits dots like the spice; when cut obliquely, the markings are something like the quills of the porcupine.

PANCREATIC JUICE. A limpid, viscid, alkaline fluid, secreted by the pancreas or sweetbread. The pancreatic fluid converts starch into sugar.

PANIFICATION. The making of BREAD. See that article.

PAPAVERINE. $C^{40}H^{21}NO^{8}$. One of the many alkaloids contained in opium. It was discovered by Merck, in 1850, but has been chiefly examined by Dr. Anderson. It has not been applied to any practical purposes.

PAPER COAL. (*Papier-kohle*, Germ.). A name given to certain layers of lignite, from their leaf-like character.

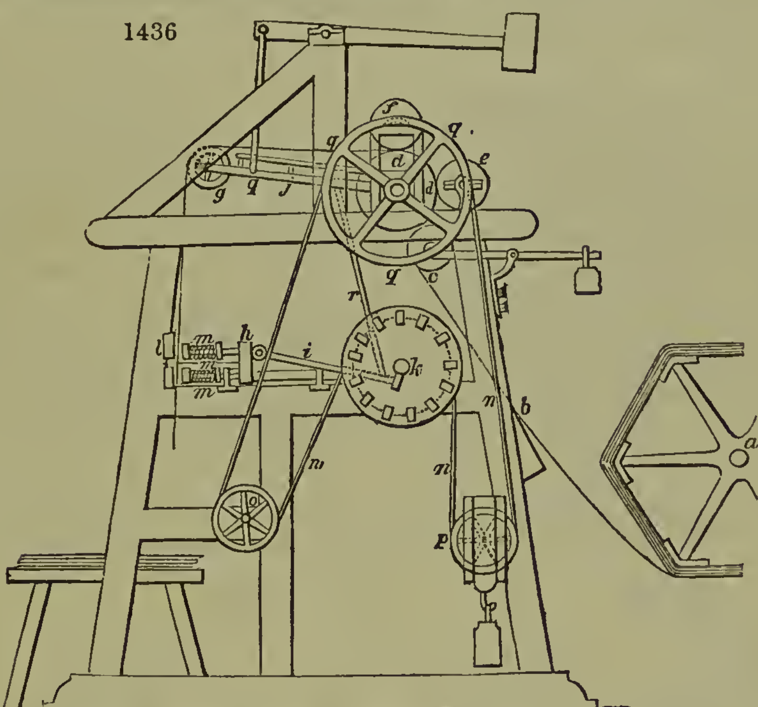
PAPER CUTTING. Some machines have been patented for this purpose. One by Mr. Crompton, of Farnworth, and another by Enoch Miller. Mr. Edward Cowper patented a machine which has been extensively employed, and which, therefore, we must describe. It consists of a machine, with a reel on which the web of paper of very considerable length has been previously wound; 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 framework, 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.* 1436, 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*,

1436



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, fall down, and are 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, *c* and *f*, are impelled slowly 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, *c*, *d*, *f*, and cause a greater or less length of the paper to descend between each movement of the knife carriage.

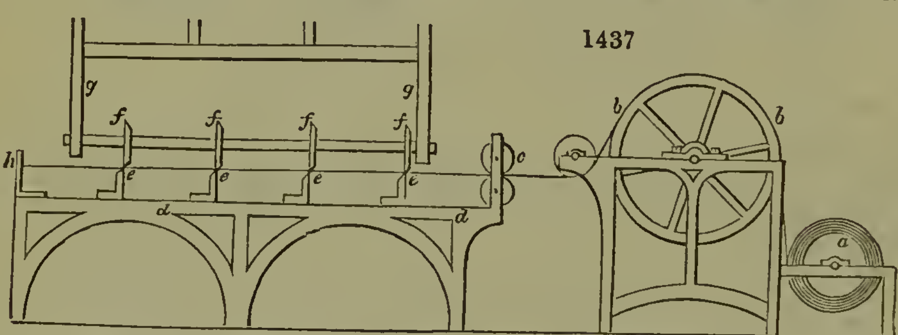
The groove of this pulley *k*, which is susceptible of enlargement, is constructed of wedge-formed blocks, passed through its sides, and meeting each other in opposite directions, so that on drawing out the wedges a short distance, the diameter of the pulley becomes diminished; or by pushing the wedges 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.* 1437, mounted upon an axle, supported in an iron frame or standard. From this

1437



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 *h*, 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.

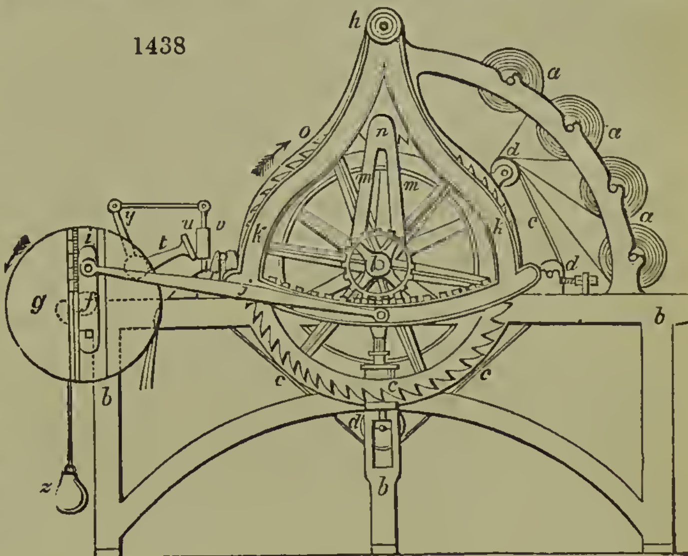
The workmen draw the paper from between the rollers *c* and bring it up to the stop *h*, in the intervals between the passing to and fro of the swing-cutters.

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.

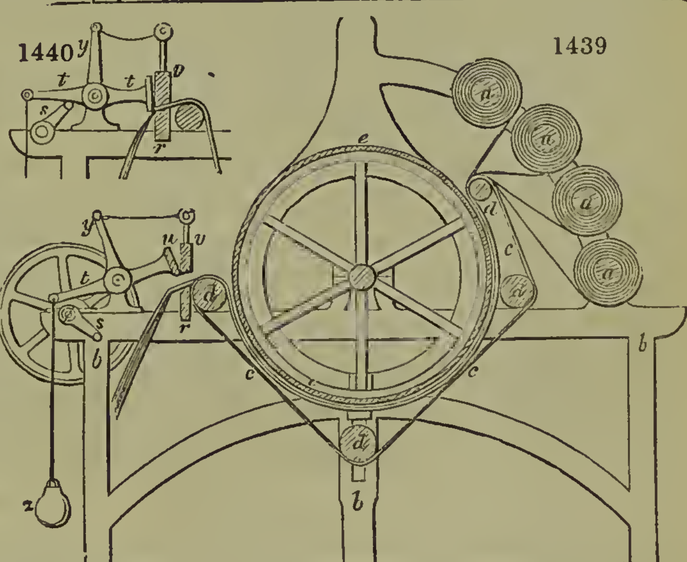
Fig. 1438 is an elevation, taken upon one side of the machine; and *fig.* 1439 is a longitudinal section. *a, a, a, a,* are four reels, each covered with one continuous sheet of paper; which reels are supported upon bearings in the frame-work *b, b, b.* *c, c, c,* is an endless web of felt-cloth passed over the rollers *d, d, d, d,* which is kept in close contact with the under side of the drum *c, e,* seen best in *fig.* 1439.

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 bevelled graduated groove, upon the face of the disc *g,* at variable distances from the axis, whereby the excentricity 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.*

1438



1440 1439



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.* 1440), 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.

PAPER HANGINGS, called more properly by the French, *papiers peints.* The art of making paper hangings 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 long exposed to a high excise duty upon the manufacture, they have only recently carried it to that extent and degree of refinement which the French have 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 tontisse*, 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 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 a 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 talc, or with China clay, and rubs it strongly with the brush. In this way the satiny lustre is produced.

The printing operations are as follows:—

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, 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 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.

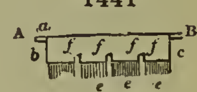
All the colours are applied in the same manner, every shade being formed by means of the blocks, which determine all the beauty and regularity of the design. A pattern drawer of taste may produce a very beautiful effect.

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 *fondu* or rainbow style of paper hangings, 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*, *b*, 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.

1441



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 7 or 8 feet long, 2 feet wide at the bottom, 3½ feet 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 workmen call this 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. The workman daubs the blocks upon the *encaustic*, 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 everywhere of the same colour, would not be agreeable to the eye, if shades could not be introduced to relieve the pattern. 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.

The use of arsenic in paper hangings has of late (1859) been the subject of much discussion, and many absurd statements have been made respecting its injurious effects. It is true that arsenic may be *brushed* out of such papers, after the size employed has decayed, or, if it has been imperfectly applied. All that has been said about the volatilisation of the arsenic under the influence of the gas used in the rooms, betrays the ignorance of those who have written on this subject. See Arsenic.

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 greys.* — Umber furnishes the brown tints. Blacks are either common ivory or Frankfort black; and greys are formed by mixture 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.

PAPER, Indelible Cheque.

The facility with which ordinary written characters can be expunged from paper by chemical bleaching liquids, acids, and alkalies has led to the adoption, by bankers, for their cheques and drafts, of papers which present obstacles to the fraudulent alteration of the amount and intent of these documents.

Instances of this description of forgery have occasionally occurred. In the spring of 1859 a cheque was paid at a branch of the Bank of England in which both the amount had been altered and the crossing extracted by chemical means.

In 1822 William Robson patented a method of securing bankers' cheques by printing upon their surface vegetable colours equally fugitive with common writing ink.

This method, and its extension to the tinting of writing papers in the pulp, has been generally adopted by bankers. Those papers which exhibit the perfection of Robson's principle are limited in practice almost exclusively to certain tints obtained from logwood.

Mr. Baildon's paper is a tinted one from which the colour is removed. The patentee states that he offers *absolute integrity and security* from alteration for any document once issued; and this is obtained by a fluid or ink, which, when used, becomes, in fact, a *permanent dye*, different from any inks yet introduced for this purpose, which are *pigments.* The least attempt to tamper with the ink or paper is instantly detected by a *dark stain* in the paper, which can *never be removed.*

As early as 1817 Gabriel Tigere patented a method of manufacturing "writing paper from which it would be extremely difficult, if not impossible, afterwards to extract or discharge any writing from such paper." This paper was impregnated during the sizing process with the ferrocyanide of potassium.

Mr. William Stone's patent, 1851, was an effort to supply the deficiencies of this method. He added a solution of the iodide of potassium and starch to the ferro or ferridcyanide of potassium. This method has been fully carried out into practice, but it failed to give the complete security desired. The chemical defects of Tigere's method may be stated thus. Although admirable in the protection it affords against the application of acids, it is powerless to resist the bleaching powers of such substances as common chloride of lime (bleaching powder) in solution, and the ink may also be removed by the application of either of the caustic alkalies. In Stone's method, although by the application of bleaching agents containing chlorine the paper is stained by the blue compound termed the iodide of starch, this is removed again by the application of an alkali.

We learn that in 1837, David Stevenson patented the manufacture of a paper which he specified as containing "a solution of manganese mixed with a solution of prussiate of potassa in a liquid form, and mixed with the pulp whereof the writing paper is to be made." In June, 1859, Mr. Robert Barclay patented a process of manufacturing a white writing paper on which writing ink is stated to be unalterable for fraudulent purposes by any existing chemical process. He incorporates in the paper an insoluble ferro-cyanide and an insoluble salt of manganese, and provides against the discolouration of the paper in the sizing process (which has been a serious objection in practice to the use of the ferrocyanide of potassium) by discarding the use of alum, and sizing the paper by the acetate of alumina in lieu of it. This paper has been examined by Professor Brande, of the Mint, Professor Miller, of King's College, and Mr. R. Warrington, of Apothecaries' Hall, who reported favourably on the invention. Writing placed upon this paper strengthens in intensity when exposed to damp, sea air, or water, influences which ordinarily cause common writing ink to fade and become illegible.

This paper has not, however, been generally adopted. As far as our inquiries have gone, the bankers appear to think they are already sufficiently secured by the known methods of engraving and printing.

PAPER, MANUFACTURE OF. It is much to be regretted that in tracing the origin of so curious an art as that of the manufacture of modern paper, any definite conclusion as to the precise time or period of its adoption should hitherto have proved altogether unattainable. The Royal Society of Sciences at Gottingen, in 1755 and 1763, offered considerable premiums for that especial object, but unfortunately all researches, however directed, were utterly fruitless. The most ancient manuscript on *cotton paper* appears to have been written in 1050, while Eustathius, who wrote towards the end of the 12th century, states that the Egyptian papyrus had gone into disuse but a little before his time. To reconcile, however, in some measure contradictory accounts, it may be observed, that on some particular occasions, and by some particular persons, the Egyptian paper might have been employed for several hundred years after it ceased to be in general use, and it is quite certain, that although the new invention must have proved of great advantage to mankind, it could only have been introduced by degrees. Amongst the records which are preserved at the Tower of London, will be found a letter addressed to Henry the Third, and written previously to 1222, which appears to be upon strong paper, of mixed materials. Several letters of the following reign, which are there preserved, are evidently written on *cotton* paper. Were we able to determine the precise time when paper was first made from cotton, we should also be enabled to fix the invention of the art of paper making as it is now practised; for the application of cotton to the purposes of paper making requires almost as much labour and ingenuity as the use of linen rags. Some have conceived, and probably with sufficient reason, that China originally gave birth to the invention. Certain it is, that the art of making paper from vegetable matter reduced to pulp was known and understood there long before it was practised in Europe, and the Chinese have carried it to a high degree of perfection. Several kinds of their paper evince the greatest art and ingenuity, and are applied with much advantage to many purposes. One especially, manufactured from the inner bark of the bamboo, is particularly celebrated for affording the clearest and most delicate impressions from copper plates, which are ordinarily termed *india proofs*. The Chinese, however, make paper of various kinds, some of the bark of trees, especially the mulberry tree, and the elm, but chiefly of the bamboo and cotton tree, and occasionally from other substances, such as hemp, wheat, or rice straw. To give an idea of the manner of fabricating paper from these different substances, it will suffice (the process being nearly the same in each), to confine our observations to the method adopted in the manufacture of paper from the bamboo, — a kind of cane or hollow reed, divided by knots, but larger, more elastic, and more durable than any other reed. The whole substance of the bamboo is at times employed by the Chinese in this operation, but the younger stalks are preferred. The canes being first cut into pieces of four or five feet in length, are made into parcels, and thrown into a reservoir of mud and water for about a fortnight, to soften them; they are then taken out, and carefully washed, every one of the pieces being again cut into filaments, which are exposed to the rays of the sun to dry, and to bleach. After this they are boiled in large kettles, and then reduced to pulp in mortars, by means of a hammer with a long handle; or as is more commonly the case, by submitting the mass to the action of stampers, raised in the usual way by cogs on a revolving axis. The pulp being thus far prepared, a glutinous substance extracted from the shoots of a certain plant is next mixed with it in stated quantities, and upon this mixture chiefly depends the quality of the paper.

As soon as this has taken place the whole is again beaten together until it becomes a thick viscous liquor, which, after being reduced to an essential state of consistency, by a further admixture of water, is then transferred to a large reservoir or vat, having on each side of it a drying stove, in the form of a ridge of a house, that is, consisting of two sloping sides touching at top. These sides are covered externally with an exceedingly smooth coating of stucco, and a flue passes through the brickwork, so as to keep the whole of each side equally and moderately warm. A vat and a stove are placed alternately in the manufactory, so that there are two sides of two different stoves adjacent to each vat. The workman dips his mould, which is sometimes formed merely of bulrushes, cut in narrow strips, and mounted in a frame, into the vat, and then raises it out again, the water passing off through the perforations in the bottom, and the pulpy paper-stuff remaining on its surface. The frame of the mould is then removed, and the bottom is pressed against the sides of one of the stoves, so as to make the sheet of paper adhere to its surface, and allow the sieve (as it were) to be withdrawn. The moisture, of course, speedily evaporates by the warmth of the stove, but before the paper is quite dry, it is brushed over on its outer surface with a size made of rice, which also soon dries, and the paper is then stripped off in a finished state, having one surface exquisitely smooth, it being seldom the practice of the Chinese to write or print on both sides of the paper. While all this is taking place the moulder has made a second sheet, and pressed it against the side of the other stove, where it undergoes the operation of sizing and drying, precisely as in the former case.

That very delicate material, which is brought from China in pieces only a few inches square, and commonly, but erroneously, termed *rice paper*, is in reality but a membrane of the bread-fruit tree, obtained by cutting the stem spirally round the axis, and afterwards flattening it by pressure. That it is not an artificial production may very readily be perceived by contrasting one of the more translucent specimens with a piece of the finest manufactured paper, by the aid of the microscope.

The precise period at which the manufacture of paper was first introduced into Europe appears to be rather a matter of uncertainty. Paper-mills, moved by water power, were in operation in Tuscany at the commencement of the fourteenth century; and at Nuremberg, in Germany, one was established in 1390, by Ulman Stromer, who wrote the first work ever published on the art of paper making. He seems to have employed a great number of persons, all of whom were obliged to take an oath that they would not teach any one the art of paper making, or make it on their own account. In the following year, when anxious to increase the means of its production, he met with such strong opposition from those he employed, who would not consent to any enlargement of the mill, that it became at length requisite to bring them before the magistrates, by whom they were imprisoned, after which they submitted by renewing their oaths. Two or three centuries later, we find the Dutch, in like manner, so extremely jealous with respect to the manufacture, as to prohibit the exportation of moulds, under no less severe a penalty than that of death.

With reference to any particular *time* or *place* at which this inestimable invention was first adopted in England, all researches into existing records contribute little to our assistance. The first paper mill erected here is commonly attributed to Sir John Spielman, a German, who established one in 1588, at Dartford, for which the honour of knighthood was afterwards conferred upon him by Queen Elizabeth, who was also pleased to grant him a licence "for the sole gathering for ten years of all rags, &c., necessary for the making of such paper." It is, however, quite certain that paper mills were in existence here long before Spielman's time. Shakspeare, in the second part of his play of Henry the Sixth, the plot of which appears laid at least a century previously, refers to a paper mill. In fact, he introduces it as an additional weight to the charge which Jack Cade is made to bring against Lord Say, "Thou hast most traitorously corrupted," says he, "the youth of the realm, in erecting a grammar school, and whereas, before, our forefathers had no other books but the score and the tally, thou hast caused printing to be used, and, contrary to the king, his crown and dignity, thou hast built a paper mill."

The earliest trace of the manufacture in this country occurs in a book printed by Caxton, about the year 1490, in which it is said of John Tate—

"Which late hathe in England doo make thys paper thynne,
That now in our Englyssh thys booke is printed inne."

His mill was situate at or near Stevenage, in Hertfordshire, and that it was considered worthy of especial notice is evident from an entry made in Henry the Seventh's Household Book, on the 25th of May, 1498—"For a rewarde geven at the paper-mylne, 16s. 8d." And again in 1499—"Geven in rewarde to Tate of the mylne, 6s. 8d."

Still, it appears far less probable that Shakspeare alluded to this mill, although established at a period corresponding in many respects with that of occurrences referred to in connection, than to that of Sir John Spielman's, which, standing as it did in the immediate neighbourhood of Jack Cade's rebellion, and being esteemed so important at the time as to call forth the marked patronage of Queen Elizabeth; while the extent of the operations carried on there, if we may judge from the remarks of a poet of the time, were equally calculated to arouse undivided national interest; one can hardly help thinking, that the prominence to which Shakspeare assigns the existence of a paper mill, coupled as such allusion is with an acknowledged liberty, inherent in him, of transposing events, to add force to his style, as also with very considerable doubt as to the exact year in which he wrote the play, that the reference made was to none other than that of Sir John Spielman's establishment of 1588, concerning which we find it said—

> "Six hundred men are set to work by him,
> That else might starve or seek abroad their bread,
> Who now live well, and go full brave and trim,
> And who may boast they are with paper fed."

Be the introduction or establishment of the invention, so far as this country is concerned, when it may, little progress appears to have resulted therefrom, even so late as the middle of the seventeenth century. In 1695, a company was formed in Scotland "for manufacturing white writing and printing paper," relating to which, "Articles concluded and agreed upon at a general meeting at Edinburgh, the 19th day of August," in the same year, may still be seen by those who are sufficiently curious in the library of the British Museum. It is also recorded in the *Craftsman* (910), that William the Third granted the Huguenots refuged in England a patent for establishing paper manufactories, and that Parliament likewise granted to them other privileges, amongst which, in all probability, that very unsatisfactory practice of putting up each ream with two quires composed entirely of sheets spoiled in course of production. Their undertaking, however, like that of many others, appears to have met with very little success.

In fact, the making of paper here scarcely reached any high degree of perfection until about 1760-5, at which period the celebrated James Whatman established his reputation at Maidstone.

The report of the Juries of the Great Exhibition of 1851,—a work from whence information might very naturally be sought, and which one would have supposed to be unexceptionable in point of authenticity,—contains an unfortunate error with reference to the position of Mr. Whatman at that time. It is there stated that he gained his knowledge of the manufacture prior to establishing these well-known mills, "by working as a journeyman in most of the principal paper manufactories of the Continent," which is altogether an erroneous assertion; for Mr. Whatman, previously to his being engaged as a manufacturer, was an officer in the Kent Militia, and acquired the information, which eventually rendered him so successful, by travelling in the suite of the British Ambassador to Holland, where the best papers were then made, and the insight thus obtained enabled his genius to effect the great improvements afterwards so universally admitted.

At the present time, Whatman's papers (so called) are manufactured at two mills, totally distinct, both of which are still worked by the descendants of Mr. Whatman's successors; the paper in the one case being readily distinguished by the water mark, "J. Whatman, Turkey Mill," and in the other, by the water mark simply "J. Whatman," but bearing upon the upper wrapper of each ream the original and well-known stamp, containing the initials L. V. G., which are those of L. V. Gerrevink, as celebrated a Dutch manufacturer prior to Mr. Whatman's improvements, as Mr. Whatman's name has since become in all parts of the world.

The comparatively recent application of continuous or rotatory motion has effected wonderful results in the singular conversion of pulp into paper.

The largest paper now made by hand, which is termed Antiquarian, measures 53 inches by 31, and so great is the weight of liquid pulp employed in the formation of a single sheet, that no fewer than nine men are required, besides additional assistance in raising the mould out of the vat by means of pulleys; while by the aid of the *paper machine*, the most perfect production may be ensured, of a continuous length, and eight feet wide, without any positive necessity for personal superintendence. As an evidence of the enormous length of paper sometimes produced, two rolls were exhibited in 1851, one of which measured 750 yards, and the other 2500 yards in length.

The principle of paper making by machinery is simply this: instead of employing moulds and felts of limited dimensions, as was originally the practice, the peculiar merit of the invention consists in the adaptation of an endless wire gauze to receive the paper pulp, and again an endless felt, to which in progress the paper is transferred; and thus by a marvellously delicate adjustment, while the wire at one end receives but a constant flow of liquid pulp, in the course of two or three minutes the finished fabric is carefully wound on a roller at the other extremity.

It is a fact, which certainly deserves to be noticed for its singularity as well as for the strong point of view in which it places the merits of this invention, that an art of such great importance to society as that of the manufacture of paper, should have remained for at least eight centuries since paper is first believed to have been in use, and that upwards of 200 of those years should have elapsed since its first introduction into England, without any mechanical improvement whatever as regards the processes which were then employed. It is true, that various attempts from time to time were made, but in every instance they appear to have met with very little success. In France, an ingenious artist (Monsieur Montgolfier) contrived three figures in wood to do the work of the vatman, the coucher, and the layer; but, after persevering for six months, and incurring considerable expense, he was at length compelled to abandon his scheme. And although paper was previously manufactured in China, in Persia, and indeed throughout all Asia, sometimes of considerable length, it was so, not by machinery, but by means of a mould of the size of the paper intended to be made, suspended like a swing, and having men placed at the distance of about every four feet, for the purpose of producing an uniform shaking motion, after the mould had been immersed in the vat, in order to compact the pulp.

Such, then, was the rude state of this important manufacture, even up to the commencement of the present century, when a small working model of a continuous machine was introduced into this country from France by Mr. John Gamble, a brother-in-law to Monsieur Leger Didot, the proprietor at that time of the paper manufactory at Essonne.

The individual to whose genius we owe that beautiful contrivance, which has since been adopted wherever the want which it was designed to remedy has been truly felt, and which has contributed in an eminent degree to the advancement of civilisation, was an unassuming clerk in the establishment of Monsieur Didot, named Louis Robert, who following his favourite pursuit of inventing and improving, not unfrequently had to bear the reproach of wasting time on an invention that could never be brought to perfection. Fortunately, however, the patience and attention of this persevering man were at length sufficiently rewarded by the completion of a small model not larger than a bird organ, which enabled him to produce paper of a continuous length although but the width of a piece of tape. So successful was this performance that his employer, instead of continuing to thwart his progress, was now induced to afford him the means of making a model upon a larger scale, and in a few months a machine was completed capable of making paper the width of Colombier (24 inches), for which the consumption in France was very great. After a series of experiments and improvements Louis Robert applied to the French Government for a patent or *brevet d'invention*, which he obtained in 1799 for a term of fifteen years, and was awarded the sum of 8000 francs as a reward for his ingenuity. The specification of this patent is published in the second volume of the " Brevets d'Inventions Expirés." Shortly afterwards M. Didot purchased Louis Robert's patent and paper machine for 25,000 francs, to be paid by instalments ; but not fulfilling his engagements, the latter commenced legal proceedings, and recovered possession of his patent, by a decision dated June 23rd, 1801. Towards the close of the year 1800 M. Didot proposed to his brother-in-law, Mr. Gamble, that patents should be taken out in England, and suggested that he being an Englishman, and holding a situation under the British Government, would in all probability accomplish it without much difficulty. To this proposition Mr. Gamble assented, and in the month of March, 1801, he left Paris for London, where, happily for the vigorous development of this project, he obtained an introduction immediately upon his arrival to one of the principal wholesale stationery houses in Great Britain—a firm of considerable opulence—and to those gentlemen he mentioned the nature and circumstances of his visit, at the same time showing them several rolls of the paper of great length, which had been made at Essonne by Louis Robert's machine, and which induced them to take a share in the patent.

The firm alluded to was that of the Messrs. Fourdrinier—a name which has indeed become alike famous and unfortunate—and this transaction it was which first connected them with the paper machine. In the year 1801 Mr. Gamble returned to Paris, and concerted measures with Monsieur Leger Didot and Louis Robert, to have the working model, which was then at Essonne, sent over to England to assist in the construction of other machines ; and the following year M. Didot arriving in London was introduced by Mr. Gamble to the Messrs. Fourdrinier, when a series of experiments for improving the machine was considered desirable and at once commenced. But in order to accomplish the arduous object which those gentlemen then had in view, they laboured without intermission for nearly six years, when, after incurring an expense of £60,000, which was borne exclusively by the Messrs. Fourdrinier, they at length succeeded in giving some further organisation and connection to the mechanical parts, for which they likewise obtained a patent, and finding eventually that there was little prospect of being recompensed for labour and risk, or even reimbursed their expenses, unless Parliament should think proper to grant an extension of the patent, they determined upon making a fresh application to the Legislature for that purpose. But, it would appear that although in the Bill as it passed the House of Commons, such prolonged period extended to fourteen years, in the Lords it was limited to seven, with an understanding that such term should be extended to seven years more in the event of the patentees proving, upon a future application, that they had not been sufficiently remunerated. No such application, however, was made, in consequence of a Standing Order of the House of Lords, placed on their Journal subsequently to the passing of the said act; which regulation had the effect of depriving the Messrs. Fourdrinier of any benefit whatever from the invention; and ultimately, so great were the difficulties they had to encounter, and so little encouragement or support did they receive, that the time and attention required to mature this valuable invention, and the large capital which it absorbed, were the means of reducing those wealthy and liberal men to the humiliating condition of bankruptcy.

In reverting strictly to the manufacture of paper, the nature of some of the materials employed first claim attention. Silks, woollens, flax, hemp, and cotton, in all their varied forms, whether as cambric, lace, linen, holland, fustian, corduroy, bagging, canvas, or even as cables, are or can be used in the manufacture of paper of one kind or another. Still, rags, as of necessity they accumulate and are gathered up by those who make it their business to collect them, are very far from answering the purposes of paper making. Rags, to the paper-maker are almost as various in point of quality or distinction, as the materials which are sought after through the influence of fashion. Thus the paper-maker, in buying rags, requires to know exactly of what the bulk is composed. If he is a manufacturer of white papers, no matter whether intended for writing or printing, silk or woollen rags would be found altogether useless, inasmuch as is well known, the bleach will fail to act upon any animal substance whatever. And although he may purchase even a mixture in proper proportions adapted for the quality he is in the habit of supplying, it is as essential in the processes of preparation that they shall previously be separated. Cotton in its raw state, as may be readily conceived, requires far less preparation than a strong hempen fabric, and thus, to meet the requirements of the paper-maker, rags are classed under different denominations, as for instance, besides *fines* and *seconds*, there are *thirds*, which are composed of fustians, corduroy, and similar fabrics; *stamps* or *prints* (as they are termed by the paper-maker), which are coloured rags, and also innumerable foreign rags, distinguished by certain well-known marks, indicating their various peculiarities. It might be mentioned, however, that although by far the greater portion of the materials employed are such as have already been alluded to, it is not from their possessing any exclusive suitableness — since various fibrous vegetable substances have frequently been used, and are indeed still successfully employed — but rather on account of their comparatively trifling value, arising from the limited use to which they are otherwise applicable.

To convey some idea of the number of substances which have been really tried; in the library of the British Museum may be seen a book printed in low Dutch, containing upwards of sixty specimens of paper, made of different materials, the result of one man's experiments *alone*, so far back as the year 1772. In fact, almost every species of tough fibrous vegetable, and even animal substance, has at one time or another been employed: even the roots of trees, their bark, the bine of hops, the tendrils of the vine, the stalks of the nettle, the common thistle, the stem of the hollyhock, the sugar cane, cabbage stalks, beet-root, wood shavings, sawdust, hay, straw, willow, and the like. Straw is occasionally used, in connection with other materials, such as linen or cotton rags, and even with considerable advantage, providing the processes of preparation are thoroughly understood. Where such is not the case, and the silica contained in the straw has not been destroyed (by means of a strong alkali), the paper will invariably be found more or less brittle; in some cases so much so as to be hardly applicable to any purpose whatever of practical utility. The waste, however, which the straw undergoes, in addition to a most expensive process of preparation, necessarily precludes its adoption to any great extent. Two inventions have been patented for manufacturing paper entirely from wood. One process consists in first boiling the wood in caustic soda lye in order to remove the resinous matter, and then washing to remove the alkali; the wood is next treated with chlorine gas or an oxygenous compound of chlorine in a suitable apparatus, and washed to free it from the hydrochloric acid formed: it is now treated with a small quantity of caustic soda, which converts it instantly into pulp, which has only to be washed and bleached, when it will merely require to be beaten for an hour or an hour and a half in the ordinary beating-engine, and made into paper. The other invention is very simple, consisting merely of a wooden box enclosing a grindstone, which has a roughened surface, and against which the blocks of wood are kept in close contact by a lever, a small stream of water being allowed to flow upon the stone as it turns, in order to free it of the pulp, and to assist in carrying it off through an outlet at the bottom. Of course the pulp thus produced cannot be employed for any but the coarser kinds of paper. For all writing and printing purposes, which manifestly are the most important, nothing has yet been discovered to lessen the value of rags, neither is it at all probable that there will, inasmuch as rags of necessity must continue accumulating, and before it will answer the purpose of the paper-maker to employ new material, which is not so well adapted for his purpose as the old, he must be enabled to purchase it for considerably less than it would be worth in the manufacture of textile fabrics, and besides all this rags possess in themselves the very great advantage of having been repeatedly prepared for paper-making by the numerous alkaline washings which they necessarily receive during their period of use.

With all the drawbacks attending the preparation of straw, there is certainly no fibre to compete with it at present as an auxiliary to that of rags. A thick brown paper, of tolerable strength, may be made from it cheaply, but for printing or writing purposes only an inferior description can be produced, and of little comparative strength to that of rag paper. Its chief and best use is that of imparting stiffness to common newspaper. Some manufacturers prefer for this purpose an intermixture of straw with paper shavings, and others in place of the paper shavings give the preference to rags. The proportion of straw used in connection with rags or paper shavings varies from 50 to 80 per cent.

The cost at the present time of producing two papers of equal quality, one entirely from straw, and the other entirely from rags, would be very nearly equal; for although the cost of the rags would be at least £17 per ton, and the cost of the straw not more than £2 per ton, in addition to the greatly increased cost of preparing the straw, the rags would only waste one-third, while the straw would waste fully one-half. Thus taking into consideration the waste which each undergoes in process of preparation, the actual cost of material in producing a ton of paper may be stated relatively as 25*l.* for rags, and 4*l.* for straw. The cost, however, of preparation, which includes power, labour, and chemicals, being so very much greater in the case of the straw,—from two to three times as much as that of rags—a similarity of value is thus ultimately attained.

In order to reduce the straw to a suitable consistency for paper-making, it is placed in a boiler, with a large quantity of strong alkali, and with a pressure of steam equal to 120 and sometimes to 150 lbs. per square inch; the extreme heat being attained in super-heating the steam after it leaves the boiler, by passing it through a coiled pipe over a fire, and thus the silica becomes destroyed, and the straw softened to pulp, which, after being freed from the alkali by washing it in cold water, is subsequently bleached and beaten in the ordinary rag engine, to which we shall presently refer.

The annual consumption of rags in this country alone far exceeds 120,000 tons, three-fourths of which are imported, Italy and Germany furnishing the principal supplies. That the condition in which the rags are imported furnishes any criterion of the national habits of the people from which they came, as has been frequently asserted, however plausible in theory, must at least be received with caution.

All that can be said as to the suitableness of fibre in general, may be summed up in very few words; any vegetable fibre having a corrugated edge, which will enable it to cohere in the mass, is fit for the purpose of paper-making; the extent to which such might be applied can solely be determined by the question of cost in its production; and hitherto everything which has been proposed as a substitute for rags has been excluded either by the cost of freight, the cost of preparation, or the expenses combined.

In considering the various processes or stages of the manufacture of paper, we have first to notice that of carefully sorting and cutting the rags into small pieces, which is done by women; each woman standing at a table frame, the upper surface of which consists of very coarse wire cloth; a large knife being fixed in the centre of the table, nearly in a vertical position. The woman stands so as to have the back of the blade opposite to her, while at her right hand on the floor is a large wooden box, with several divisions. Her business consists in examining the rags, opening the seams, removing dirt, pins, needles, and buttons of endless variety, which would be liable to injure the machinery, or damage the quality of the paper. She then cuts the rags into small pieces, not exceeding 4 inches square, by drawing them sharply across the edge of the knife, at the same time keeping each quality distinct in the several divisions of the box placed on her right hand. During this process, much of the dirt, sand, and so forth, passes through the wire cloth into a drawer underneath, which is occasionally cleaned out. After this, the rags are removed to what is called the *dusting machine*, which is a large cylindrical frame covered with similar coarse iron wire-cloth, and having a powerful revolving shaft extending through the interior, with a number of spokes fixed transversely, nearly long enough to touch the cage. By means of this contrivance, the machine being fixed upon an incline of some inches to the foot, the rags, which are put in at the top, have any remaining particles of dust that may still adhere to them effectually beaten out by the time they reach the bottom.

The rags being thus far cleansed, have next to be boiled in an alkaline lye or solution, made more or less strong as the rags are more or less coloured, the object being to get rid of the remaining dirt and some of the colouring matter. The proportion is from four to ten pounds of carbonate of soda with one-third of quick lime to the hundred weight of material. In this the rags are boiled for several hours, according to their quality.

The method generally adopted is that of placing the rags in large cylinders, which are constantly, though slowly, revolving, thus causing the rags to be as frequently turned over, and into which a jet of steam is cast with a pressure of something near 30 lbs. to the square inch.

After this process of cleansing, the rags are considered in a fit state to be torn or macerated until they become reduced to pulp, which was accomplished, some five and thirty or forty years since, by setting them to heat and ferment for many days in close vessels, whereby in reality they underwent a species of putrefaction. Another method subsequently employed was that of beating them by means of stamping-rods, shod with iron, working in strong oak or stone mortars, and moved by water-wheel machinery. So rude and ineffective however was this apparatus, that no fewer than forty pairs of stamps were required to operate a night and a day in preparing one hundred weight of material. At the present time, the average weekly consumption of rags, at many paper mills, exceeds even 30 tons. The cylinder or engine mode of comminuting rags into paper pulp appears to have been invented in Holland, about the middle of the last century, but received very little attention here for some years afterwards. The accompanying drawing will serve to convey some idea of the wonderful rapidity with which the work is at present accomplished. No less than

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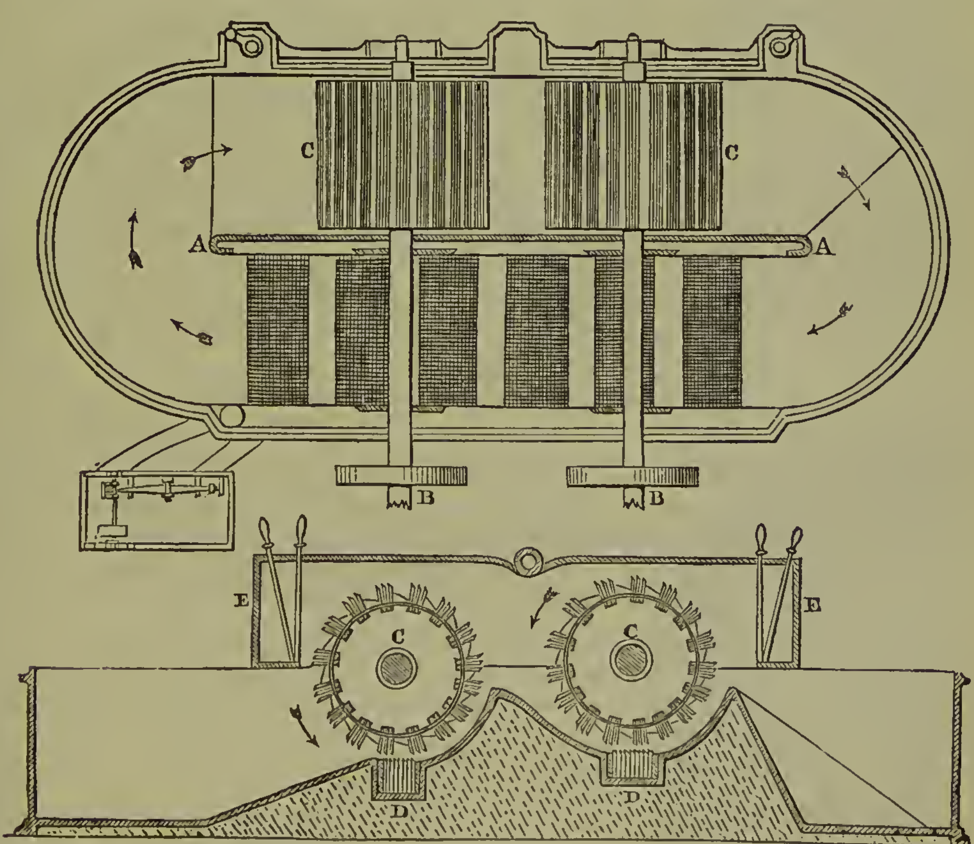


twelve tons per week can now be prepared by means of this simple contrivance. The horizontal section represents an oblong cistern, of cast iron, or wood lined with lead, into which the rags, with a sufficient quantity of water, are received. It is divided by a partition, as shown (A), to regulate the course of the stuff. The spindle upon which each cylinder C moves, extending across the engine, and being put in motion by a band wheel or pinion at the point B. One cylinder, is made to traverse at a much swifter rate than the other, in order that the rags may be the more effectually triturated. The cylinders C, as shown in the vertical section, are furnished with numerous cutters, running parallel to the axis, and again beneath them similar cutters are mounted (D) somewhat obliquely, against which, when in motion, the rags are drawn by the rapid rotation of the cylinders, and thus reduced to the smallest filaments requisite, sometimes not exceeding the sixteenth of an inch in length; the distance between the fixed and movable blades being capable of any adjustment, simply by elevating or depressing the bearings upon which the necks of the shaft are supported. When in operation, it is of course necessary to enclose the cylinders in a case, as shown, E, otherwise a large proportion of the rags would, inevitably, be thrown out of the engine. The rags are first worked coarsely, with a stream of water running through the engine, which tends effectually to wash them, as also to open their fibres; and in order to carry off the dirty water, what is termed a *washing drum* is frequently employed, consisting simply of a framework covered with very fine wire gauze, in the interior of which, connected with the shaft or spindle, which is hollow, are two suction tubes, and by this means, on the principle of a siphon, the dirty water constantly flows away through a larger tube running down outside, which is connected with that in the centre, without carrying away any of the fibre.

After this, the mass is placed in another engine, where, if necessary, it is bleached by an admixture of chloride of lime, which is retained in the engine until its action becomes apparent. The pulp is then let down into large slate cisterns to steep, prior to being reduced to a suitable consistency by the beating engine, as already described. The rolls or cylinders, however, of the beating engine are always made to rotate much faster than when employed in washing or bleaching, revolving probably from 120 to 150 times per minute, and thus, supposing the cylinders to contain 48 teeth each, passing over eight others, as shown in the drawing, effecting no fewer than 103,680 cuts in that short period. From this the great advantage of the modern engine over the old fashioned mortar machine, in turning out a quantity of paper pulp, will be at once apparent. The introduction of colouring matter in connection with the paper manufacture is accomplished simply by its intermixture with the pulp while in process of beating in the engine.

Although the practice of bluing paper is not, perhaps, so customary now as was the case a few years back, the extent to which it is still carried may be a matter of considerable astonishment. On its first introduction, when, as regards colour, the best paper was anything but pleasing, so striking a novelty would no doubt be hailed as a great improvement, and as such received into general use, but the superior delicacy of a *first-class* paper now made without any colouring matter whatever, and without any superfluous marks on its surface, is so truly beautiful, both in texture and appearance, as to occasion some surprise that it is not more generally used.*

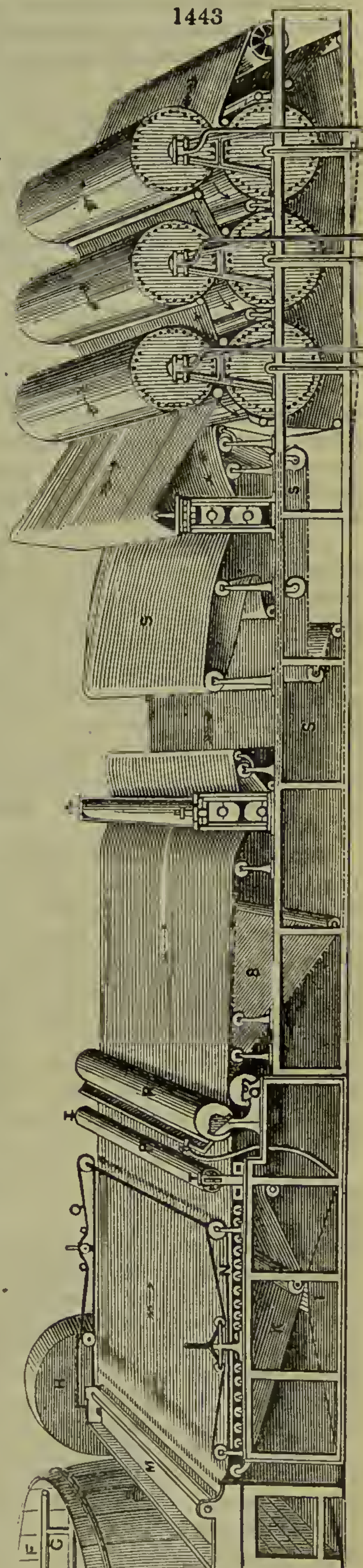
Common materials are frequently and very readily employed, through the assistance of colouring matter, which tends to conceal the imperfection. Indeed it would be difficult to name an instance of apparent deception more forcible than that which is accomplished by the use of ultramarine. Until very recently the fine bluish tinge given to many writing papers was derived from the admixture of that formerly expensive, but now, being prepared artificially, cheap, mineral blue (see ULTRAMARINE), the oxide of cobalt, generally termed *smalts,* which has still the advantage over the ultramarine of imparting a colour which will endure for a much longer period. 1 pound of ultramarine, however, going further than 4 of smalts, the former necessarily meets with more extended application, and where the using is rightly understood, and the materials employed instead of being fine rags, comparative rubbish, excessively bleached, its application proves remarkably serviceable to the paper-maker in concealing for a time all other irregularities, and even surpassing in appearance the best papers of the kind.

At first the introduction of ultramarine led to some difficulty in sizing the paper, for so long as smalts continued to be used, any amount of alum might be employed, and it was actually added to the size to preserve it from putrefaction. But since artificial ultramarine is bleached by alum, it became of course necessary to add this salt to the size in very small proportions, and as a natural consequence the gelatine was no longer protected from the action of the air, which led to incipient decomposition, and in such cases the putrefaction once commenced, proceeded even after the size was dried on the paper, and gave to it a most offensive smell, which rendered

* See Richard Herring's "Pure Wove Writing Paper."

the paper unsaleable. This difficulty, however, has now been overcome, and providing the size be quite free from taint when applied to the paper, and quickly dried, putrefaction will not subsequently occur; but if decay has once commenced, it cannot be arrested by drying only.

1443



The operation of paper making, after the rags or materials to be used have been thus reduced and prepared, may be divided into two kinds; that which is carried on in hand-mills, where the formation of the sheet is performed by manual labour; and that which is carried on in machine-mills, where the paper is produced upon the machine wire-cloth in one continuous web.

With respect to hand-made papers, the sheet is formed by the vatman's dipping a mould of fine wire cloth fixed upon a wooden frame, and having what is termed a deckle, to determine the size of the sheet, into a quantity of pulp which has been previously mixed with water to a requisite consistency; when after gently shaking it to and fro in a horizontal position, the fibres become so connected as to form one uniform fabric, while the water drains away. The deckle is then removed from the mould, and the sheet of paper turned off upon a felt, in a pile with many others, a felt intervening between each sheet, and the whole subjected to great pressure, in order to displace the superfluous water; when after being dried and pressed without the felts, the sheets are dipped into a tub of fine animal size, the superfluity of which is again forced out by another pressing; each sheet after being finally dried, undergoing careful examination before it is finished.

Thus we have, first, what is termed the *water-leaf*, the condition in which the paper appears after being pressed between the felts — this is the first stage. Next, a sheet from the bulk, as pressed without the felts, which still remains in a state unfit for writing on, not having been sized. Then a sheet after sizing, which completely changes its character; and lastly one with the finished surface. This is produced by placing the sheets separately between very smooth copper plates, and then passing them through rollers, which impart a pressure of from 20 to 30 tons. After only three or four such pressures, it is simply called rolled, but if passed through more frequently, the paper acquires a higher surface, and is then called glazed.

The paper making machine is constructed to imitate in a great measure, and in some respects to improve, the processes used in making paper by hand; but its chief advantages are the increased rapidity with which it accomplishes the manufacture, and the means of producing paper of any size which can practically be required.

By the agency of this admirable contrivance, which is so adjusted as to produce the intended effect with unerring precision, a process which, in the old system of paper making, occupied about three *weeks*, is now performed in as many *minutes*.

The paper making machine is supplied from the "chest" or reservoir F, into which the pulp descends from the beating engine, when sufficiently ground; being kept in constant motion, as it descends, by means of the agitator G, in order that it shall not settle. From this reservoir the pulp is again conveyed by a pipe into what is technically termed the "lifter" H, which consists of a cast-iron wheel, enclosed in a wooden case, and having a number of buckets affixed to its circumference. The trough I, placed immediately beneath the endless wire K, is for the purpose of receiving the water which drains away from the pulp during the process of manufacture, and as this water is frequently impregnated with certain chemicals used in connection with paper making, it is returned again by a conducting spout, into the "lifter," where, by the rotation of the buckets, both the pulp and back-water become again thoroughly mixed, and are together raised by the lifter through the spout L, into the trough M, where the pulp is strained by means of a sieve or "knotter," as it is called, which is usually formed of brass, having fine slits cut in it to allow the comminuted pulp to pass through, while it retains all lumps and knots; and so fine are these openings, in order to free the pulp entirely from anything which would be liable to damage the quality of the paper, that it becomes necessary to apply a means of exhaustion underneath, in order to facilitate the passage of the pulp through the strainer.

The lumps collected upon the top of this knotter, more particularly when printing papers are being manufactured, are composed to a considerable extent, of india-rubber, which is a source of much greater annoyance to the paper maker than is readily conceived. For, in the first place, it is next to impossible in sorting and cutting the rags to free them entirely from the braiding, and so forth, with which ladies adorn their dresses, and in the next, the bleach failing to act upon a substance of that character, the quality of the paper becomes greatly deteriorated, by the large black specks which it occasions, and which, by the combined heat and pressure of the rolls and cylinders enlarge considerably as it proceeds.

Passing from the strainer the pulp is next made to distribute itself equally throughout the entire width of the machine, and is afterwards allowed to flow over a small lip or ledge, in a regular and even stream, whence it is received by the upper surface of the endless wire K, upon which the first process of manufacture takes place. Of course the thickness of the paper depends in some measure upon the speed at which the machine is made to travel, but it is mainly determined by the quantity of pulp allowed to flow upon the wire, which by various contrivances can be regulated to great nicety. Paper may be made by this machine, considerably less than the thousandth of an inch in thickness, and although so thin, it is capable of being coloured, it is capable of being glazed, it is capable of receiving a water-mark; and what is perhaps still more astonishing, a strip not exceeding 4 inches in width, is sometimes capable of sustaining a weight of 20 lbs., so great is its tenacity.

But, to return to the machine itself. The quantity of pulp required to flow from the vat M being determined, it is first received by the continuous woven wire K, upon which it forms itself into paper; this wire gauze, which resembles a jack-towel, passing over the small copper rollers N, round the larger one marked O, and being kept in proper tension by two others placed underneath. A gentle vibratory motion from side to side is given to the wire, which assists to spread the pulp evenly, and also to facilitate the separation of the water, and by this means, aided by a suction pump, the pulp solidifies as it advances. The two black squares on either side of the "dandy" roller P indicate the position of two wooden boxes, from which the air is partially exhausted, thus causing the atmospheric pressure to operate in compacting the pulp into paper, the water and moisture being drawn through the wire and the pulp retained on the surface.

Next, we have to notice the deckle or boundary straps Q which regulate the width of the paper, travelling at the same rate as the wire, and thus limiting the spread of pulp. The "dandy" roller P, is employed to give any impression to the paper that may be required. We may suppose for instance, that the circumference of that roller answers exactly to the length or breadth of the wire forming a hand mould, which, supposing such wire to be fixed or curved in that form, would necessarily leave the same impression as when employed in the ordinary way. Being placed between the air boxes, the paper becomes impressed by it when in a half formed state, and whatever marks are thus made, the paper will effectually retain. The two rollers following the dandy, marked R and O, are termed couching rollers, from their performing a similar operation in the manufacture of machine made papers to the business of the coucher in conducting the process by hand. They are simply wooden rollers covered with felt. In some instances, however, the upper couch roll R is made to answer a double purpose. In making writing or other papers where smalts, ultramarine, and various colours are used, considerable difference will frequently be found in the tint of the paper when the two sides are compared, in consequence of the colouring matter sinking to the lower side, by the natural subsidence of the water, or from the action of the suction boxes; and to obviate this, instead of employing the ordinary couch roll, which acts upon the *upper* surface of the paper, a hollow one is substituted, having a suction box within it, acted upon by an air pump, which tends in some measure to counteract the effect, justly considered objectionable. Merging from those rollers the paper is received from the wire gauze by a continuous felt s, which conducts it through two pair of pressing rollers, and afterwards to the drying cylinders. After passing through the first pair of rollers the paper is carried along the felt for some distance, and then turned over, in order to receive a corresponding pressure on the other side, thus obviating the inequality of surface which would otherwise be apparent, especially if the paper were to be employed for books.

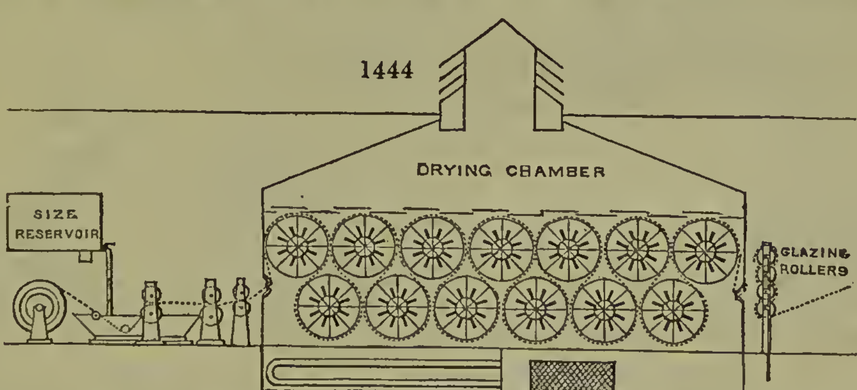
The advantage gained by the use of so great a length of felt, is simply, that it becomes less necessary to stop the machine for the purpose of washing it, than would be the case if the felt were limited in length to its absolute necessity.

In some instances, when the paper being made is sized in the pulp with such an ingredient as *resin*, the felt becomes so completely clogged in the space of a few hours, that unless a very great and apparently unnecessary length of felt be employed, a considerable waste of time is constantly incurred in washing or changing the felt.

The operation of the manufacture will now be apparent. The pulp flowing from the reservoir into the lifter, and thence through the strainer, passes over a small lip to the continuous wire, being there partially compacted by the shaking motion, more thoroughly so on its passage over the air boxes, receiving any desired marks by means of the dandy roller passing over the continuous felt between the first pressing rollers, then turned over to receive a corresponding pressure on the other side, and from thence off to the drying cylinders, which are heated more or less by injected steam; the cylinder which receives the paper first, being heated less than the second, the second than the third, and so on; the paper after passing over those cylinders, being finally wound upon a reel, as shown, unless it be printing paper, which can be sized sufficiently in the pulp, by an admixture of alum, soda, and resin, or the like; in which case it may be at once conducted to the cutting machine, to be divided into any length and width required. But, supposing it to be intended for writing purposes, it has first to undergo a more effectual method of sizing, as shown in the accompanying drawing; the size in this instance being made from parings obtained from tanners, curriers, and parchment-makers, as employed in the case of hand-made papers. Of course, sizing in the pulp or in the engine offers many advantages, but as gelatine, or animal size, which is really essential for all good writing qualities, cannot at present be employed during the process of manufacturing by the machine without injury to the felts, it becomes necessary to pass the web of paper, after it has been dried by the cylinders, through this apparatus.

In most cases, however, the paper is at once guided as it issues from the machine, through the tub of size, and is thence carried over the skeleton drums shown, inside each of which are a number of fans rapidly revolving; sometimes there are forty or fifty of these drums in succession, the whole confined in a chamber heated by steam. A paper-machine with the sizing apparatus attached, sometimes measures, from the wire-cloth where the pulp first flows on, to the cutting machine at the extremity, no less than one thousand feet. The advantage of drying the paper in this manner over

1444



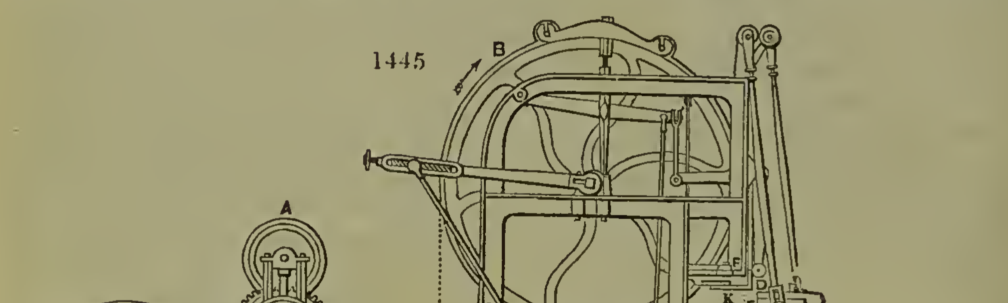
so many of these drums is, that it turns out much harder and stronger, than if dried more rapidly over heated cylinders. Some manufacturers adopt a peculiar process of sizing, which in fact answers very much better, and is alike applicable to papers made by hand or by machine, provided the latter description be first cut into pieces or sheets of the required dimensions. The contrivance consists of two revolving felts, between which the sheets are carried under several rollers through a long trough of size, being afterwards hung up to dry upon lines, previously to rolling or glazing. The paper thus sized becomes much harder and stronger, by reason of the freedom with which the sheets can contract in drying; and this is mainly the reason why paper made by hand continues to be so much tougher than that made by the machine, in consequence of the natural tendency of the pulp to contract in drying, and consequently becoming, where no resistance is offered, more entwined or entangled, which of course adds very considerably to the strength and durability of the paper. In making by the machine, this tendency is completely checked.

It may be interesting to mention, that the first experiment for drying paper by means of heated cylinders was made at Gellibrand's calico printing factory, near Stepney; a reel of paper, in a moist state, having been conveyed there from Dartford, in a post chaise. The experiment was tried in the presence of the patentees of the paper machine and Mr. Donkin, the engineer, and proved highly satisfactory, and the adoption of copper cylinders, heated by steam, was thenceforth considered indispensable.

The next operation to be noticed, now that the paper is finished, is that of cutting it into standard sizes. Originally, the reel upon which it was finally wound, was formed so that its diameter might be lessened or increased at pleasure, according to the sizes which were required. Thus, for instance, supposing the web of paper was required to be cut into sheets of 18 inches in length, the diameter of the reel would be lessened to 6 inches, and thus the circumference to 18 inches, or if convenient it would be increased to 36 inches, the paper being afterwards cut in two by hand with a large knife, the width of the web being regulated by the deckle straps, Q, to either twice or three times the width of the sheet, as the case might be. However, in regard to the length, considerable waste, of necessity, arose, from the great increase in the circumference of the reel as the paper was wound upon it, and to remedy this, several contrivances have been invented. To dwell upon their various peculiarities or separate stages of improvement, would prove of little comparative interest to the general reader, it will, therefore, be well to limit attention to the cutting machine, of which an illustration is given, which is unquestionably the best, as well as the most ingenious, invention of the kind.

The first movement or operation peculiar to this machine is that of cutting the web of paper longitudinally, into such widths as may be required; and this is effected by means of circular blades, placed at stated distances, which receive the paper as it

1445



issues direct from the other machinery, and by a very swift motion, much greater than that at which the paper travels, slit it up with unerring precision wherever they may be fixed.

A pair of those circular blades is shown in the drawing, A, the upper one being much larger than the lower, which is essential to the smoothness of the cut. And not only is the upper blade larger in circumference, but it is also made to revolve with much greater rapidity, by means of employing a small pinion, worked by one at least twice its diameter, which is fixed upon the same shaft as the lower blade, to which the motive power is applied. The action aimed at is precisely such as we obtain from a pair of scissors.

The web, as it is termed by the paper-maker, being thus severed longitudinally, the next operation is that of cutting it off into sheets of some particular length horizontally; and to do this requires a most ingenious movement. To give a very general idea of the contrivance, the dotted line represents the paper travelling on with a rapidity in some cases of 80 feet per minute, and yet its course has to be temporarily arrested while the required separation is effected, and that too without the paper's accumulating in any mass, or getting creased in the slightest degree.

The large drum B, over which the paper passes, in the direction indicated by the arrows, has simply an alternating motion, which serves to gather the paper in such lengths as may be required; the crank arm C, which is capable of any adjustment either at top or bottom, regulating the extent of the movement backwards and forwards, and thus the length of the sheet. As soon as the paper to be cut off has passed below the point D, at which a *presser* is suspended, having an alternating motion given to it, in order to make it approach to, and recede from, a stationary presser-board; it is taken bold of as it descends from the drum, and the length pendant from the presser, is instantly cut off by the movable knife E, to which motion is given by the crank F, the connecting rod G, the lever H, and the connecting rod I. The combined motion of these rods and levers, admits of the movable knife E, remaining nearly quiescent for a given time, and then speedily closing upon the fixed knife K, cutting off the paper in a similar manner to a pair of shears, when it immediately slides down a board, or in some instances is carried along a revolving felt, at the extremity of which several men or boys are placed to receive the sheets, according to the number into which the width of the web is divided.

As soon as the pressers are closed for a length of paper to be cut off, the motion of the gathering drum is reversed, smoothing out the paper upon its surface, which is now held between the pressers; the tension roll L, taking up the slack in the paper as it accumulates, or rather bearing it gently down, until the movement of the drum is again reversed to furnish another length. The handle M, is employed merely to stop a portion of the machinery, should the water-mark not fall exactly in the centre of the sheet, when by this means it can be momentarily adjusted.

The paper being thus made, and cut up into sheets of stated dimensions, is next looked over and counted out into quires of 24 sheets, and afterwards into reams of 20 quires; which subsequently are carefully weighed, previously to their being sent into the market.

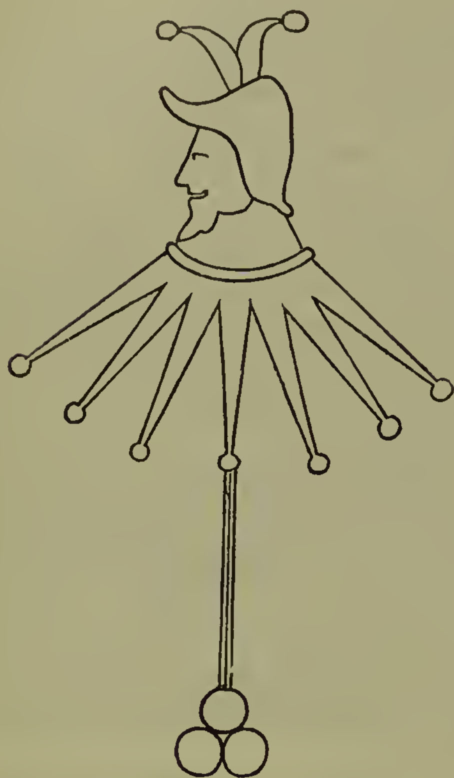
Connected with the manufacture of paper, there is one point of considerable interest and importance, and that is, what is commonly, but erroneously, termed the *water-mark*, which may be noticed in the *Times* newspaper, in the Bank of England Notes, Cheques, and Bills, as also in every Postage and Receipt Label of the present day.

The curious, and in some instances absurd terms, which now puzzle us so much in describing the different sorts and sizes of paper, may frequently be explained by reference to the various paper marks which have been adopted at different periods. In ancient times, when comparatively few people could read, pictures of every kind were much in use where writing would now be employed. Every shop, for instance, had its sign, as well as every public-house, and those signs were not then, as they often are now, only painted upon a board, but were invariably actual models of the thing which the sign expressed—as we still occasionally see some such sign as a bee-hive, a tea-canister, or a doll, and the like. For the same reason printers employed some device, which they put upon the title pages and at the end of their books, and paper-makers also introduced marks, by way of distinguishing the paper of their manufacture from that of others; which marks becoming common, naturally gave their names to different sorts of paper. And since names often remain long after the origin of them is forgotten and circumstances are changed, it is not surprising to find the old names still in use, though in some cases they are not applied to the same things which they originally denoted. One of the illustrations of ancient water-marks given in the accompanying plate, that of an open hand with a star at the top, which was in use as early as 1530, probably gave the name to what is still called *hand* paper, *fig.* 1446.

Another very favourite paper-mark, at a subsequent period 1540-60, was the jug or pot which is also shown, *fig.* 1447, and would appear to have originated the term *pot* paper. The foolscap was a later device, and does not appear to have been nearly of such long continuance as the former, *fig.* 1448. It has given place to the figure of Britannia, or that of a lion rampant, supporting the cap of liberty on a pole. The name, however, has continued, and we still denominate paper of a particular size, by the title of *foolscap*. The original figure has the cap and bells, of which we so often read in old plays and histories, as the particular head-dress of the fool, who at one time formed part of every great man's establishment.

The water-mark of a *cap* may sometimes be met with of a much simpler form than just mentioned — frequently resembling the jockey caps of the present day, with a trifling ornamentation or addition to the upper part. The first edition of "Shakspeare," printed by *Isaac Jaggard and Ed. Blount*, 1623, will be found to

1448



1446

1449

1447

1450

contain this mark, interspersed with several others of a different character. No doubt the general use of the term *cap* to various papers of the present day owes its origin to marks of this description.

The term *imperial* was in all probability derived from the finest specimens of papyri, which were so called by the ancients.

Post paper seems to have derived its name from the post-horn, which at one time was its distinguishing mark, *fig.* 1449. It does not appear to have been used prior to the establishment of the general post-office (1670), when it became the custom to blow a horn, to which circumstance no doubt we may attribute its introduction. The mark is still frequently used, but the same change which has so much diminished the number of painted signs in the streets of our towns and cities, has nearly made paper-marks a matter of antiquarian curiosity; the maker's name being now generally used, and the mark, in the few instances where it still remains, serving the purpose of mere ornament, rather than that of distinction.

Water-marks, however, have at various periods been the means of detecting frauds, forgeries and impositions, in our courts of law and elsewhere, to say nothing of the protection they afford in the instances already referred to, such as bank notes, cheques, receipt, bill, and postage stamps. The celebrated Curran once distinguished himself in a case which he had undertaken by shrewdly referring to the water-mark, which effectually determined the verdict. And another instance, which may be introduced in the form of an amusing anecdote, occurred once at Messina, where the monks of a certain monastery exhibited, with great triumph, a letter as being written by the Virgin Mary with her own hand. Unluckily for them, however, this was not, as it easily might have been, written upon the ancient papyrus, but on paper made of rags. On one occasion a visitor, to whom this was shown, observed, with affected solemnity, that the letter involved also a *miracle*, for the paper on which it was written was not in existence until several centuries after the mother of our Lord had died.

A further illustration of the kind occurs in a work entitled "Ireland's Confessions," which was published respecting his fabrication of the Shakspeare manuscripts,—a literary forgery even still more remarkable than that which is said to have been perpetrated by Chatterton, as Rowley's Poems.

The interest which at the time was universally felt in this production of Ireland's may be partially gathered from the fact, that the whole of the original edition, which appeared in the form of a shilling pamphlet, was disposed of in a few hours; while so great was the eagerness to obtain copies afterwards, that single impressions were sold in an auction room at the extravagant price of a guinea.

This gentleman tells us, at one part of his explanation, that the sheet of paper which he used was the outside of several others, on some of which accounts had been kept in the reign of Charles the First; and being at that time wholly unacquainted with the water-marks used in the reign of Queen Elizabeth, "I carefully selected (says he) two half-sheets, not having any mark whatever, on which I penned my first effusion." A few pages further on he writes — "Being thus urged forward to the production of more manuscripts, it became necessary that I should possess a sufficient quantity of old paper to enable me to proceed; in consequence of which I applied to a bookseller, named Verey, in great May's Buildings, St. Martin's Lane, who, for the sum of five shillings, suffered me to take from all the folio and quarto volumes in his shop the fly leaves which they contained. By this means I was amply stored with that commodity; nor did I fear any mention of the circumstance by Mr. Verey, whose quiet unsuspecting disposition, I was well convinced, would never lead him to make the transaction public, in addition to which he was not likely even to know anything concerning the supposed Shaksperian discovery by myself, and even if he had, I do not imagine that my purchase of the old paper in question would have excited in him the smallest degree of suspicion. As I was fully aware, from the variety of water-marks which are in existence at the present day, that they must have constantly been altered since the period of Elizabeth, and being for some time wholly unacquainted with the water-marks of that age, I very carefully produced my first specimens of the writing on such sheets of old paper as had no mark whatever. Having heard it frequently stated that the appearance of such marks on the papers would have greatly tended to establish their validity, I listened attentively to every remark which was made upon the subject, and from thence I at length gleaned the intelligence that a jug was the prevalent water-mark of the reign of Elizabeth, in consequence of which I inspected all the sheets of old paper then in my possession, and having selected such as had the jug upon them, I produced the succeeding manuscripts upon these, being careful, however, to mingle with them a certain number of blank leaves, that the production on a sudden of so many water-marks might not excite suspicion in the breasts of those persons who were most conversant with the manuscripts."

Thus, this notorious literary forgery, through the cunning ingenuity of the perpetrator, ultimately proved so successful as to deceive many learned and able critics of the age. Indeed, on one occasion a kind of certificate was drawn up, stating that the undersigned names were affixed by gentlemen who entertained no doubt whatever as to the validity of the Shaksperian production, and that they voluntarily gave such public testimony of their convictions upon the subject. To this document several names were appended by persons as conspicuous for their erudition as they were pertinacious in their opinions.

The water-mark in the form of a letter *p*, of which an illustration is given, *fig.* 1450, was taken from Caxton's well-known work, "The Game of the Chess," a *fac simile* of which has recently been published as a tribute to his memory. Paper was made expressly for the purpose, in exact representation of the original, and containing this water-mark, which will be found common in works printed by him.

The ordinary mode of effecting such paper marks as we have been describing is that of affixing a stout wire in the form of any object to be represented to the surface of the fine wire-gauze, of which the hand-mould, or machine dandy roller is constructed.

The perfection, however, to which water-marks have now attained, which in many instances is really very beautiful, is owing to a more ingenious method recently patented, and since adopted by the Bank of England, as affording considerable protection to the public in determining the genuineness of a bank-note.

To produce a line water-mark of any autograph or crest, we might either engrave the pattern or device first in some yielding surface, precisely as we should engrave a copper-plate for printing, and afterwards, by immersing the plate in a solution of sulphate of copper, and electrotyping it in the usual way, allow the interstices of the engraving to give as it were a casting of pure copper, and thus an exact representation of the original device, which, upon being removed from the plate, and affixed to the surface of the wire-gauze forming the mould, would produce a corresponding impression in the paper: or, supposing perfect identity to be essential, as in the case of a bank note, we might engrave the design upon the surface of a steel die, taking care to cut those parts in the die deepest which are intended to give greater effect in the paper, and then, after having hardened, and otherwise properly prepared the die, it would be placed under a steam hammer or other stamping apparatus, for the purpose of producing what is technically termed a "force," which is required to assist in transferring an impression from the die to a plate of sheet brass. This being done, the die, with the mould-plate in it, would next be taken to a perforating or cutting machine, where the back of the mould-plate—that is, the portion which projects above the face of the die—would be removed, while that portion which was impressed into the design engraven would remain untouched, and this being subsequently taken from the interstices of the die and placed in a frame upon a backing of fine wire-cloth, becomes a mould for the manufacture of paper of the pattern which is desired, or for the production of any water-mark, autograph, crest or device, however complicated.

Light and shade are occasioned by a very similar process, but one which perhaps requires a little more care, and necessarily becomes somewhat more tedious. For instance, in the former case the pulp is distributed equally throughout the entire surface of the wire forming the mould, whereas *now* we have to contrive the means of increasing to a very great nicety the thickness or distribution of the pulp, and at the same time to make provision for the water's draining away. This has been accomplished by first taking an electrotype of the raised surface of any model or design, and again from that, forming in a similar manner a matrix or mould, both of which are subsequently mounted upon lead or gutta percha, in order that they may withstand the pressure which is required to be put upon them in giving impression to a sheet of very fine copper wire-gauze, which, in the form of a mould, and in the hands of the vatman, suffices ultimately to produce those beautiful transparent effects in paper pulp. The word "Five" in the centre of the Bank of England note is produced in the same manner. The deepest shadows in the water-mark being occasioned by the deepest engraving upon the die, the lightest, by the shallowest, and so forth; the die being employed to give impression by means of the stamping press and "force" to the fine wire-gauze itself, which by this means, providing the die be properly cut, is accomplished far more successfully than by any other process, and with the additional advantage of securing perfect identity.

It may be interesting to call attention to the contrast as regards the method of mould-making originally practised, and that which has recently been adopted by the Bank of England. In a pair of five-pound note moulds, prepared by the old process, there were 8 curved borders, 16 figures, 168 large waves, and 240 letters, which had all to be separately secured by the finest wire to the waved surface. There were 1,056 wires, 67,584 twists, and the same repetition where the stout wires were introduced to support the under surface. Therefore, with the backing, laying, large waves, figures, letters, and borders, before a pair of moulds was completed, there were some hundreds of thousands of stitches, most of which are now avoided by the new patent. But further, by this multitudinous stitching and sewing, the parts were never placed precisely in the same position, and the water-mark was consequently never identical. Now, the same die gives impression to the metal which transfers it to the water-mark, with a certainty of identity unattainable before, and one could almost say, never to be surpassed.

And may we not detect principles in this process which are not only valuable to the Bank, but to all public establishments having important documents on paper, for what can exceed the value of such a test for discovering the deceptions of dishonest men? One's signature, crest, or device of any kind, rendering the paper exclusively one's own, can now be secured in a pair of moulds, at the cost merely of a few guineas.

Manufactured paper, independently of the miscellaneous kinds, such as blotting, filtering, and the like, which are rendered absorbent by the free use of *woollen* rags, may be divided into three distinct classes, *viz.* writing, printing, and wrapping. The former again into *five*, cream wove, yellow wove, blue wove, cream laid, and blue laid. The printing into *two*, laid and wove, and the latter into *four*, blue, purple, brown, and whited brown, as it is commonly termed.

To obtain a simple definition of the mode adopted for distinguishing the various kinds, we must include, with the class denominated *writing* papers, those which are used for drawing, which being sized in like manner, and with the exception of one or two larger kinds, of precisely the same dimensions as those passing by the same name, which are used strictly for writing purposes (the only distinction, in fact, being, that the drawings are cream wove, while the writings are laid), there would of course be no necessity for separating them. Indeed, since many of the sizes used for printing are exactly the same as those which would be named as writing papers, for the sake of abridgment we will reduce the distinctions of difference to but two heads, fine and coarse; under the latter including the ordinary brown papers, the whited brown, or small hand quality, and the blues and purples used by grocers. The smallest size of the fine quality, as sent from the mill, measures 12½ by 15 inches, and is termed pot; next to that foolscap, 16½ by 13½; then post, 18¾ by 15¼; copy, 20 by 16½; large post, 20¾ by 16½; medium post, 18 by 22½; sheet-and-third foolscap, 22½ by 13¼; sheet-and-half foolscap, 24½ by 13¼; double foolscap, 27 by 17; double pot, 15 by 25; double post, 30½ by 19; double crown, 20 by 30; demy, 20 by 15½; ditto printing, 22½ by 17¾; medium, 22 by 17½; ditto printing, 23 by 18½; royal, 24 by 19; ditto printing, 25 by 20; super-royal, 27 by 19; ditto printing, 21 by 27; imperial, 30 by 22; elephant, 28 by 23; atlas, 34 by 26; columbier, 34½ by 23½; double elephant, 26¾ by 40; and antiquarian, 53 by 31. The different sizes of letter and note paper ordinarily used are prepared from those kinds by the stationer, whose business consists chiefly in smoothing the edges of the paper, and afterwards packing it up in some tasteful form, which serves to attract attention.

Under the characteristic names of coarse papers may be mentioned Kent cap, 21 by 18; bag cap, 19½ by 24; Havon cap, 21 by 26; imperial cap, 22½ by 29; double 2-lb., 17 by 24; double 4-lb., 21 by 31; double 6-lb., 19 by 28; casing of various dimensions, also cartridges, with other descriptive names, besides middle hand, 21 by 16; lumber hand, 19½ by 22½; royal hand, 20 by 25; double small hand, 19 by 29; and of the purples, such significations as copy loaf, 16¾ by 21¾, 38-lb.; powder loaf, 18 by 26, 58-lb.; double loaf, 16½ by 23, 48-lb.; single loaf, 21½ by 27, 78-lb.; lump, 23 by 33, 100 lb.; Hambro', 16½ by 23, 48-lb.; titler, 29 by 35, 120-lb.; Prussian or double lump, 32 by 42, 200-lb.; and so forth, with glazed boards of various sizes, used chiefly by printers for pressing, which are manufactured in a peculiar manner by hand, the boards being severally composed of various sheets made in the ordinary way, but turned off the mould one sheet upon another, until the required substance be attained; a felt is then placed upon the mass and another board formed. By this means, the sheets, when pressed, adhere more effectually to each other, and the boards consequently become much more durable than would be the case if they were produced by pasting. Indeed, if any great amount of heat be applied to pasteboards, they will split, and be rendered utterly useless. The glazing in this case is accomplished by friction.

To complete the category of coarse papers, must be mentioned milled boards, employed in book-binding, of not less than 150 descriptions, as regards sizes and substances. Still, however, an incomplete idea is conveyed of the extraordinary number of sizes and descriptions into which paper is at present divided. For instance, we have said with reference to writing qualities, that there are *five* kinds, cream wove, yellow wove, blue wove, cream laid, and blue laid; and again, that of each of those kinds there are numerous sizes; but in addition there are, as a matter of course, various thicknesses and makes of each size and kind. In fact, no house in London, carrying on the wholesale stationery trade, is without a thousand different sorts; many keep stock of twice that number.*

The quantity of paper manufactured in this country at the commencement of the eighteenth century, appears to have been far from sufficient to meet the necessities of the time. Even in 1721, it is supposed that there were but about 300,000 reams of paper annually produced in Great Britain, which were equal merely to two-thirds of the consumption. But in 1784, the value of the paper manufactured in England alone is stated to have amounted to 800,000*l.*; and that, by reason of the increase in price, as also of its use, in less than twenty years it nearly doubled that amount.

With a view to greater exactness, it may be well to append some extracts from various Parliamentary returns, relating to the Excise duties levied upon paper, which, since an article of the kind is necessarily subjected to great alteration in value, according to the scarcity or abundance of raw materials, are, of course, better calculated to show a steady increase in the demand, than any mere references to statements of supposed value, from time to time.

In one return, specifying the rates of duty and amount of duty received upon each denomination of paper since 1770, it appears that the total amount of duty on paper manufactured in England for the year 1784, to which I have just alluded as being estimated in value at 800,000*l.*, was 46,867*l.* 19*s.* 9¼*d.*, the duty at that time being divided into seven distinct classes or rates of collection; while twenty years after, when the mode of assessing the duty was reduced to but three classes, it had risen to 315,802*l.* 4*s.* 8*d.*; in 1830, fifteen years after, to 619,824*l.* 7*s.* 11*d.*; in 1835, for the United Kingdom, to 833,822*l.* 12*s.* 4*d.*, or, in weight, to 70,655,287 lbs., which was, again, within so short a period as fifteen years, very nearly doubled. The quantity of paper charged with Excise duty in the United Kingdom, since 1844 being:—

* For further information upon this point, see the "Practical Guide to the Varieties and Relative Values of Paper." Longman & Co.

Date.	Charged with Duty.	Exported on Drawback, or Free of Duty.	Returned for Home consumption.
	lbs.		
1844	109,495,148	4,900,274	104,594,874
1845	124,247,071	4,864,185	119,382,886
1846	127,442,482	4,836,556	122,605,926
1847	121,965,315	5,853,979	116,111,336
1848	121,820,229	5,180,286	116,639,943
1849	132,132,660	5,966,319	126,166,341
1850	141,032,474	7,762,686	133,269,788
1851	150,903,543	8,305,598	142,597,945
1852	154,469,211	7,328,886	147,140,325
1853	177,633,010	13,296,874	164,336,135
1854	177,896,224	16,112,020	161,784,204
1855	166,776,394	11,118,551	155,657,843
1856	187,716,575	14,798,979	172,917,596
1857	191,721,620	16,031,063	175,690,557
1858	192,847,825	16,548,828	176,298,997
1859	217,827,197	20,142,350	197,684,847

As the duty has ceased, we shall probably lose the means of determining in future the value of this mauufacture, but the above table will ever be of interest as showing what has been done.

Those observations, which are partly technical, because, without technicality, the view would be incomplete,—may give some idea of the skill required in the workman, and the expenditure demanded of the capitalist, to produce so simple a thing as a sheet of paper. The most exact care, the most ingenious invention, the nicest work of hand, and the most complicated machinery, are essential to that superiority which the British manufacture of paper has at length established.

But the capabilities of paper are still more extensive. There are probably few branches of use, taste, or ornament, to which it may not be applicable. We have it already moulded into many forms of utility, and even of elegance, under the well-known name of *papier mache*—a material which may yet be formed into works of art, painted and enamelled tables, antique candelabra, models of busts, statuettes, classic temples, and everything which can be shaped in a mould.*

Considering the enormous extent of the paper manufacture, and the vast improvements which have taken place in connection therewith, it is not a little remarkable that, with the exception of the unfortunate Fourdriniers, who sacrificed their all to present to mankind the bare principles of the art, as in the main they now exist, no other name should rest upon the page of history as being similarly associated with those many introductions and improvements which have successively raised the paper manufacture to the apparently perfect standard which it has at length attained. It is true there would be no difficulty in recording the names of very many who, by the employment of the wealth which they have inherited, are now altogether unsurpassed as paper manufacturers; and it is equally true that if we turn to the Reports of the Jurors of the Great Exhibition of 1851, we shall find many other names more or less distinguished by the greater or lesser importance of the materials or means for which they have themselves applied for and obtained the security of a patent. Still we search in vain for any name upon record as indicating the true genius to whom is chiefly owing the surpassing beauty of the finest specimens of the paper fabric.

Undoubtedly the most enterprising and successful paper manufacturer of the present day is Mr. William Joynson, of St. Mary Cray, Kent, who by individual effort has succeeded in working his upward way from a poor and uneducated journeyman, in a humble paper mill, to the level of the most respected, and probably the most wealthy of paper manufacturers.

But Mr. Joynson, distinguished as he greatly is for the superior finish of his writing papers, was not the originator of the process by which that finish was attained. At the cost of much time and some thousands of pounds, Mr Joynson laboured to acquire a knowledge of the means by which that peculiar character aud surface was so successfully accomplished which, it is said, was first given to writing papers at the Hele paper mills, near Collumpton, Devon, by the late Mr. John Dewdney.

* For various particulars relative to patents in connection with paper-making machinery, the reader is referred to the Report of the Jurors of the Great Exhibition of 1851.

Not only in this respect, but in many others, Mr. Dewdney rendered very distinguished service to the art of paper-making; probably no man more so, and yet throughout his entire life as a paper manufacturer he never once patented a single invention, or refused admitting to his mill any person who wished to go over it. Whether the same kind-hearted and generous spirit that appears uniformly to have prompted Mr. Dewdney in the conduct of his business would be consistent now-a-days, many may question, as indeed in practice most do; but with Mr. Dewdney it certainly answered no bad end, for after acquiring a competency for himself and each member of a large family, he quietly retired from the paper manufacture; and in the early part of the year 1852, immediately after the Commissioners of the Great Exhibition had awarded him a prize medal "for the excellence of his writing papers, and also for the permanent dye of his blue papers for the use of starch manufacturers," he disposed of his well-known mills and everything connected with them, to his old friend and competitor, Mr. Joynson, to whom to the last day of his life he continued warmly attached, and by whom he was ever consulted upon the various alterations and inventions which were adopted at St. Mary Cray.

The circumstances of Mr. Dewdney's decease formed a painful coincidence at the close of so remarkably energetic and useful a career. He it was who first introduced a steam-engine into the county of Devon; and at the Hele station, adjoining the Hele mills, almost on the same spot that thirty years previously he reared it, the engine of the express train from Bristol to Exeter, through unpardonable neglect of the officials, and without an instant's consciousness of his danger, struck him dead.

Another method of making paper, which was invented by Mr. Dickenson, consists in causing a polished hollow brass cylinder, perforated with holes or slits, and covered with wire-cloth, to revolve over and in contact with the prepared pulp. The cylinder being connected with a vessel from which the air has been exhausted, the film of pulp adheres to the hollow cylinder. It is then turned off continuously upon a 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. This description of machine is not suitable for the manufacture of any paper requiring strength. Indeed, throughout the United Kingdom there are probably not more than a dozen in work, and those chiefly in the manufacture of thin tissue papers.

Our *imports* of papers in 1858, were as follows:—

	lbs.	Computed real value.
Paper hangings	167,619	£8,380
Fancy papers of all kinds, not hangings	149,485	11,211
Brown and waste	988,917	16,482

Our *exports* of British manufacture were:—

	Yards.	Declared real value.
Paper hangings	14,778,375	£17,082
	lbs.	Value.
Other kinds not entered under stationery	381,727	£6,592
Stationery entered at		803,738

R. H.

PAPIER-MÂCHÉ. The fine old philosopher Boyle says:—

"Though paper be one of the commonest bodies that we use, there are very few that imagine it is fit to be employed other ways, in writing and printing, or wrapping up of other things, or about some such obvious piece of service; without dreaming that frames of pictures, and divers fine pieces of embossed work, with other curious moveables, may, as trial has informed us, be made of it."

The origin of the manufacture of articles for use or ornament from paper, is not very clearly made out; we are naturally led to believe, from the name, that the French must have introduced it. We find, however, a French writer ascribes the merit of producing paper ornaments, to the English. After describing some peculiar ornamental work, the writer proceeds:—

As this work had to be done on the spot, and with much rapidity of execution, in order to prevent the stucco from setting before it had acquired the intended form, the art was somewhat difficult; the workman had to design almost as he worked; therefore, to do it well, it was necessary that he should have some of the requirements and qualities of an artist. This circumstance, of course, tended very much to limit the number of workmen, and their pay became proportionally large. The artisans assumed more than belonged to their humble rank in life, and ultimately the workers in stucco combined together to extort from their employers a most inordinate rate of wages. It would be superfluous here to detail all that followed; it is sufficient to state that the total ruin of their art was the final result of these delusive efforts to promote their individual interests.

Contrivances were resorted to by the masters which soon supplanted the old mode of working in stucco. The art of moulding and casting in plaster, as previously practised in France, was generally introduced, and the art of preparing the *pulp of paper* became improved and extended, so as ultimately to render practicable the adoption of papier-mâché in the formation of architectural decorations. Thus, at last, was extinguished the original mode of producing stucco ornaments, and there probably has not been for many years a single individual in England accustomed to that business.

From the *Gentleman's Magazine*, we learn that many of the fine old ceilings in deep relief of the Elizabethan era are of papier-mâché. The handsome ceilings in Chesterfield House are of this material.

A kind of papier-mâché has been introduced, called fibrous slab ; for the preparation of this important material the coarse varieties of fibre only are required. These are heated and subjected to much agitation, to secure the reduction of the fibre to the proper size. This being effected, the pulp is removed and subjected to the action of the desiccating apparatus, or centrifugal drying machine. By the means of this apparatus the water is driven, by the action of the centrifugal force, from the fibre, and the pulp cau thus be obtained in a few minutes of an equal and proper degree of dryness, and this without the application of any heat. The mass thus obtained may be regarded as a very coarse mixture.

This fibrous pulp is next combined with some earthy matter to ensure its solidity, and certain chemical preparations are introduced, for the double purpose of preserving it from the attacks of insects and to ensure its incombustibility. The whole being mixed with a cementing size, is well kneaded together, steam being applied during the process. While the kneading process is going forward, an iron table running on wheels is properly adjusted and covered with a sail-cloth ; this table being arranged so that it passes under an immense iron roller. The fibrous mixture is removed from the kneading troughs and is laid in a tolerably uniform mass upon the sail-cloth, so as to cover about one half of the table ; over this again is placed a length of sail-cloth equal to that of the entire slab, as before. This being done, the table and roller are set in action, and the mass passes between them. It is thus squeezed out to a perfectly uniform thickness, and is spread over the whole table. The fibrous slab is passed through the rollers some three or four times, and it is then drawn off upon a frame fixed upon wheels prepared to receive it, by means of which it can be removed to the drying ground. The drying process of course varies much with the temperature and dryness of the air. It does not appear necessary that these slabs should dry too quickly, and there are many reasons why the process should not be prolonged.

We tried an experiment upon the non-inflammability of this material, by having a fire of wood made upon a slab and maintained there some time. When the ashes, still in a state of vivid combustion, were swept away, the slab was found to be merely charred by the intense heat. Beyond this, a piece of fibrous slab was thrown into the middle of the fire and the flames were urged upon it : under the influence of this intense action it did not appear possible to kindle it into a flame ; it smouldered very slowly, the organic matter charring, but nothing more.

The Fibrous Slab Company is certainly producing a material which, in many of its applications, must prove of the greatest utility, while great additional value is given to it from the circumstance of its resisting the attacks of insects, and being non-inflammable, under any of the ordinary operations of combustion.

Papier-Mâché may be said, therefore, to consist of three varieties. 1. Sheets of paper pasted together, exposed to great pressure, and then polished ; 2. Sheets of considerable thickness, made from ordinary paper pulp ; and 3. Such as we have described in the manufacture of the fibrous slab. — E. J. H.

A new composition has recently (1858) been patented by Mr. John Cowdery Martin, which he designates a " Plastic compound for the manufacture of articles in imitation of wood carvings, &c." The patentee thus describes his process, and the resulting material : —

" The object I have had in view is the production of a plastic compound applicable to the manufacture of moulded articles, which, when hardened, resembles wood in the closeness of its texture and fibrous character throughout, and is particularly applicable to the manufacture of articles intended to imitate wood carvings. The new manufacture may also be called ceramic papier-mâché, from the wax-like character of the compound when in a soft state, or before hardening. The compound consists of twenty-eight parts (dry) by weight of paper pulp, or of any fibrous substances of which paper may be made, reduced to pulp by means of an ordinary beating engine, or other means used for the manufacture of pulp; twenty parts of resin, or rosin, or pitch, or other resinous substance. I prefer resin or rosin; ten parts of soda or potash to render the resin soluble; twenty-four parts of glue, twelve parts of drying oil, and one part of acetate or sugar of lead, or other substance capable of hardening or drying oil. The pulp after leaving the beating engine is to be drained and slightly pressed under a screw or other press, to free it partly from water. The resin and alkali are then to be boiled or heated together and well mixed. The glue is to be broken up in pieces and melted in a separate vessel with as much water as will cover it, and then to be added to the resin and alkali, which mixture is then to be added to the pulp and thoroughly incorporated with it. The acetate of lead well mixed in the oil is then to be added, and the whole mass or compound is then to be thoroughly mixed. The quantity of resin and alkali, in proportion to the glue used, might vary, or glue might even be dispensed with when the acetate of lead would be proportionately increased. After mixing the compound, it is to remain exposed to the air for three or four days before using, and to be continually turned to free it from some of its moisture, for the purpose of partially drying, when it is to be well kneaded, and again exposed to the air for a few hours; and this operation of kneading and partial drying may be repeated until the compound is considered to be sufficiently stiff and plastic, as, during the process of kneading or working together, it becomes extremely plastic, resembling from this quality, when sufficiently kneaded, wax or clay, and it may then be worked, pressed, or moulded into any required form. The compound may be kept in a plastic state for some weeks, or even months before using, if required, by keeping it from exposure to the air and occasionally kneading or working it together. The moulds should, previous to pressing therein the compound, be brushed with oil, or with oil in which is mixed a little acetate of lead. The article taken from the mould is to be thoroughly dried, and afterwards it may be baked in an oven at a moderate heat, the temperature to be low at first, and gradually increased, care being taken not to scorch or injure the fibres of the compound. The plastic compound so made and treated acquires many of the peculiarities of wood, as regards hardness and strength, and it may be cut, or carved and polished, if required. Any colour may be added to the compound when in a soft state, or two or more portions of the compound, stained with different colours, may be worked together to form a grain to more nearly imitate the appearance of wood. The use of the alkali being to render the resinous substance sufficiently soluble to combine with the wet pulp, a more or less quantity than that given in proportion to the resin may be used, according to the degree of solubility thought to be necessary. When potash is used, it may be dissolved in water before being heated with the resin. The quantity of glue may vary, and may be increased to twice the quantity of resin, or even more, or sufficiently so as to dispense with the acetate of lead, as it gives hardness, and with oil prevents the compound from sticking; but mixed in this manner it cannot be so well kneaded, and does not retain so fine an impression. I prefer using with the ingredients as above mentioned the acetate of lead; but half a part by weight of a solution of sulphuric or other acid, diluted with twenty times its volume of water, may be substituted for the one part of acetate of lead. The oil mixed with the other ingredients is used to prevent the compound from adhering to the surface of the moulds, but the less oil consistently with this object that is used, the better. Only half the proportion of oil stated to be used as above may be added at the time of mixing the ingredients of the compound, and the remainder may be added during the process of kneading or working up the mass. I wish it to be understood, although I prefer to use resin or rosin or pitch to form the compound, that other resinous bodies soluble with alkalies may be used, as the gums copal, mastic, elemi, lac, Canadian balsam, Venice turpentine, or other resinous bodies of a like kind, either separately, or mixed according to the facility with which they will combine with wet pulp, and the convenience with which the compound may be worked, as will be well understood by persons conversant with these substances."

PAPIN'S DIGESTER. See Digester.

PARAFFINE; from *parum affinis*, indicating the want of affinity which this substance exhibits to most other bodies.

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 olefiant gas. It is decomposed neither by chlorine, strong acids, alkalies, nor potassium; and unites by fusion with sulphur, phosphorus, wax, and rosin. It dissolves readily in warm fat oils, in cold essential oils, and in ether, but sparingly in boiling absolute alcohol. Paraffine is a singular solid bicarburet of hydrogen. It has been obtained by the destructive distillation of peat.

The solid obtained is manufactured into beautiful candles, not more than 300 tons, however, being employed annually in this manufacture. See NAPHTHA; MINERAL OILS; PEAT; DESTRUCTIVE DISTILLATION.

PARAGUAY TEA. The leaves of the *Ilex Paraguaiensis*, which are used as tea in Brazil. They appear, like tea, to contain some *theine*, with resin, tannic acid, oil, and albumen.

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.

Everything 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 CURRYING. It is a semi-circular double-edged knife, made fast in 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 soon gets 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 equalise 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 Strasburg 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 crystallised 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.

PARCHMENT, VEGETABLE. Vegetable parchment is made from waterleaf or unsized paper, of which ordinary blotting paper is a common example, and is well adapted for the process. This is manufactured from rags of linen and cotton, thoroughly torn to pieces in the pulping machine, and it is found that long fibred paper is not so good for the production of vegetable parchment as that which is more thoroughly pulped. The structure of the waterleaf may be regarded as an interlacement of vegetable fibres in every direction, simply held together by contact, and consequently offering a vast extension of surface and minute cavities to favour capillary action.

To make vegetable parchment, the waterleaf or blotting paper is dipped in diluted sulphuric acid when the change takes place, and though nothing appears to be added or subtracted, the waterleaf loses all its previous properties and becomes vegetable parchment.

This very remarkable transformation is, however, a most delicate chemical process. The strength of the acid must be regulated to the greatest nicety, for if on the one hand it is too dilute, the fibre of the paper is converted into a soluble substance, probably dextrine, and its paper-like properties are destroyed. If, however, the acid be too strong, it also destroys the paper and renders it useless.

For the most perfect result, the sulphuric acid and water should be at ordinary temperatures in the proportion of about two volumes of oil of vitriol and one volume of water, and if the paper be simply damped before immersion, the strength of the acid is altered at these spots, and the part so acted upon is destroyed.

To make vegetable parchment, the waterleaf is dipped into the sulphuric acid exactly diluted to the desired strength, when in the course of a few seconds the paper will be observed to have undergone a manifest change, by which time the transformation is effected in all its essential points. The acid has then done its work, and is to be thoroughly removed from the paper, firstly by repeated washings in water, and subsequently by the use of very dilute ammonia to neutralise any faint trace of acid which escapes the washing in water. All minute traces of sulphate of ammonia left by the former process are removed as far as possible by further washings, and in certain cases the infinitesimal trace of ammonia may be removed by lime or baryta.

The action and intent of these several processes are to render the vegetable parchment perfectly free from any acid or salt, and the object is thoroughly obtained in the large way.

When the paper has undergone its metamorphosis, it is simply dried when it becomes vegetable parchment, differing from blotting paper, and possessing peculiarities which separate it from every other known material. The surfaces of the paper appear to have undergone a complete change of structure and composition. All the cavities of the waterleaf are closed, and the surface is solidified to such an extent, that if a portion of vegetable parchment be heated over a flame, blisters will occur from pent-up steam, which are evolved in the centre of the paper, and even in the aerial state the vapour cannot pass either surface. The material of the metamorphosed surfaces is certainly one of the most unalterable and unchangeable of all known organic substances, and requires a distinctive name to indicate its individuality.

From Dr. Hofmann's report on this remarkable substance we extract the following remarks:—

"In accordance with your request, I have carefully examined the new material, called vegetable parchment, or parchment paper, which you have submitted to me for experiment, and I now beg to communicate to you the results at which I have arrived.

"I may here state that the article in question is by no means new to me; I became acquainted with this remarkable production very soon after Mr. W. E. Gaine had made known his results, and I have now specimens before me which came into my possession as early as 1854.

"The substance submitted to me for examination exhibits in most of its properties so close an analogy with animal membrane, that the name adopted for the new material seems fully justified. In its appearance, vegetable parchment greatly resembles animal parchment; the same peculiar tint, the same degree of translucency, the same transition from the fibrous to the hornlike condition. Vegetable, like animal parchment, possesses a high degree of cohesion, bearing frequently-repeated bending and rebending, without showing any tendency to break in the folds; like the latter, it is highly hygroscopic, acquiring by the absorption of moisture increased flexibility and toughness. Immersed in water, vegetable parchment exhibits all the characters of animal membrane, becoming soft and slippery by the action of water, without, however, losing in any way its strength. Water does not percolate through vegetable parchment, although it slowly traverses this substance like animal membrane by endosmotic action.

"In converting unsized paper into vegetable parchment or parchment paper by the process recommended by Mr. Gaine, viz. immersion for a few seconds in oil of vitriol diluted with half its volume of water, I was struck by the observation, how narrow are the limits of dilution between which the experiment is attended with success. By using an acid containing a trifle more of water than the proportion indicated, the resulting parchment is exceedingly imperfect; whilst too concentrated an acid either dissolves or chars the paper. Time, also, and temperature are very important elements in the successful execution of the process. If the acid bath be only slightly warmer than the common temperature, 60° F. (15·5° C.)—such as may happen when the mixture of acid and water has not been allowed sufficiently to cool—the effect is very considerably modified. Nor do the relations usually observed between time, temperature, and concentration, appear to obtain with reference to this process; for an acid of inferior strength, when heated above the common temperature, or allowed to act for a longer time, entirely fails to produce the desired result. Altogether, the transformation of ordinary paper into vegetable parchment is an operation of considerable delicacy, requiring a great deal of practice; in fact, it was not until repeated failures had pointed out to me the several conditions involved in this reaction, that I succeeded in producing papers in any way similar to those which you have submitted to me for experiment.

"It is obvious that the transformation, under the influence of sulphuric acid, of paper into vegetable parchment, is altogether different from the changes which vegetable fibre suffers by the action of nitric acid; the cellulose receiving, during its transition into *pyroxylin* and *gun-cotton*, the elements of hyponitric acid in exchange for hydrogen, whereby its weight is raised, in some cases by forty, in others, by as much as sixty per cent. As the nitro-compounds thus produced differ so essentially in composition from the original cellulose, we are not surprised to find them also endowed with properties altogether different; such as, increased combustibility, change of electrical condition, altered deportment with solvents, &c., whilst vegetable parchment, being the result of a molecular transposition only, in which the paper has lost nothing and gained nothing, retains all the leading characters of vegetable fibre, exhibiting only certain modifications which confer additional value upon the original substance.

"The nature of the reaction which gives rise to the formation of vegetable parchment having been satisfactorily established, it became a matter of importance to ascertain whether the processes used for the mechanical removal of sulphuric acid from the paper had been sufficient to produce the desired effect. It is obvious that the valuable properties acquired by paper, by its conversion into vegetable parchment, can be permanently secured only by the entire absence or perfect neutralisation of the agent which produced them. The presence of even traces of *free* sulphuric acid in the paper would rapidly loosen its texture, the paper would gradually fall to pieces, and one of the most important applications which suggest themselves, viz. the use of vegetable parchment in the place of animal parchment for legal documents, would thus, at once, be lost. The paper was found to be entirely free from this acid.

"The absence of free sulphuric acid in the parchment paper was, moreover, established by direct experiment. The most delicate test papers left for hours in contact with moistened vegetable parchment, did not exhibit the slightest change of colour. For this purpose, bands of vegetable and of animal parchment both ⅞ of an inch in width, and as far as possible of equal thickness, were slung round an horizontal cylinder, and appropriately fixed by means of an iron screw-clamp pressing both ends upon the upper part of the cylinder. The band assumed in this manner the shape of a ring, into the bend of which a small cylinder of wood was placed projecting on each side about an inch over the band, and carrying by means of strings fastened to each end a pan, which was loaded with weights, until the band gave way. A set of experiments made in this manner led to the following result:—

Waterleaf paper broke, when loaded with

I.	II.	III.	Mean.
17lb.	15lb.	15lb.	15·6lb.

Vegetable parchment broke, when loaded with

I.	II.	III.	Mean.
78lb.	75lb.	70lb.	74lb.

Animal parchment broke, when loaded with

I.	II.	III.	Mean.
92lb.	78lb.	56lb.	75lb.

The strips of vegetable and animal parchment were selected as nearly as possible of equal thickness, but the strips of the artificial product were somewhat heavier than those of real parchment. On an average the former weighed 18 grains, and the latter only 12·75 grains. Calculated for equal weights, the strength of animal parchment, as compared with that of artificial parchment, is obviously $\frac{18}{12{\cdot}75} \times 75 = 105$. In round numbers, it may be said that vegetable parchment has three-fourths the strength of animal parchment."

PARIAN. See POTTERY.

PARQUETRY, *Parquetage.* Inlaid flooring. In most cases thin veneers are cut into geometric forms and cemented to the planks which are to form the floors. Lately the Messrs. Arrowsmith have introduced their "solid parquetry," in which the wood is cut of the required thickness, and ingeniously joined together in geometric patterns. See BUHL, MARQUETRY, REISNER.

PARTING. See REFINING of GOLD and SILVER.

PARTRIDGE-WOOD. The wood of several trees appears to be imported under this name. It is principally used for walking-canes, and for umbrella and parasol sticks.

PARVOLINE, $C^{18}H^{13}N$. A volatile nitryle base found in the naphtha from the Dorset Shale. It is isomeric with cumidine. It is the highest known member of the pyridine series.—(C. G. W.)

PASTEL is the French name of coloured crayons.

PASTEL is a dye-stuff, allied to INDIGO, which see.

PASTES, or FACTITIOUS GEMS. (*Pierres précieuse artificielles*, Fr.; *Glaspasten*, Germ.) As this may be regarded as a purely French manufacture, we retain the authorities relied on by Dr. Ure. 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 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, ½ grain 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 pearlash; and the borax should be refined by one or two crystallisations. 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.

	Grains.
Rock crystal	4056
Minium	6300
Pure potash	2154
Borax	276
Arsenic	12

No. II.

Sand	3600
Ceruse of Clichy (pure carbonate of lead)	8508
Potash	1260
Borax	360
Arsenic	12

No. III.

	Grains.
Rock crystal	3456
Minium	5328
Potash	1944
Borax	216
Arsenic	6

No. IV.

Rock crystal	3600
Ceruse of Clichy	8508
Potash	1260
Borax	360

Topaz.

	Grains.
Very white paste	1008
Glass of antimony	43
Cassius purple	1

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 :—

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

These mixtures 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 Ancient 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 :—

Paste.	Grains.
Litharge	100
White sand	75
White tartar, or potash	10

Amethyst.	Grains.
Paste	9216
Oxide of manganese	from 15 to 24
Oxide of cobalt	1

Emerald.	Grains.
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. Pastille, is the French name of certain aromatic sugared confections ; called also *tablettes*. See PERFUMERY.

PATINA. The green coating—carbonate of oxide of copper—which covers ancient bronzes and copper medals. True Patina, is an *ærugo* or verdigris produced by the long-continued action of carbonic acid on the metal buried in the soil. It is very commonly imitated by fraudulent dealers. *Patina*, or Patella, was also the name of a bowl made of either metal or earthenware.—*Fairholt.*

PEACH. A Cornish miners' term, given to chlorite and chloritic rocks. A *peachy lode* is a mineral vein composed of this substance; generally of a bluish-green colour, and rather soft.

PEARLASH, POTASH. See POTASH, CARBONATE.

PEARLS (*Perles*, Fr.; *Perlen*, Germ.) are the productions of certain shell-fish, the pearl oyster. These molluscæ 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 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.

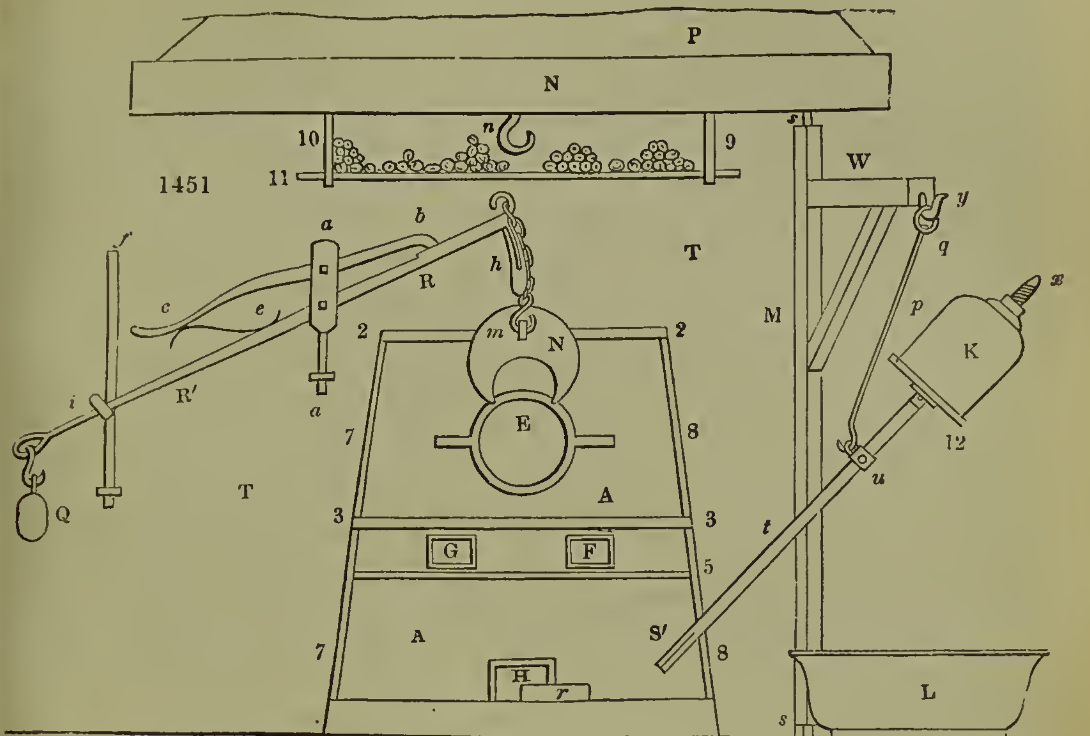
PEARLS, ARTIFICIAL. These are small globules or pear-shaped spheroids of thin glass, perforated with two opposite holes, through which they are strung, and mounted into necklaces, &c., like real pearl ornaments. They must not only be white and brilliant, but exhibit the iridescent reflections of mother 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 *lamellæ*, separated by washing and friction, of the scales of a small river fish, the bleak, called in French *ablette*. 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 volatilised in the act of drying the globules. See *Beckman's History of Inventions* for an interesting account of this manufacture.

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 greatly excel in this ingenious branch of industry.

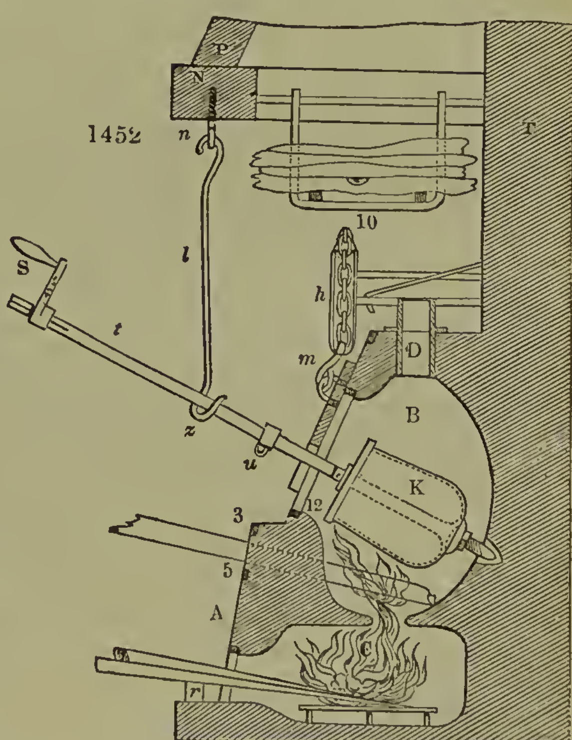
These false pearls were invented in the time of Catherine de Medicis, by a person of the name of Jaquin. The manufacture of pearls is principally carried on in the department of the Seine in France. There are also manufactories in Germany and Italy, but to a small extent. In Germany, or rather Saxony, 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 discovered 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.

The material out of which these beads are formed is small glass tubing like that 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. 1451 and 1452 represent a new apparatus for rounding the beads; *fig.* 1451 is a front view of the whole ; *fig.* 1452 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.* 1452) a nearly egg-shaped space, B, 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, E, *fig.* 1451. Beneath are two smaller oblong rectangular orifices, F, G, which extend somewhat obliquely into the laboratory, B. H serves for introducing the wood into the fire-place. All these four openings are, as shown in *fig.* 1451, secured from injury by iron mouth pieces. The wood is burned upon an iron or clay bottom piece, *r*. A semi-circular cover, N, closes during the operation the large opening E, which at other times remains open. By means of a hook, *m*, and a chain, which rests upon a hollow arch, *h*, the cover N is connected with the front end of the long iron lever R, R′. A prop supports at once the turning axis of this lever and the catch *b*, *c*; the weight Q draws the arm R down, and thereby holds up N; E therefore remains open. By rods on the back wall, T T, the hook *i*, in which R′ rests, proceeds from *f*. When R′ is raised R sinks. The catch *c b* enters with its front tooth into a slanting notch upon the upper edge of R spontaneously by the action of the spring *e*, whereby the opening E 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, K 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 *x* (*fig.* 1451) rests during the working in a conical iron step of the laboratory, *fig.* 1452. On the mouth of the drum K 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 K 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 *n*, upon the mantel beam N. On the upper end of *t* the handle s is fixed for turning round continuously the vessel K while the fire is burning in the furnace, the fuel being put not only in its bottom chamber, but also into the holes F, G (*fig.* 1451). The fire-wood is made very dry before being used, by piling it in logs upon the iron bars 9, 10, 11, under the mantelpiece, as shown in *figs.* 1451, 1452.

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 K, a projection at *u*. Alongside the furnace (*fig.* 1451) there is a crane, M, that turns upon the step, *s*, on the ground. The upper pivot turns in a hole of the mantel-beam, N. Upon the horizontal arm W of the crane there is a hook, *y*, and a ring, *q*, 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*, *q*, any desired position can be given to the drum. *Fig.* 1451 shows how the workman can with his hand applied to s′ depress the axle *t*, and thereby raise the drum K so high that it will empty itself into the pot L 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.* 1452.

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 and finally 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 sub-nitrate of bismuth. See BISMUTH.

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 appears; *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 12 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 $3\frac{1}{4}$ per cent., whilst the lowest four 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 succulent material being lost, and in the lower we find the change still more 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 localites, 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 attention 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 $\frac{3}{4}$ lb. of dry turf, and $\frac{1}{4}$ lb. of water. The $\frac{3}{4}$ lb. can only evaporate $4\frac{1}{2}$ lbs. of water; but out of this it must first evaporate the $\frac{1}{4}$ lb. contained in its mass, and hence the water boiled away by such turf is reduced to $4\frac{1}{4}$ 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 $5\frac{1}{3}$ 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; there is, however, as some experiments made on Dartmoor show, some liability to that burning away of the metal which may arise from the local intensity of coke. If it be required, it is quite possible to obtain a very intense heat with turf.

The removal of the 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 utilise turf in its natural condition, or compressed or impregnated pitchy matter, but we may carbonise 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 1157 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 coked in close vessels.

The economical carbonisation 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 carbonisation 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 coke, and little inferior to wood charcoal.

It is peculiarly important, in the preparation of the charcoal from the 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 lower strata contains from 20 to 30 per cent. This latter quantity might altogether unfit it for practical purposes.—*Ansted.*

Peat is cut and prepared in a very simple manner. The surface matter being removed, a peculiar kind of spade called a *slade* is employed. This is a long spade with a portion of the blade turned up at right angles on one side. With this the turf is cut out in the shape of thick bricks; these are piled loosely against each other to dry. The longer peat is kept, and allowed to dry, the more important it becomes as a heating agent.

On Dartmoor the peat is cut by the convicts, working in gangs, and being dried, it is carefully stored in one of the old prisons. From this peat, by a most simple process gas is made, with which the prisons at Prince Town are lighted. The illuminating power of this gas is very high. The charcoal left after the separation of the gas is used in the same establishment for fuel, and for sanitary purposes, and the ashes eventually go to improve the cultivated lands of that bleak region. Attempts were made here many years since to distil the peat for naphtha, paraffine, &c., but the experiments not proving successful the establishment was abandoned.

Experiments of a similar character have been made in Ireland, especially by a company working under the patents of Mr. Rees Reece. A government commission made their Report on these experiments. The whole matter was so ably examined by Sir Robert Kane (Director of the Museum of Irish Industry), and by his assistant Dr. Sullivan, that we quote somewhat largely from their Report.

The object being to ascertain the necessary facts regarding the products of commercial value, the following was the course pursued:—

Specimens of turf representing the several ordinary varieties were separately experimented on, and the results examined.

The products of the distillation were collected as—

1. Charcoal.
2. Tar.
3. Watery liquids.
4. Gases.

The relative quantities produced by 100 parts of peat were found to be—

	Average.	Maximum.	Minimum.
Charcoal - - -	29·222	39·132	18·973
Tarry products - -	2·787	4·417	1·462
Watery products - -	31·378	38·127	21·819
Gases - - - -	36·616	57·746	25·018

The peats yielding those proportions of products had been found to contain previous to distillation, as dried in the air, a quantity of hygrometric moisture, and to yield a proportion of ashes in 100 parts as follows:—

	Average.	Maximum.	Minimum.
Moisture - - -	19·71	29·56	16·39
Ashes - - - -	3·43	7·90	1·99

The several products of the distillation thus carried on were next specially examined for the several materials of which the quantities and commercial value had been the principal sources of the public interest of this inquiry.

The inquiry having reference, however, to the technical objects of the process, was carried on by examining the produce of

I. Tar for— 1. Volatile oils.
2. Fixed (less volatile) oils.
3. Solid fats, or paraffine.
4. Kreosote.

II. Watery liquids for—1. Acetic acid.
2. Ammonia.
3. Pyroxylic spirit.

III. Gases for illuminating and heating power.

The following numbers will indicate the results obtained in average. All the details of the processes of separation, and the numbers of the individual experiments, were given in special reports.

In seven series of distillation in close vessels, there was obtained from 100 parts of peat—

	Average.	Minimum.	Maximum.
Ammonia - - -	0·268	0·181	0·404
or as			
Sulphate of ammonia -	1·037	0·702	1·567
Acetic acid - - -	0·191	0·076	0·286
or as			
Acetate of Lime - -	0·280	0·111	0·419
Pyroxylic spirit - -	0·146	0·092	0·197
Volatile oils - - -	0·790	0·571	1·262
Fixed oils - - -	0·550	0·266	0·760
Paraffine - - -	0·134	0·024	0·196

It is thus seen that the proportions of those products vary within wide limits, which are determined by differences of quality of the turf or temperature in the distillation.

Several trials were made to determine the amount of kreosote present in the tar, but although its presence could be recognised, its proportion was so minute as to render its quantitative estimation impossible. This circumstance constitutes an essential distinction of peat-tar from wood-tar, and indicates for the former an inferior commercial value, as the presence of kreosote, now so extensively employed, is an element in the estimate of the price of the tar obtained by distilling wood.

"It will be understood," writes Sir Robert Kane, "that the materials indicated in the foregoing table by the names 'fixed and volatile oils' are in reality mixtures of a variety of chemical substances of different volatilities and compositions—generally carbohydrogens—of which the further separation would be a labour of purely scientific curiosity, without having any bearing upon the objects of the present report. Although, therefore, those liquids were carefully examined, and observations made regarding their chemical history, I shall not embarrass the present report by reference to them in any other point of view than as products of destructive distillation whose properties, analogous to the highly volatile and to the fixed oils respectively, may give them a commercial value such as has been represented. I may remark also, that as a purely scientific question, the true nature of the solid fatty product is of much interest. The name paraffine has been given to this body, but in some of its characters it appears to deviate from those of the true paraffine, as described by Reichenbach to be obtained from wood-tar; those differences should, however, not contravene its commercial uses." See PARAFFINE.

"The inquiry so far carried on sufficiently established that the peat by destructive distillation in close vessels yielded the several products that had been described, and were identical, or closely analogous, to those afforded in the distillation of wood or coal. The process in close retorts, however, being not at all that proposed or economically practicable for commercial purposes, it was necessary to proceed to determine whether the same varieties of peat, being distilled in a blast furnace, with a current of air, so that the heat necessary for the distillation was produced by the combustion of the peat itself, would furnish the same products, and whether in greater or in less quantities than in the process in close vessels.

"For this purpose, the cylinder which in the former series of experiments had been set horizontally in the furnace, was placed surrounded by brickwork vertically, its mouth projecting a little at top, so that the tube for conveying away the products of the distillation passed horizontally from the top of the brickwork casing to the condensing apparatus. Near the bottom of the cylinder the brickwork left a space where the cylinder was perforated by an aperture $1\frac{1}{4}$ inch diameter, to which the tube of a large forge bellows was adapted. The arrangement thus represented nearly the construction of an iron cupola. The cylinder being charged with peat, of which some fragments were first introduced lighted, and the blast being put on, the combustion spread, and the cover of the cylinder being screwed down, the distillation proceeded, the products passing with the current of air into the series of condensing vessels, and the gases and air finally being conducted by a waste pipe to the ashpit of a furnace where they were allowed to escape.

"By this means there was obtained, on a moderate scale, a satisfactory representation of the condition of air-blast distillation of peat which has been proposed as the commercial process. In so carrying it on several interesting observations were made which will require to be noticed here in a general point of view.

"First, as to the nature and quantities of the products. The specimens of peat operated on were selected as similar to those employed in the former series of which the results have been quoted, and the products similarly treated were found to be, from 100 parts—

	Average.	Maximum.	Minimum.
Watery products - -	30·714	31·678	29·818
Tarry products - -	2·392	2·510	2·270
Gases - - - -	62·392	65·041	59·716
Ashes - - - -	4.197	7·226	2·493

"These several products having been further examined, as in the former case, gave from 100 parts of peat—

	Average.	Maximum.	Minimum.
Ammonia - - - -	0·287	0·344	0·194
or as			
Sulphate of ammonia - -	1·110	1·330	0·745
Acetic acid - - -	0·207	0·268	0·174
or as			
Acetate of lime - - -	0·305	0·393	0·256
Pyroxylic spirit - - -	0·140	0·158	0·106
Volatile oils - - -	1·059	1·220	0·946
Paraffine - - - -	0·125	0·169	0·086

"It is now important to compare these average results with those of the former series obtained by distillation in close vessels; we obtain—

	Average produce from close distillation.	Average produce by air-blast distillation.
Ammonia - - -	0·268	0·287
or as		
Sulphate of ammonia -	1·037	1·110
Acetic acid - - -	0·191	0·207
or as		
Acetate of lime - -	0·280	0·305
Pyroxylic spirit - -	0·146	0·140
Oils - - - - -	1·340	1·059
Paraffine - - - -	0·134	0·125"

Experiments were made at the request of Sir Robert Kane, by Dr. Hodges, Professor of Agriculture, to determine the commercial value of the peat products.

The quantities and nature of the products, as certified by Dr Hodges, in the one trial which he superintended, compared with the Museum average results reduced to the same standard (Dr. Hodges' acetic acid having been 25% of real) are—

	Professor Hodges. From a ton.	From 100 parts.	Museum. From a ton.	From 100 parts.
Sulphate of ammonia -	22¾ lbs.	1·000	24$\frac{8}{10}$ lbs.	1·110
Acetic acid real hydrated	7¼ lbs.	·328	4⅔ lbs.	·207
Wood naphtha - -	83¼ oz.	·232	50⅕ oz.	·140
Tar - - - -	99½ lbs.	4·440	53¾ lbs.	2·390

It hence is evident that the quantity of ammonia obtained at Newtown Crommelin is rather under that obtained at the Museum; but the produce of acetic acid, tar, and naphtha, has been found in average decidedly inferior to that stated, although the maximum results found in particular trials have approximated closely to Dr. Hodges' numerical results. There having been, however, apparently but a single trial so accurately followed up at Newtown Crommelin, it is necessary to contrast the results of the Museum experiments more specially with the quantitative produce expected by Mr. Reece.

Mr. Reece's statement of the produce from 100 tons of peat distilled is compared with the average results of the Museum trials in the following table:—

From 100 parts of peat.	Statement in Mr. Reece's prospectus.	Average results of Museum trials by blast process.
Sulphate of ammonia - -	1·000	1·110
Acetate of lime - - -	·700	·305
Wood naphtha - - -	·185	·140
Paraffine - - - -	·104	·125
Fixed oils - - - -	·714	1·059
Volatile oils - - -	·357	

From this comparison it is evident that the quantity of ammonia obtained is rather greater than that expected by Mr. Reece; secondly, that the quantity of paraffine and of oils may be considered the same; thirdly, that the quantity of wood-naphtha expected by Mr. Reece is more than was obtained in average, but not more than was obtained in some Museum trials. That the quantity of acetate of lime expected by Mr. Reece is more than double that which was in average obtained in the Museum, unless the commercial acetate of lime calculated for by Mr. Reece shall contain such excess of lime, &c., as shall render its weight double that which the pure article, calculated in the result of the Museum trials, should have. This latter circumstance may possibly explain the difference.

After a minute detail of the numerous experiments made by Dr. W. Sullivan, in the Laboratory of the Museum of Irish Industry, Sir Robert Kane gives the following summary of his results—

"From these considerations of the results of the experiments made in the Museum of Industry, and the trials at Newtown Crommelin, and of the circumstances of the manufacture of the same products from the other species of fuels by processes more or less analogous, it appears to me that some general conclusions may be deduced:—

"1. That the quantities of ammonia, of wood spirit, and of so called paraffine, fixed and volatile oils, stated by Mr. Reece to be obtained by distillation from peat, do not appear to be exaggerated, as they fall within the limits of the results obtained in the Museum laboratory, and approach closely to the average results. That the quantity of acetic acid or acetate of lime, stated by Mr. Reece and Dr. Hodges, could not be obtained, the result of the Museum trials affording but from one-half to two-thirds of the expected quantity of that substance. That, further, the produce of paraffine may possibly be rendered much more considerable than was stated by Mr. Reece, through a more judicious treatment of the resinous materials of the tar than had been proposed by that chemist.

"2. That the distillation with combustion of the peat in the blast furnaces must be considered to produce only the raw materials for the subsequent chemical operations, just as in the processes of wood or coal distillations, there are produced tar and ammonia, and acetic acid, which have long been the objects of manufacture.

"3. That those materials, if charged with the total cost of the peat consumed, the cost of erecting and working the furnaces, the blast engines, and condensing apparatus, and proportion of management, would not appear to be very much more economically obtained from peat, than they are now obtained from the products of wood and coal distillation, where they are sold at very low prices, and, at least as regards gas tar and gas liquor, in most places in Ireland, have been regarded as waste products.

"4. That the principal value of the class of products obtained from peat is derived from the cost of their subsequent purification and conversion into a commercial form, and that consequently the principal advantage of a new mode of obtaining them must be looked for in the more economical treatment of those materials.

"5. That to this principle the extraction of the paraffine may be an exception, it being itself a material new to commerce on a large scale, and hence not having its value determined by the comparative economy of preparation from sources of little value.

"6. That the economies introduced in the treatment of the tarry and watery products of peat distillation are reducible to two (so far as I have been able to learn):—1, the separation of the wood spirit, by means of an improved distilling apparatus; and 2, the utilisation of the waste gases from the condensing pipes, so as to supersede the use of other fuel by burning the gas in jets under the steam boilers, tar and acetic acid stills, evaporating pans, &c.

"7. That the former economy cannot be of paramount influence, as it affects but one stage of the preparation of a single product, and further might be applied in a similar way to lessen the cost of production of wood spirit from any other source.

"8. That the latter economy is of the most important character, and appears more than any other one condition to influence the probable success of the manufacture on the great scale; that therefore the amount of advantage derived from similar employment of gases in iron-smelting works will deserve careful comparison, and that it will be necessary particularly to take into account the difference of combustibility of gaseous mixtures when very hot, as when from an iron furnace, and when quite cold, as from the condensing apparatus of a peat blast furnace.

"9. That under the circumstances of a manufacture presenting so many new and complex processes, which, in analogous branches of industry, it is found convenient to separate and commit to different and individual interests, and that its conditions, as to the supply of peat, require its establishment in localities of but little industrial activity, it can scarcely be expected that even as much economy and advantage should be realised as might be expected after experience of the same process on a working scale and with trained labour.

"10. That although the excessive returns stated by the proposers of the manufacture may not be obtained, it is yet probable that, conducted with economy and the attention of individual interests, the difficulties connected with so great complexity of operations would be overcome, and the manufacture be found in practice profitable; and certainly it must be regarded as of very great interest and public utility that a branch of scientific manufacture should be established, specially applicable to promote the industrial progress of Ireland by conferring a commercial value on a material which has hitherto been principally a reproach, and by affording employment of a remunerative and instructive character to our labouring population."

PECTIC ACID (*Acid pectique*, Fr.; *Gallertsaüre*, Germ.), so named on account of its jellying property, from πηκτις, *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 neutralising it with an acid. This liquor contains pectate 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 gelatinises when alcohol, acids, alkalies, 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.

PECTIN, 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, pectin 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.

Fremy has published a very comprehensive investigation on the ripening of fruit, in which he shows that this peculiar body only exists in fruit arrived at maturity. Not a trace of pectin can be detected in the juice expressed from an unripe apple; but on boiling the juice for some seconds with the pulp, pectin immediately appears, and is indicated by the liquid becoming viscid. Fremy considers the following as the only way to procure pure pectin.

From the juice of ripe pears, expressed in the cold, and filtered, the lime is to be separated by means of oxalic acid, and the albuminous substance by the aid of tannic acid. From this liquid pectin is now precipitated by means of alcohol; it separates in long threads, which after being washed with alcohol are to be dissolved in water, and again precipitated with alcohol. This is to be repeated three or four times, until the liquid is free from sugar and oxalic acid; hot water must be avoided in these operations. If the pectin be pure, it will be precipitated from its solution so thoroughly by baryta water, that not a trace of organic matter can be found in the filtrate. See *Ure's Dictionary of Chemistry.*

PELTRY. (*Pelleterie*, Fr.; *Pelzwerk*, Germ.) This term comprehends all the skins of the wild animals found in high northern latitudes, especially on the American continent. Under FUR these are described. It should be understood that when the skins are received in their unprepared state they are properly called *peltry* or *pelts*, when tawed or tanned they become *furs*. See FUR DRESSING.

PELOPIUM. One of the very rare metals which have been extracted from minerals known as Tantalites. See TANTALUM.

PELT WOOL. Wool plucked from the pelts or skins of sheep after they are dead.

PEMMICAN. The North American Indians cut the muscular portions of meat into thin slices, having separated the fat, and dry it in the sun. This tough dry meat cannot undergo putrefaction; it is stamped closely together, so as to occupy the smallest possible space. This pemmican affords the largest amount of nutritive food in the least quantity of solid matter.

PENANG CANES are small palms which are brought from the island of that name.

PENCIL BLUE. See CALICO PRINTING.

PENCIL MANUFACTURE. (*Crayons, fabrique 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, though this includes also pencils made of differently coloured earthy compositions. See CRAYON DRAWING CHALKS.

The best black-lead pencils of this country are formed of slender parallelopipeds, cut out by a saw, from sound pieces of plumbago, especially such as have been obtained from Borrowdale, in Cumberland. (See PLUMBAGO.) These parallelopipeds are generally enclosed in cases made of cedar wood, though of late years they are also used alone, under the name of ever-pointed pencils, in peculiar pencil-cases, 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.

Pieces of plumbago sufficiently large to be thus employed, are very rare, and the supply from the Cumberland mine can no longer be relied on. The mine has been closed for some years, but during the past year (1859) a company has been formed for again working it. Many attempts have been made to utilise the smaller fragments of plumbago—as by grinding them, melting them with sulphur or antimony, and the like; but few of these have been attended with any success.

The late Mr. Brockedon was long occupied in seeking for some method which might enable him to employ the pure powder of black lead without cementing it by any substance, which inevitably injures the quality. He endeavoured to render the powder coherent by submitting it to enormous pressure; but the different machines and apparatus he at first made use of for this purpose, however strongly they were made, were broken under the pressure, and his endeavours were thus unsuccessful, until the happy idea suggested itself of operating in a vacuum. But it was with extreme difficulty, if not impossible, to introduce under the receiver of an air pump an apparatus for compressing the powder of graphite. Mr. Brockedon overcame this difficulty by an arrangement as simple as it is easily executed; for, after having compacted the powder by a moderate pressure, and thus reduced it to a certain size, he enclosed it in very thin paper glued over the whole surface. He then pierced it in one place with a small round hole permitting the escape of the air from within, when the block thus prepared was placed under an exhausted receiver, and the air having been removed, the orifice was closed with a little piece of paper (a small adhesive wafer was usually employed for this purpose) and in this state it was found that it might be left for 24 hours without injury. Being submitted to a regulated pressure once more, the different particles became agglomerated, and an artificial block of graphite (see GRAPHITE) was produced by simple pressure, as solid as the specimens obtained from the mine.

The artificial masses of plumbago thus obtained owed much of their character to the extreme fineness to which the plumbago was reduced by previous grinding under rollers. In this manner a great deal of useless plumbago is worked up into excellent black lead pencils. The different degrees of darkness in drawing pencils should be secured by the selection of specimens of plumbago of varying degrees of density. It is, however, commonly obtained by combining, with the plumbago, sulphur, or sulphuret of antimony, and by subjecting the plumbago to the action of heat. In the commoner kinds of pencil a very heterogeneous mixture is employed ; indeed, many pencils are little more than black chalks.

The description of the pencil works at Keswick, given in Chambers's Journal, in 1848, is so graphic and correct that we do not hesitate to transfer much of it to these pages.

The factory consists of a house of several stories, in the lower of which is a huge water-wheel turned by the Greta, outside being the cedar wood ready for use. The quantity of cedar consumed annually by the establishment is four thousand cubic feet. These cedar logs are sawed into planks, and then a circular saw cuts the planks into smaller pieces, preparatory for the grooving engine ; this grooving engine consists of two revolving saws, going at inconceivable speed ; one saw cutting the slips of wood into narrow square rods, and the other making a groove along the rod and cutting to size at the same time ; adjoining the grooving apparatus is a circular saw, cutting slips of cedar as covers to the grooved lengths.

The plumbago, if good, needs no refining ; it is used precisely in the condition in which it leaves the mine. To ascertain its qualities each piece is scraped with the edge of a knife, besides being otherwise tested ; and in proportion as there is no gritty particles in it, so is it the more valuable. Some pieces are harder, some a little darker in colour, than others ; and according to these peculiarities, they are employed for pencils of various hardness and shades. The whole knack of pencil-making seems to depend on the detection of these niceties in the bits of lead, and also, of course, in their honest adaptation to the varieties which are dealt out to the public. Plumbago of an impure kind is ground to powder ; the grit, as far as possible, separated from it, and the cleansed material, mingled with a cohesive liquid, is dried and pressed into hard lumps for use. This process, however, is applied principally, if not exclusively, to the plumbago imported from India, and only in reference to pencils of the commonest sort. Pencils made with such stuff are valueless to artists ; for independently of their want of tone, they are never altogether free from grit. The only good pencil is one made from genuine Borrowdale lead, pure from the mine, and adapted by a skilful manufacturer to its assigned purpose. The mode of preparing the pieces of good plumbago for the pencil is very simple. All the bits, with their surface merely scraped, are glued to a board, in order to fix them in a position for being sawn. When so fixed they are brought under the action of a saw, which divides them into thin slices or scantlings. These slices are now handed to the fitter. This is an operative who, with a lot of grooved rods before him, sticks slices of the lead into grooves, snapping off each slice level with the surface, so as just to leave the groove properly filled. In the making of a single pencil, perhaps as many as three or four slice lengths are required ; but however many, each slice is fitted exactly endlong with another, so as to leave no intervals. The rods being thus filled, are carried to the fastener-up. This person glues the cedar covers or slips over the filled rods ; and having got a certain number arranged alongside of each other, he fixes them tightly together, and lays them aside to dry. When dried they are ready for being rounded. The rounding is done by an apparatus fixed to a bench — a thing of revolving planes or turning tools. Into this engine, rods are put one after another, and out they come as fast as the eye can follow them, rounded to a perfect nicety. By this simple and efficient machine a man will round from six hundred to eight hundred dozens of pencils in a day. After being rounded they get a smoothing with a plane, and then they are polished by being rubbed with a peculiar kind of fish-skin ; this latter operation being performed by girls. Being polished, the next step is to cut the rods into lengths with a circular saw, after which the lengths are respectively smoothed at the ends. Nothing now remains but to stamp the name of the maker, with the letters significant of their quality. The stamping engine is as ingenious a piece of machinery as is in the establishment. Fed into it, the pencils are stamped in less than an instant of time. A girl will with this apparatus stamp two hundred pencils per minute. Gathered from a box below into which the pencils fall, they are carried away to be tied in bundles.

In the year 1795 M. Conté invented an ingenious process for making artificial black-lead pencils.

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 siphon 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.

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 parallelopipeds, 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 Wedgewood; 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 gridiron, 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 tabular 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 mould 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 described.

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.

PENS, STEEL, and of other Metals. As peculiar elasticity is required in these pens, now so commonly used, the best metal, made from either Dannemora or hoop iron, is selected and laminated into slips about 3 feet long, and 4 inches broad, of a thickness corresponding to the desired thickness 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.

The following description of the pens made at the works of Joseph Gillott, Birmingham, was written by Mr. W. C. Aitken, of Birmingham, for the illustrated catalogue of the Great Exhibition of 1851. 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 plyers, 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. In this manufactory there are employed 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 manufacture.

Between those two descriptions there will be little difficulty in understanding the processes employed for the production of these very useful articles. Since steel necessarily corrodes by the constant action of the acids in the ink, it has been thought that they would be protected by coating them with gold or silver; and this has been effected by the electrotype process. In most cases, however, the thin film of gold is rapidly removed, and the protection therefore afforded is very small. The manipulatory details in the manufacture of gold and silver pens are so nearly similar to those above described, that it is thought unnecessary to repeat them. The best gold pens are tipped with the native alloy (see ALLOY, NATIVE), which is a compound of OSMIUM and IRIDIUM.

PEPERINO. Basaltic tuffa—a light porous species of volcanic rock, so called on account of the peppercorn-like fragments of which it is composed.

PEPPER. (*Poivre*, Fr.; *Pfeffer*, Germ.) The pepper tree (*Piper nigrum*) is cultivated in many parts of India, and to some extent in the West Indies. When the berries begin to change colour from green to red, they are collected, spread out, and dried in the sun. The stalks are separated by hand rubbing, and then winnowing. The dry and shrivelled berries constitute the *black pepper;* the soundest grains are selected for *white pepper*. These are soaked in water until they swell and burst their corticle, which is afterwards separated by hand rubbing and winnowing.

In McCulloch's *Dictionary of Commerce* is a paper on the production of pepper, by Mr. Crawford, in which we find the following distribution:—

	lbs.
Sumatra (west coast)	20,000,000
Sumatra (east coast)	8,000,000
Islands in the Straits of Malacca	3,600,000
Malay peninsula	3.733,333
Borneo	2.666,667
Siam	8,000,000
Malabar	4.000,000
Total	50,000,000

Pereira particularises the following kinds of pepper:—

1. *Malabar pepper.*—The most valuable—a *brownish black.*
2. *Penang pepper.*—*Brownish black*, but dusty; sometimes used in England to manufacture white pepper.
3. *Sumatra pepper.*—This is the cheapest sort. This is the black pepper of commerce. The heavier kinds are the most esteemed. and are known as *shot pepper.*
4. *Fulton's decorticated pepper.*—Black pepper, deprived of its husks by mechanical trituration.
5. *Bleached pepper.*—Penang pepper bleached by chlorine.
6. *White pepper*, described above.
7. *Tellicherry pepper.*
8. *Common white pepper.*—Comes from Penang by Singapore.

Pepper is stated to be adulterated with sago. This can always be detected by the microscope, the starch grains of sago being very much larger than those of pepper. Dr. Hassel has stated in the *Lancet* that although he frequently found pepper to be adulterated with linseed-meal, rice, and wheat flour, yet, that out of forty-three samples obtained from various sources, he did not detect sago meal in any.

The Editor was acquainted with a druggist who was constantly in the habit of preserving all the exhausted vegetable matters of his tinctures, decoctions, and infusions. These were dried, ground at the drug mills, and sold indiscriminately to the grocers and snuff-dealers for adulterating pepper and snuff. Dr. Ure has the following remarks on an Excise case connected with the supposed adulteration of pepper:—

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 8½ 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 of 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.

Four pounds of black pepper yield only about one ounce of piperine, or one 636th 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. See PIPERINE.

Our *imports* of pepper in 1858, were as follows: —

Pepper.

Imported from —	lbs.	Computed value. £
Hamburg	39,584	721
Holland	48,634	816
Eastern Coast of Africa	7,789	138
Siam	64,381	1,139
Java	193,388	3,376
Sierra Leone	9,561	76
St. Helena	5,309	94
British East Indies	11,974,101	215,057
Other ports	14,761	244
Total weight in lbs.	12,357,508	£221,691

PEPPER BETEL. The *Chavica betle*, and the *Chavica Siriboa*, yield the leaf which is employed for mastication by many of the nations of the East. See BETEL.

PEPPER, JAMAICA. See PIMENTO.

PEPPER, LONG. *Piper Longens* of *Lin.* This shrub is cultivated in Bengal, and forms a considerable article of commerce all over India. The common long pepper is of a greyish brown; it is cylindrical and of about an inch in length.

PERCUSSION CAPS. The universal employment of the percussion cap in the place of the flint-lock, has given rise to many most extensive manufactories devoted to their construction.

Thin rolled copper, as pure as possible, is selected. This is first cut into pieces called *blanks*. These are then punched up into the required shape.

They are charged by touching the bottom of each cap with a strong adhesive liquid, and before this hardens, the fulminating composition is dropped in. All that does not adhere is shaken out. The caps are varnished, and preserved for use. See FULMINATES.

PERFUMERY, ART OF. (*Parfumerie*, Fr.; *Wohlriechende-Kunst*, Germ.;) consists in the extraction of the odours of plants, isolating them, A and B,—and in combining them with inodorous materials; such as grease, C, spirit, D, starch, E, soaps, F; also in the manufacture of cosmetics, G, dentifrices, pastes, tinctures, H, incense and pastils, I. pomades, oils, and other toilet appendages, K, hair washes, hair dyes, depilatories, L.

(A and B.) There are three distinct methods of procuring the odours of plants

1st. By Distillation. If cloves, cinnamon bark, or the odorous leaves of plants or wood, be distilled, the fragrant principle contained therein rises with the steam, which, being condensed, the otto, or essential oil, will be found floating upon the water. This process has already been described (see Distillation, Refrigeration, Ottos, or Oils, Volatile, the author of this paper preferring the term Otto—and using it for Essential Oil); but can only be beneficially applied by the perfumer to the procuring of certain odours: from woods, such as santal and cedar; from leaves, such as patchouli and bay leaves; from various grasses, such as the lemon grass and citronella of Ceylon; from the several seeds, such as carraway and nutmeg; and but to two or three flowers, such as orange blossom, rose, and lavender. The various fragrant woods, seeds, and leaves are, however, almost as numerous as there are plants upon the earth, and as a consequence, the perfumer can have as great a variety of ottos by distilling for them.

(C.) 2nd. Enfleurage. When it is desired to obtain the odours of flowers, such as those of jasmin, acacia, violet, tuberose, jonquil, and numerous others, the process of distillation is inapplicable and useless, and that peculiar but simple method, termed "Enfleurage," must be adopted. This plan is founded on the fact, that greasy bodies readily absorb odorous particles, and will as freely part with them if in contact with pure alcohol. The operation of enfleurage is thus conducted at Messrs. Piesse and Lubin's laboratory of flowers, near Nice, in Sardinia (now France, 1860).

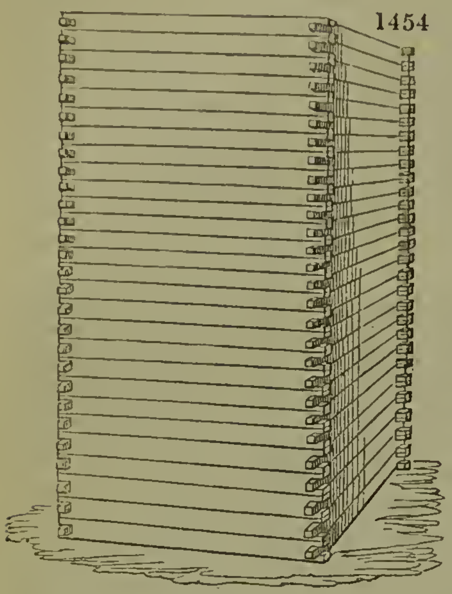
Purification of the grease. A corps, or body grease, is first produced by melting together equal parts of deer or beef suet (the former is preferred), mutton suet, and lard; it is then clarified thus:—take 1 cwt. of grease, divide it into portions of about 2 lbs., place one of these in a mortar and well pound it; when it is well crushed wash it with water repeatedly, so long, in fact, until the water is as clear, after withdrawing the grease, as before it was put in. The several lots of grease prepared in this way have now to be melted over a slow fire, adding thereto about 3 ounces of crystallised alum in powder and a handful of sea salt (common salt); now let the grease boil, but allow it to bubble for a few seconds only; then strain the grease through a fine linen into a deep pan and allow it to stand to clear itself from impurities for about two or three hours. The clear grease is then again put into the melting vessel over a charcoal fire, adding thereto about three or four quarts of rose water and half a pound of powdered gum benzoin; it is then allowed to boil gently, and all scum that rises carefully removed until it ceases to be produced. Finally, the grease is poured into deep pans to cool; when solid it is removed off the sedimentary water, and again being liquefied may be placed in store vessels for future use, where it may be kept for an indefinite period without change or becoming rancid. This purification of the grease gives employment to those engaged in the laboratory at a season when the flowers are not in bloom. M. Herman, of Cannes, and M. Pilar, of Grasse, prepare in this way during winter, together, one hundred and twenty thousand pounds of *perfectly inodorous* grease.

The growers of the flowers, of course, pay due attention to their cultivation, so as to produce an abundance of blossom in due season. Although it is not necessary that the flower farmer should be a perfumery factor, it is useful that the latter should have some knowledge of the former avocation, so as to be prepared for each harvest of flowers as they succeed each other, and when it is practicable to unite the occupations, better pecuniary results follow. At Cannes and Grasse, in France, which are separated from the frontier of Sardinia only by the river Var, and are distant from Nice about 30 miles, the entire population is more or less interested in this particular manufacture. The various flowers there cultivated do not come into blossom at one time, but in succession; so that there is ample time to attend to each in turn.

The enfleurage process is thus conducted:—Square frames varying in size from 20 to 30 inches are made, in the centre of which is fixed a piece of stout glass as in *fig.* 1453. Each frame is $1\frac{1}{2}$ inch deep from the top edge to the glass, so that if two frames be placed together face to face, there is, as it were, a glass box with a wooden frame, having a depth of 3 inches between each glass. This affords ample room for the blossoms to lie between them without being crushed.

1453

In due season, that is, when the flowers begin to bloom, about half a pound of the purified grease is spread upon each side of the glass with a spatula or palate knife. The gathered blossoms are then hand-sprinkled or broad-cast over the grease in one frame, and another frame is put over it so as to enclose the flowers. This operation is repeated as many times as there are flowers to spread over each. These frames are termed *Châsse*, which literally means "Sash." Now we are all familiar with window sashes—that is, a glass with a frame round it—and such is in truth the Châsse used in the enfleurage process. Doubtless our window "sash" is derived from the French. Châsse may also be rendered in English, "a frame." Enfleurage then, is conducted upon a glass frame or sash. About every other day, or every third day, the spent flowers being thrown away, fresh ones are placed upon the grease; this manipulation being repeated so long as the plants yield blossoms, a time that varies from 1 to 2 months. After every addition of flowers, it will be observed that the grease increases in the fragrance of the flower with which it was sprinkled, and this continues till the enfleurage is complete, at which time the grease, now called "Pomade," is scraped off the sashes, put into vessels, then placed in hot water—a water bath. By so doing the pomade is liquefied, but is not made hot enough to destroy its odour. By this treatment various extraneous matters, such as a few anthers of flowers, a stray bee, some pistils, or loose part of the corolla, a wayward butterfly and moth, and such similar things, are removed, by pouring the clear pomade into the canisters through fine linen. When the pomade is cold enough it sets in these vessels, and is then fit for exportation or for ulterior uses. *Fig.* 1454 represents a pile of châsse.



1454

3. Maceration. In some few instances better results are obtained by adopting the process of maceration, which consists in infusing the fresh flowers in liquefied grease. For this purpose, the purified grease is placed in a hot water bath, that is, the vessel containing the grease is set in another of a larger size, in which water is kept warmed over a stove. In the French laboratories, this apparatus is known as the *bain marie,* salt being put into the water to increase its boiling point. Every time fresh flowers are gathered the spent ones are strained away, and the fresh flowers put into the partially scented grease. In a few instances it is found advantageous to begin perfuming the grease by maceration, and to finally finish it by enfleurage; this is especially the case with violet pomade.

After the maceration is completed, that is, when there are no more flowers to be had, the grease must be kept steadily at a uniform degree of liquefaction, in order that friable portions of the flowers, &c., may subside, so that the fair pomade can be separated therefrom pure and unsullied. Oils are scented by enfleurage and maceration processes by a slight difference of mechanical arrangement. Thus, the sash in lieu of glass contains a wire gauze, like a coarse wire blind (*châsse en fer*); upon this gauze is laid a thick piece of fustian-like cotton fabric (*molleton du coton*), which has previously been steeped in the purest olive oil. Upon each molleton laid in the sash frame the flowers are sprinkled in the same way as if it were for pomade, and the flowers are changed as often as possible. When the plants cease to bloom, each molleton is wrapped in a strong cord net, and placed in a hydraulic or other press, for the purpose of squeezing the fragrant oil away from it. Oils of tuberose, rose, violet, jonquil, acacia, and orange are thus prepared.

According to the length of time the enfleurage process occupies, and the quantity of flowers employed over the same grease, the pomade or oil bears numbers respectively. Thus we have No. 12 pomade, No. 18 oil, No. 24 pomade, indicating their relative strength of fragrance, that is, the quantity of flowers employed in their manufacture.

(D.) Scented Spirits are produced by four separate plans.

1. By distilling alcohol with an otto, such as lavender otto, to produce spirit of lavender. For this purpose, and to produce the finest distillate, take

Otto of English lavender - - - - -	8 ounces
Rectified spirit, 60 o. p. - - - - -	8 pints
Rose water - - - - - - -	1 pint.

Mix the otto first with the spirit, then gradually add the water; finally distil off eight pints for sale. This distillate is unalterable by age, remains perfectly white, and will keep good in any climate. A great variety of scented spirits are made in this way, of which Hungary water and Eau d'Arquebuzade are good examples, the different scent or flavour being imparted by varying the combination of ottos.

2. All ottos being soluble in alcohol, a ready way of producing some kinds of concentrated essences is to dissolve the fragrant otto in the spirit. Thus, for

Essence of Roses,

Take alcohol, 60 o. p.	1 gallon.
pure otto of roses	3 ounces.

The otto quickly dissolves at a summer heat, but in cold weather beautiful acicular crystals appear throughout the liquid. Innumerable other concentrated essences may be produced in a similar way, but the standard strength varies with the otto used. Thus, for every gallon of spirit employed we should use two ounces of otto vitivert, three ounces of otto patchouli, six ounces otto geranium, eight ounces otto santal, &c.

3. TINCTURATION. Musk, orris root, ambergris, tonquin beans, castor, vanilla, civet, and a few other odorous substances, yield their odours to spirit by tincturation, that is, by putting the fragrant material into the spirit and allowing it to remain there for a period till the alcohol has extracted all the scent. The standard strength of these tinctures should be, for one gallon of alcohol, two ounces of grain musk, three ounces of ambergris, eight ounces of vanilla, eight pounds of orris root, one pound tonquin beans. The standard strength of these essences is regulated, like that of "jewellers' gold,"—by the selling price, but the above is that figuratively indicated as alone worthy of the "hall mark."

4. ENFLEURAGE ESSENCES. The great bulk of the fine quality perfumes are procured by extracting the fragrance from the enfleurage-made pomades and oils, by contact of fine alcohol with the grease or oil. The pomade is chopped up very fine and put into the spirit, and allowed to remain together for one month at a summer heat.

Supposing the finest, or No. 24 pomade or oil are used, the standard strength of these essences should be, for one gallon spirit rectified 60 o. p., of rose pomade or oil, eight pounds; of acacia, six pounds; of orange flower, eight pounds; jasmin, tuberose, violet, jonquil, seven pounds.

If oils be used, the spirit and oil require to be well shaken together daily, because the oils, by their greater specific gravity, sink out of contact with the spirit. By continual agitation the oil will not require many hours to part with their fragrance, in consequence of the mechanical subdivision which they are capable of, and hence are more intimately blended for the time with the spirit.

In this way are obtained essences of tuberose, orange flowers, violet, jonquil, rose, acacia, and jasmin. What are called "bouquets" and "nosegays" are mere mixtures of the above primitive odours. A few examples we now give.

Her Majesty's Perfume.

Enfleurage rose	1 pint.
„ violet	1 „
„ orange	½ „
„ tuberose	½ „
Tincture orris	¼ „
„ vanilla	¼ „

Albion Nosegay.

Essence of rose	1 pint.
Enfleurage rose	1 „
Tincture orris	½ „
„ vanilla	¼ „
„ musk	⅛ „
„ castor	⅛ „
Otto of bergamot	¾ ounce.

White Roses.

Enfleurage rose	1 pint.
Essence of rose	1 „
Enfleurage acacia	½ „
„ jasmin	¼ „
Essence patchouli	⅛ „

Excelsior Perfume.

Enfleurage acacia	1 pint.
„ orange	1 „
„ jasmin	1 „
Essence rose	1 „
Tincture vanilla	½ „
„ civet	¼ „
Otto almonds	½ drachm.

Frangipanni's Scent.

Enfleurage violet - - - - - - - -	1 quart.
Tincture of orris - - - - - - - -	1 ,,
,, vanilla - - - - - - -	1 pint.
Essence neroli - - - - - - -	1 ,,
,, rose - - - - - - -	1 ,,
Tincture tonquin beans - - - - - -	½ ,,
,, musk - - - - - - -	¼ ,,
Essence santal wood - - - - - -	¼ ,,
Otto of cloves - - - - - - -	⅓ drachm.

St. Valentine's Nosegay.

Enfleurage acacia - - - - - - -	1 quart.
,, jasmin - - - - - - -	1 pint.
,, jonquil - - - - - -	1 ,,
Esprit rose - - - - - - - -	1 ,,
Tincture balsam of Peru - - - - -	¼ ,,
Otto, citron zeste - - - - - - -	1 ounce.
Otto, orange zeste - - - - - - -	½ ,,

Every perfumer has some special formula, so that scarcely two houses work exactly the same mixture, although the *predominating* otto may be recognised which gives each particular perfume some specialty, as the bergamot does in the Albion nosegay, and the patchouli does in the white roses of the above.

Hungary Water and Eau de Cologne.

These preparations have long possessed great celebrity, in consequence chiefly of the numerous virtues ascribed to them. They are resorted to by many votaries of fashion as a panacea against ailments of every kind. They are, however, nothing more than aromatised alcohol, and as such are agreeable companions to the toilet.

Eau de Cologne derives its name from the city of Cologne, on the Rhine, at which place there are annually manufactured about 4,000,000 bottles. Hungary water is said to take its name from one of the queens of Hungary, who is reported to have derived great benefit from a bath containing it, at the age of 75 years. This preparation contains rosemary, which is said to excite the mind to vigorous action.

As will be seen by the following recipes, these waters are similarly constituted and prepared :—

Eau de Cologne — best quality.

Rectified alcohol, 60° over proof - - -	10 gallons.
Otto of neroli of orange - - - -	7 ounces.
,, rosemary - - - - - -	3 ,,
,, orange zeste - - - - -	16 ,,
,, bergamot - - - - - -	3 ,,

Eau de Cologne — second quality.

Alcohol, 50° over proof - - - - -	10 gallons.
Otto of petit-grain orange - - - -	5 ounces.
,, rosemary - - - - - -	4 ,,
,, lemon - - - - - - -	5 ,,
,, bergamot - - - - - -	5 ,,

Hungary Water.

Rectified alcohol, 60° over proof - - -	10 gallons.
Otto of neroli of lemon - - - - -	15 ounces.
,, petit-grain of orange - - - -	5 ,,
,, rosemary - - - - - - -	6 ,,
,, citron zeste - - - - - -	3 ,,
,, neroli of orange - - - - -	2 ,,

Very fine Eau de Cologne and Hungary water can be made by merely mixing the ingredients as indicated in the recipes, but it is far better to mix the citrine ottos with the spirit, and then to distil the mixture, finally adding to the distillate the orange neroli, and the rosemary.

Both these perfumes are preferred when made with grape spirit in lieu of corn spirit. When, however, corn alcohol can only be used, its fragrance is greatly improved by the addition of one drachm of acetic ether to every gallon of spirit employed.

(E.) Powders.

Inodorous powders, such as starch, and talc, are rendered fragrant—

1. By mixing with them odorous flowers, such as orange blossom, violet, broken cloves, acacia buds, &c., allowing them to remain together for twenty-four to forty-eight hours, then sifting away the powder from the spent flowers.

2. By the addition of certain ottos, such as rose, lavender, &c., first rubbing a small portion of starch or talc in a mortar with the otto, then mixing this strongly scented portion with the remainder, by sifting the whole well together in a trough.

In this way is prepared

Rose-Scented Toilet Powder.

Wheat starch	14 lb.
Rose pink	1 oz.
Otto of rose	¼ oz.

The rose pink and the otto of rose is rubbed well with about eight ounces of starch, and finally sifted with the remainder as above described.

3. By reducing some fragrant substance, such as cinnamon, nutmeg, orris-root, to a fine powder, and mixing them with a given proportion of the inodorous starch: the violet powder of commerce is a good example.

Infants' Violet Powder.

Starch of wheat	14 lb.
Orris-root powder	3 lb.
Otto of bergamot	½ oz.
Otto of almond	¼ drachm.

Sachée Powders

consist entirely of odorous substances reduced to powder, mixed and sifted in various proportions.

Rose Sachée Powder

consists of

Rose leaves, ground	1 lb.
Santal wood powder	½ lb.
Cedar wood dust	½ lb.
Otto of rose	1 drachm.

After certain tinctures are made, there is found in the perfume laboratory a vast quantity of residue, or spent material, such as musk pods, vanilla, tonquin beans, ambergris, civet, &c. These spent materials, although not strong enough to yield any perfume to spirit, are yet fragrant, and may be judiciously used in combination with a little otto to produce a good sachée, such as

Olla Podrida,

which consists entirely of spent materials well ground together, and a little otto, rose, and lavender rubbed in to increase and sweeten its odour.

Frangipanni Sachée.

Orris-root	1 lb.
Rose leaves	1 lb.
Santal wood	½ lb.
Ground Tonquin beans	½ lb.
Grain musk	1 drachm.
Civet	¼ "
Otto rose	½ "

The civet, the musk, and otto of rose, are to be rubbed well with a little of the orris, and then mixed with the other ingredients; it being understood that all the materials, rose leaves, orris root, and santal wood, have all been previously reduced to powder.

Some odorous materials are sold pure, such as patchouli herb, which is merely the leaves of the plant rubbed on a sieve to powder. Santal wood and orris root have to be reduced to powder at the drug grinder's mill.

(F.) Scented Soaps.

Soaps are perfumed by two methods.

1. By melting the soap in a hot water or steam bath, and then adding the scent when the soap is perfectly soft; various kinds and qualities of soap are used for this purpose.

Curd, or tallow soap, palm-oil soap, cocoa-nut oil or marine soap, olive-oil soap, yellow or rosin soap, potash (soft) soap. See Soap.

When mixed in different proportions, and melted and scented, they bear various fanciful names, given to them by the makers, and in some instances indicating their perfume; such as almond and rose soap. No one soap made by the soap-makers appears to give entire satisfaction to the consumer: soaps of oil do not lather sufficiently, or with freedom enough; tallow soaps are too hard, rosin or yellow soap has an unpleasant odour; cocoa-nut soap, being too alkaline, acts upon the skin. The perfumers, therefore, to make a good body soap, mix these in various proportions. Thus Piesse and Lubin prepare

Windsor Castle Soap.

Curd soap -	1 cwt.	Grain musk -	½ oz.
Marine soap -	21 lbs.	Otto of cloves -	of each 3 oz.
Olive-oil soap -	14 lbs.	„ rosemary -	
Pale yellow soap	7 lbs.	„ thyme -	
Otto carraway -	8 oz.	„ cassia -	

The soap is sliced into thin slabs and put into the steam pan in proportions of what is termed "a round," that is, the slabs are placed perpendicularly all round the side of the pans, so as to be in contact with the metal. In about half an hour this soap will have melted, or "run down." Another round is then introduced, and so continued every half hour, till the whole melting is finished.

The different soaps that are being melted must be put into the pan separately, because they do not all take the same time to liquefy: thus we must have a round of curd, then a round of marine, then of curd again, varying each time or half hour; but each round must be of the same sort; the mixture being rendered perfect by stirring the soap with a crutch, or tool like an inverted ⊥ with a long handle. When the melting is finished, the ottos and musk are added; then the soap is turned out into a cooling frame.

The musk, before being put into the soap, has to be well rubbed in a mortar with a little water, then passed through a sieve to remove extraneous matters. When new, this soap has little fragrance, but when old its "bouquet" is delightful: the alkaline reaction of soap improves the perfume of the musk.

Brown Windsor Soap

is made of various qualities, generally inferior; the brown colouring added to the soap disguising its *yellow* origin. The scents used for perfuming it are also generally of a common quality, although there are some honourable exceptions.

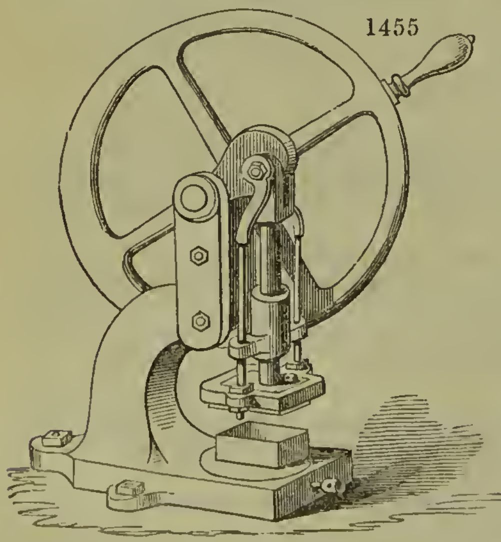
Glycerine Soap.

In consequence of the many virtues attributed to glycerine in a pure state, various soaps under the *name* of Glycerine Soap have been foisted upon the public. It is known to chemists that glycerine is one of the proximate elements of fatty bodies, and that during the saponification of grease it is eliminated as an educt. The better the soap, as a rule, the freer from glycerine. The presence of glycerine in soap is indicative that the soap is imperfectly made. To add glycerine to good soap, is, in fact, to spoil the virtues of both articles.

Almond Soap

is made with a mixture of soaps such as is given above, and when melted, perfumed with 1 lb. of otto of almonds to every cwt. of soap used. Other fancy soaps are prepared in a similar way; the proportion of perfume regulating the retail price, or *vice versa*.

1455



2. Soaps are also perfumed by the "cold process," as it is termed; that is, the soap is reduced to a state of fine division by shaving it up into a mortar, by putting the bars over an inverted cutting plane. The best curd soap is generally selected for this purpose. After the soap is reduced to shavings, the scent is well incorporated, and then thoroughly beaten together with a heavy pestle. The soap is then moulded by the hand into lumps of about 4 oz. each, placed on racks to dry for a few days; when sufficiently firm each lump is placed in the die-press or stamp (see *fig.* 1455) to give it the desired form and lettering. In this way are made all the finest scented soaps, of which we now give a few illustrations.

Orange Flower Soap.

Curd soap	7 lb.	Otto orange	2 oz.
Otto neroli	2 oz.	Petit gr.	½ oz.

Thibet Musk Soap.

Grained musk	3 drachms.
Curd soap	7 lbs.

The musk is to be powdered with a little starch and sifted through lawn—a work of no little labour—before it is mixed with the soap. The alkaline reaction of soap is favourable to the development of the musk fragrance. It requires, however, fully three months to bring this soap to perfection, and the older it is the better.

Patchouli Soap.

Curd soap	7 lb.
Otto Patchouli	1 oz.
Bergamot	2 oz.

Otto Rose Soap.

Curd soap (previously coloured with vermilion)	7 lb.
Otto rose	1 oz.
Indian geranium	½ oz.
,, santal	½ oz.

(G.) Cosmetics, or Toilet Appendages.

These are rather a numerous class of substances used to "make up" artificial beauty and the deficiencies of natural imperfections. Whether this be strictly moral or otherwise is not our business to inquire. The practice is, however, sanctioned by its antiquity; and it is in the laboratory of the perfumer those things are made, which, as an old author upon the subject says, "Can brighten the skin, give force to beauty, and take off the appearance of old age and decay." There are preparations "To prevent wrinkles;" "To make the skin smooth, soft, and glossy;" "To remove moulds, warts, and longing marks;" "To improve the complexion, prevent freckles, blotches, and to whiten a tanned or sun-burnt skin;" "To brighten the eye and increase the memory;" and numerous others, which our limits prevent detailing. We subjoin a few recipes as examples—

Milk of Pistachio Nuts, for improving the Complexion.

Spanish Pistachio nuts	4 ounces.
Violet water	3¼ pints.
Spirit of neroli	¾ pint.
Palm soap, Green oil, Wax and spermaceti, each	1 ounce.

Dr. Startin, of Saville-row, gives the following recipe as "an excellent cosmetic":—

Glycerine Lotion.

Orange flower water	1 pint.
Pure glycerine	1 oz.
Sub-borate of soda (borax)	1 drachm.

Glycerine Jelly,

which is much approved of in winter seasons as a remedy for chapped hands, and for a dry skin, is made thus:—

Pure glycerine	2 oz.
White soft soap	½ oz.
Almond oil	1 lb.
Scented with otto thyme, otto cloves, and bergamot, each	½ drachm.

The soap and the glycerine are first perfectly blended, then the oil is gradually added, mixing the whole by constant trituration in a mortar; finally, the perfume is added.

Cold Cream of Roses.

This is justly a favourite and universal cosmetic.

Almond oil	1 lb.
Provence rose-water	1 lb.
White wax and spermaceti, each	1 oz.
Otto of roses	½ drachm.

Melt the wax aud sperm in the oil, then gradually stir the running rose-water; when nearly finished add the scent.

(H.) Dentifrices, Pastes, &c.

Under the general title of Dentifrices, various scented tooth powders, mouth washes, tooth pastes, breath lozenges, are included in the perfumer's repertory.

Piesse and Lubin's Tooth Powder.

Precipitated chalk	1 lb.
Orris powder	1 lb.
Carmine	¼ drachm.
Very fine powdered sugar	¼ lb.
Otto rose and neroli, each	1 drachm.

Opiate Tooth Paste.

Honey	½ lb.
Precipitated chalk	½ lb.
Orris powder	½ lb.
Tincture of opium and myrrh, each	¼ oz.
Otto, cloves, nutmeg, and rose, each	½ drachm.

(I.) Fumigating Perfumes.

The earliest records of "sweet savours" show us that sweet smells were produced from throwing volatile and odorous resins on to a smouldering fire; and so much were they prized that they were considered worthy offerings to the Most High. The formula for incense for holy places is given in Exodus xxx. 34. The following is a pleasing incense :—

Santal wood in powder	1 lb.
Vitivert in powder	2 oz.
Cascarilla bark	½ lb.
Gum benzoin powder	½ lb.
Grain musk	½ oz.
Powdered nitre	2½ oz.

Ribbon of Bruges, for sweet fumigation.

Make a solution of saltpetre, *i. e.* nitrate of potassa, of two ounces to a pint of water; into this steep good undressed cotton tape, then hang up to dry; now steep it in the following tincture which has stood one month :—

Spirit	½ pint.
Musk	½ oz.
Otto rose	1 drachm.
Benzoin	4 oz.
Myrrh	½ oz.
Orris	½ pint.

When dry it is fit for use; light it, blow out the flame, and as it smoulders a fragrant vapour will rise into the air.

(K.) Fluids, Pomades.

Unguents for the hair are prepared in endless variety. The following are good examples :—

Philocome.

Enfleurage oil of any or mixed flowers	1 lb.
Virgin wax	3 oz. in summer,

or in winter one-third less.

Crystallised Oil.

Enfleurage oil of any flower	1 lb.
Spermaceti	2 oz

Cool gradually.

Hungarian Pomade.

Pour Moustache a la Crinoline.

White wax	1 lb.
Oil soap	½ lb.
Gum arabic	¼ lb.
Rose-water	1 pint.
Bergamot	1 oz.
Thyme	1 drachm.

Hair washes are for cleaning the head, and removing effete pomade.

Spirit - - - - - - - - -	1 pint.
Marine soap - - - - - - - -	1 lb.

Melt the soap in the spirit in a bath, then add rose or orange-water, ¼ pint.

Athenian Hair Wash.

Rosemary-water - - - - - - - -	1 gallon.
Sassafras chips - - - - - - - -	¼ lb.
Pearlash - - - - - - - - -	2 oz.

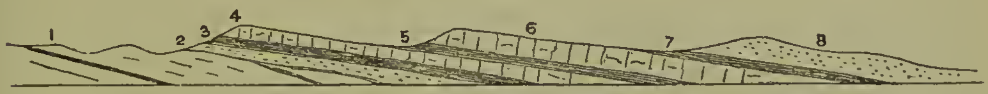
Boil for half an hour; when cold, add spirit or Hungary-water, 1 pint.

(L.) Several other products of the perfumer's laboratory, such as hair dyes, fixateur, depilatory, court plaster, &c.; but these cannot be well taught by books. — S. P.

PERFUMERY, INDIAN. The natives place on the floor 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 the seeds are treated as before; a process which is repeated several times if a very rich perfumed oil be required. The sesamum seeds thus embued with the essential oil of the plant, whether jasmine, bela, or chumbul, are placed in their swollen state in a press, 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. Attar of roses is extensively produced at Ghazepore, and is obtained by distillation.

PERMIAN. The Permian rocks were so called by Sir Roderick Murchison, from the Government of Perm, in European Russia, where these rocks are largely developed. They had previously been termed the Lower New Red series. As, however, these strata have nothing in common with the New Red Sandstone, except occasionally colour, and as the magnesian limestone is often absent, the word Permian now generally supersedes the older denominations. The Permian rocks form the uppermost member of the palæozoic strata, lying, when the series is complete, on the Upper Coal Measures. They skirt the carboniferous rocks on the east unconformably from Nottinghamshire to the river Tyne, and where complete the section is as follows, in Nottinghamshire and South Lancashire:—

1456



1. Coal measures.

Permian rocks:
2. Red and variegated sandstone and conglomerates.
3. Marly shale, "marl slate."
4. Magnesian limestone, often sandy.
5. Red marl.
6. Thin bedded magnesian limestone.
7. Red marl.

8. New Red Sandstone.

The sandstone, 2, contains plant remains, and the limestones, productas, spirifers, nautili, and other marine shells of palæozoic types. It is from the Lower Limestone that the stone for building the houses of Parliament was obtained. It forms frequently an excellent building stone, and may be obtained in places in blocks of great size. It is also extensively burned for lime.

Permian strata, believed to belong to the sandstone beds, No. 2, surround more or less the Lancashire, North and South Staffordshire, the Warwickshire, and the Shropshire coal fields, &c. They are in places 1000 feet thick, and consist chiefly of red marls, sandstones, and conglomerates. The Magnesian Limestone is generally absent in these districts, but thin bands of it occur in Lancashire, and in parts of Cumberland.

There are *magnesian limestones* in other formations, not to be confounded with those of Permian age. — A. C. R.

PERNAMBUCO WOOD. See Brazil Wood.

PERRY is the fermented juice of pears, prepared in exactly the same way as Cyder.

PERSIAN BERRIES. See Berries, Persian.

PETROLEUM. See Naphtha.

PE-TUNT-SE is the Chinese name for what is thought by geologists to be a partially decomposed granite, used by them in the manufacture of their porcelain. It is analogous to our Cornish china stone. See China Stone; Porcelain Clay.

PETWORTH MARBLE. A shelly limestone, occurring in the Wealden strata, in the neighbourhood of Petworth, in Sussex. See SUSSEX MARBLE.—H. W. B.

PEWTER. (*Potier d'étain*, Fr.) Pewter is, generally speaking, an alloy of tin and lead, with a little antimony or copper, combined in several different proportions, according to the purposes which the alloy is to serve. The English pewterers 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. The English ley pewter contains often much more than 20 per cent. of lead. As the tendency of the manufacturer is to put in as much of the cheap metal as is compatible with the appearance of his alloy in the market, and as an excess of lead may cause it to act poisonously upon all vinegars and many wines, the French government 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 83½ of tin in 100 parts, with a tolerance of error amounting to 1½ 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.

Britannia metal, the kind of pewter of which English teapots are made, is an alloy of equal parts of brass, tin, antimony, and bismuth; but the proportions differ in different workshops, and in many much more tin is 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 teapots 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. Under TIN, will be found the description of an easy method of analysing its lead alloys.

The pewterer fashions most of his articles by casting them in brass moulds, 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.

It is the practice, however, in the metal works of Birmingham, to raise various articles, as tea-pots, milk jugs, and the like, from the flat into their proper forms, by a process called SPINNING: this consists in bringing the sheet of pewter against a rapidly-revolving tool, by which, with a little dexterity on the part of the workman, it is gradually fashioned.

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, but in many cases the oxyhydrogen or lime light is employed. 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 japanned in black, along three parts of the circumference of which a crescented 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 movable 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 movable 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.

Beechy's Trinoptric Lantern, which has been long manufactured by Mr. Abrahams of Liverpool, is an improvement on the ordinary *phantasmagoria*.

PHORMIUM TENAX. New Zealand flax. See FLAX; FIBRES.

PHOSPHATES. Combinations of phosphoric acid with metallic, earthy, or alkaline bases. A few only of these require notice in this work; all will of course be described in *Ure's Dictionary of Chemistry.*

Phosphate of Lime, or Acid Phosphate of Lime, is formed when bone-earth is treated with sulphuric acid. If bone-earth is digested with this acid for some time, and then water added, the clear solution filtered from the insoluble sulphate of lime will on evaporation yield crystals of phosphate of lime. Ground bones are frequently employed as a manure: their action depends in part upon the decomposed gelatine, and on the phosphate of lime, which they contain in the condition of a triphosphate. See BONES. When, as for turnip crops, a large supply of phosphoric acid is required, it is found advantageous to treat the bones with sulphuric acid, by which the triphosphate is converted into the acid phosphate of lime. The usual practice is to mix bone dust with one fourth of its weight of oil of vitriol, adding an equal quantity of water after each portion of acid; the mass is allowed to remain in a heap until quite dry. It is then sold as *supherphosphate,* which is a mixture of the gelatinous portion of the bone with the acid phosphate and sulphate of lime.

Phosphate of Magnesia enters into the composition of the bones of animals.

Amongst the native phosphates may be enumerated:—

Apatite. Phosphate of lime, the composition of which mineral is, phosphoric acid 42·26; lime, 50·00; fluorine, 3·77.

Zwieselite. Phosphate of iron and manganese.

Pyromorphite. Phosphate of lead.

Lazulite. Blue spar. Hydrous-diphosphate of alumina and magnesia.

Turquoise. See TURQUOISE.

Vivianite. Blue iron earth. Phosphate of iron.

Libethenite. Phosphate of copper.

Wavelite. Sub-phosphate of alumina.

Childrenite, consists of phosphoric acid, 27·8; alumina, 14·4; protoxide of iron, 31·3; protoxide of manganese, 8·9; water, 17·6.

Phosphochalcite. Hydrous phosphate of copper,

Dufrenite. Green iron ore. Phosphoric acid, 28·0; peroxide of iron, 63·1; water, 8·9.

Uranite. Phosphoric acid, 15·7; oxide of uranium, 62·7; lime, 6·1; water, 15·5.

There are many other combinations which it is unnecessary to describe.

PHOSPHATIC NODULES. Concretions and nodules of phosphate of lime, which occur in layers in the Gault and Upper Green Sand. They are now much used for artificial manure. See COPROLITES.

PHOSPHORIC ACID exists abundantly in the mineral kingdom: it is found in several of the igneous rocks, in combination with metallic oxides and earths. In the vegetable kingdom, it is discovered in the ashes of many plants, and it forms a large and important portion of the animal kingdom. *Anhydrous phosphoric acid,* is the acid formed by the vivid combustion of phosphorus. *Monobasic* or *Metaphosphoric acid,* commonly known as glacial phosphoric acid, is now much employed in England, though for some time it did not attract 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 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. (*Ure.*) 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.

Another method of forming this monobasic acid is the following: one part of phosphorus is cut into small pieces, and introduced into a retort connected with a receiver, and containing thirteen parts nitric acid, sp. gr. 1·2. The retort is moderately heated on a sand bath, and the nitric acid which distils over returned to it from time to time until the phosphorus has disappeared. The greater part of the nitric acid is then distilled off, and the residual liquor evaporated, so long as any water is evolved upon cooling: the phosphoric acid appears as a colourless glass, which dissolves slowly in water.

PHOSPHORUS. (The following detailed description of the manufacture of phosphorus is left in Dr. Ure's own words, it being a good example of his descriptive powers when applied to scientific manufactures.) 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 and 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, is 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 the 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 reverbatory; 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 MERCURY) 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 equably 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 adopter.

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 130°, 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 vial 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., crystallising 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 oxidised, and burns with great vehemence and splendour.

Inflammable match-boxes (*briquets phosphoriques*), no longer used, were prepared by putting into a small phial of glass or lead a bit of phosphorus, and oxidising it slightly by stirring it round with a red-hot iron wire. The vial should be unstoppered 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 concreted 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.

See *Ure's Dictionary of Chemistry* for a description of the various combinations of phosphorus.

PHOSPHORUS, AMORPHOUS; or Red Phosphorus. If a stick of phosphorus be put into an hermetically closed tube and exposed to the action of the spectrum, one end will become *white* and the other *red*. It may be prepared also by exposing phosphorus for a long time in an atmosphere quite free of oxygen or moisture, to a temperature of 470° F. At this temperature the phosphorus fuses; it remains for some time colourless, and then gradually becomes red and opaque. Amorphous phosphorus was investigated by Dr. Schrötter, of Vienna. 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 has 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 470° F. 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. It is identical in composition with ordinary phosphorus, and may be reconverted into it without loss of weight, and that merely by 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 ordinary 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. When perfectly dry amorphous phosphorus is a scarlet or carmine powder, which becomes darker when heated. On the large scale it is prepared in dark masses of a red or dark brown colour. The great advantages of this singular condition of phosphorus are, that it does not appear to affect those persons who are employed in the manufacture of lucifer matches with the loathsome disease which the use of the ordinary phosphorus produces. See Lucifer Matches.

PHOSPHORUS MATCHES. See Lucifer Matches.

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 oxidised on the surface. Rats and mice eat this mixture with avidity; after which they swell out and soon die. Several similar preparations are now made in this country for the destruction of vermin.

PHOTO-GALVANOGRAPHY. A name given to a process invented by Mr. Pretsch, for producing engravings from photographs, by the application of the *galvano-plastic* process. It is not now employed, although great efforts were made to introduce it to the public. The principles involved, are sufficiently described in Photographic Engraving.

PHOTOGEN. Syn. *Paraffine Oil.* A term which has recently found its way into commerce, to designate certain oils or naphthas for illuminating purposes. It is generally prepared from shales, brown coals, or cannels. Boghead coal, and the numerous varieties of inflammable shales which more or less resemble it, are specially adapted for the preparation of photogen. The chief physical difference between photogen and ordinary coal oils of the same boiling point, is the specific gravity, which with the former varies from 0·820 to 0·830, whereas common coal naphtha never has a less density than 0·850°. It is true that photogen may be obtained of as high a density as 0·900, but then it will be of an excessively high boiling point, and, in all probability, saturated with paraffine.

The light oil known as photogen may be obtained from common bituminous coals by distilling them at a lower temperature than is employed in gas works. To obtain the maximum amount of photogen from coal, the temperature should not be much above 700° C.

Preparation.—The coals broken into small pieces, the smaller the better, are to be heated in vertical or horizontal iron retorts, the tar being received through a very wide worm into large tanks. Some manufacturers use vertical, and others horizontal retorts; it is also common to distil the coals by the heat produced by their own combustion If the latter process be employed, the arrangements for condensing the product must be very perfect, or great loss will be sustained, owing to the air which supports the combustion carrying away a considerable quantity of the hydrocarbons. This power of air to saturate itself with vapours, is of great importance in the economy of all processes where the distillation of one portion of substance is carried on by the heat evolved by the combustion of another. It is not uncommon in practice, where the cylinders are horizontal, to place the coal or other matters to be distilled in semi-cylindrical trays, which are capable of being inserted into the retorts, and also of being removed to make way for another charge at the completion of the operation.

The tar obtained by any of the above processes is to be redistilled: the lighter portions form (when purified by means of sulphuric acid and alkalies) the fluid known in commerce as "Boghead naphtha." See Naphtha, Boghead. In Germany and some other places, it is usual to divide the distillate from the tar into two portions, one being for the preparation of photogen, and the other for "solar oil." This division is made as the fluid runs from the still; the more volatile constituting the photogen, and the less the solar oil.

The following table by Wagenmann will be found of great importance to those who are interested in the commercial value of the different varieties of coals and bitumens as sources of illuminating oils:—

Name.	Locality.	Tar per cent.	Specific grav.	Crude oil sp. gr. from 0·700 to 0·950.	Crude oil sp. gr. from 0·850 to 0·900.	Crude Paraffine.
Trinidad Pitch -	Trinidad.	70	·875	40	20	1½
Boghead coal - -	Scotland.	33	·860	12	18	1¼
Torbane mineral -	"	31	·861	11	16	1¼
Dorset shale -	England.	9	·910	1	6	1/30
Rangoon naphtha	Burmah.	80	·870	50	20	3
Belmar turf -	Ireland.	3	·920	1	1	1/6
George's bitumen	Neuwied.	29	·865	8¼	14	1¾
Paper coal, No. 1.	Liebengebirge	20	·880	6	9	¾
" No. 2.	"	15	·880	5	7	½
" No. 3.	"	11	·880	3	6	½
" " -	Hesse.	25	·880	6	12	1
" " -	Rhenish Provinces.	11	·880	3	5	½
" " -	Bonn.	4	·930	1/10	3	¼
Brown coal -	Saxony (Province).	7	·910	2	3	½
" - -	Saxony, (Kingdom.)	10	·920	2	4	¾
" - -	" "	6	·915	½	4	½
" - -	" "	5	·910	½	3½	¼
" - -	" "	6	·910	¾	4½	⅓
" - -	" "	9½	·920	2	5	1
" - -	" "	6	·910	1	4	½
" - -	" "	4	·910	1	2	⅓
" - -	" "	9½	·920	2	5	⅔
" - -	Thuringen.	5	·918	1½	1	¾
" - -	"	5	·920	¼	3½	¼
" - -	Neuwied.	5½	·920	1	5	½
" - -	Bohemia.	11	·860	3	5	¾
" - -	Westerwald.	5½	·910	1½	1½	
" - -	"	3½	·910	1	1	
" - -	Nassau.	4	·910	2	1½	
" - -	"	3	·910	1	1	
" - -	Frankfort.	9	·890	2	6	

The process of purification is the same in both cases, namely, alternate treatments with concentrated sulphuric acid to remove the highly coloured and odorous constituents of the crude distillate, and washing with an alkali to remove carbolic acid and its congeners; also that portion of sulphuric acid which remains suspended in the naphtha, and the sulphurous acid produced by the decomposition of a portion of the sulphuric acid by the carbon of certain easily decomposed organic matters in the crude distillate. This decomposition of the sulphuric acid happens thus:—

$$2SO^3HO + C = 2SO^2 + 2HO + CO^2.$$

There is another advantage in the treatment of the fluid by alkalies, inasmuch as some sulphide of hydrogen, and probably other fœtid sulphur compounds, is decomposed and the resulting products removed.

In preparing photogen from any of the sources enumerated, much must be left to the discretion of the manufacturer both as regards the apparatus and the chemical processes. In some instances the solar oil and photogen are with advantage prepared separately, but in this country it is more usual to mix the heavy and light oils together so as to produce a fluid of medium density and volatility. It must be remembered that while the more volatile hydrocarbons confer extreme inflammability and fluidity, they are at the same time more odorous than the less volatile portion of the distillate, which is the true paraffine oil.

The more odorous impurities in photogen appear to be easily susceptible of oxidation. This is evident from the facility with which foully smelling photogen loses its offensive odour in contact with bichromate or manganate of potash, or even animal charcoal. Their exposure to air even greatly improves the odour, and a recently distilled photogen, which is very unpleasant, becomes comparatively sweet if kept in tanks or barrels for a few days. The same thing happens with many essential oils, such as those of peppermint, cloves, &c. The presence of sulphurous acid in photogen may be instantly detected by shaking a little in a test tube with a few drops of a very weak solution of bichromate of potash; if sulphurous acid be present a portion of the chromic acid will be reduced to green oxide, which will instantly betray the presence of the reducing agent alluded to.

Photogen often shows the phenomenon of dichroism, but the more it is purified by acids the more feebly is the coloration by reflected light observed, and if the less volatile portion of the distillate be rejected, the property alluded to will not be perceived.

In distilling the heavy oils or tars produced by distilling Boghead coal or other photogen-yielding substances, it is particularly to be observed that the worms or other tubes proceeding from the stills, if of too small diameter, are liable to become choked up with paraffine; this, if unobserved, might lead to serious results. It is very convenient to have a steam pipe inserted into the worm tubes or condensing tanks, to enable the water to be heated to such a point as to melt any solid matters in the worms, and allow them to be washed into the recipient by the fluids distilling over.

None of the cannel or bituminous coal, shales, or other substances used for yielding burning fluids by distillation, give distillates of such purity and freedom from odour, as Rangoon tar. The more volatile portion of the distillate from the latter has obtained in commerce the absurd name of Sherwoodole; it is used instead of coal benzole, for removing grease, &c. The paraffine obtained from Rangoon tar has a greater value for commercial purposes than that from Boghead coal, inasmuch as it has a higher melting point, which renders it better adapted for candles. The following are the melting points of various samples of paraffine:—

	Melting point.
Boghead coal paraffine	114° Fahr.
Ditto ditto, another specimen	108° "
The last, after being distilled	108° "
Turf paraffine	116° "
Bituminous coal paraffine, prepared by Atwood's process	110° "
Rangoon tar paraffine	140° "

It is curious to observe the effect of light upon photogen. Some samples of extremely dark colour, when exposed to its influence for a few days, become as completely bleached as animal oils would under these circumstances. At the same time, as we have before hinted, the odour becomes much improved. A photogen of good quality has by no means a repulsive odour, but if much of the more volatile constituents be present, it is impossible to avoid its being disagreeable if spilled about. The less volatile hydrocarbons have comparatively little odour. It should not be too inflammable, that is to say, it must not take fire on the approach of a light. If it does, it is owing to the more volatile portion not having been sufficiently removed.—C. G. W.

PHOTOGRAPHIC ENGRAVING. The first who appears to have had any idea of heliographic engraving was Nicephore Nièpce. According to M. Aime Girard the first proof taken by him by means of this process bears date 1827, some dozen years before the publication of Mr. Talbot's *Photogenic processes.* This process, which is now almost forgotten, was very simple; it consisted in spreading a thin layer of bitumen of Judea upon a copper or pewter plate, which was then placed in the camera obscura, where it was allowed to remain some hours, until it had received the impression of the external objects towards which the lens had been directed. On withdrawing the plate it was submitted to the action of the essence of lavender, which dissolved the portions of the bitumen not acted upon by the light, leaving the metal bare, while the remaining bitumen reproduced the design. Passing the plate afterwards through an acid solution it was found that it had eaten hollows in the metallic plate, while the other parts were preserved by the protecting varnish. Such was the process that M. Nièpce revealed to Daguerre when he entered into a partnership with him. Nièpce died in 1833, after struggling twenty years, during which he spent his time and money in endeavouring to perfect his discovery, poor and almost unknown.

Six years later, that is in 1839, M. Daguerre made his discovery public. In the meantime he had considerably improved on Nièpce's process; but the introduction of the Calotype led to the abandonment of the process for some years.

The next process to which we shall refer is that of M. Fizeau. He took a Daguerreotype plate and submitted it to the action of a mixture of nitric, nitrous, and hydrochloric acids, which did not affect the whites of the picture but attacked the blacks with a resulting formation of adherent chloride of silver, which speedily arrested the action of the acid. This he removed by a solution of ammonia, and the action of the acid was continued. This process he continued until a finely engraved plate was the result; but the lines of this plate were not deep enough to allow of prints being taken from it; and to remedy this, he covered the plate with some drying oil, and then, wiping it from the surface, left it to dry in the hollows. He afterwards submitted the plate to an electro-chemical process which covered the raised parts with gold, leaving the hollows in which the varnish remained untouched. On the completion of the gilding this varnish was removed by means of caustic potash, and the surface of the plate, covered with *grains de gravure*, producing what is technically termed an *aquatint* ground, and the deepening of the lines was proceeded with by means of the acid. The Daguerreotype plate was by these means converted into an engraved plate, but as it was silver it would have worn out very soon; to obviate which an impression was taken on copper by an electro-chemical process, which could of course be renewed when it showed signs of wear.

M. Claudet and Mr. Grove both produced some very beautiful engravings on the Daguerreotype plate, but as these processes have proved rather curious than useful, they need not be described.

On the 29th of Oct., 1852, Mr. Fox Talbot patented a process, which was similar to the PHOTOGALVANOGRAPHIC process previously used by MM. Pretsch and Poitevin, as regards the substance first used, viz., a mixture of bichromate of potash and gelatine; but the remaining portion of the process was conducted on the same principle, though in a different manner, to that of M. Fizeau.

Mr. Mungo Ponton discovered the use of the bichromate of potash as a photographic agent, and Mr. Robert Hunt subsequently published a process, called the "Chromotype." In both these processes the peculiar property of the chromic acid liberated under the action of sunshine, to combine with organic matter, was pointed out. MM. Pretsch, Poitevin, and Talbot only availed themselves of this previous discovery, and in each instance gelatine was rendered insoluble by the decomposition of the bichromate of potash under the influence of *actinic* power. By dissolving off the still soluble portions of the gelatine, either metal could be precipitated by the voltaic battery, or an etching produced.

In 1853 M. Nièpce de St. Victor, the nephew of Nicephore Nièpce, took up his uncle's plan, and with the assistance of M. Lemaitre, who had also assisted his uncle, endeavoured to perfect it: but though he modified and improved it, his success was not very great; it was always found necessary to have the assistance of an engraver to complete the plate.

After this many others, among whom may be enumerated MM. Lerebours, Lemercier, Barreswil, Davanne, and finally Poitevin, endeavoured to obtain a design by similar means on stone. The last appears to have succeeded. His method is based on the chemical reaction of light on a mixture of gelatine and bichromate of potash, as above. This mixture, which when made is perfectly soluble in water, becomes insoluble after exposure to the light. His mode of proceeding is as follows:—He spreads the mixture on the stone, and after drying lays the negative upon it and exposes it to the light. After a suitable exposure the negative is removed, and the portions not acted upon by the light are washed away with water, and the design remains with the property of taking the ink like an ordinary lithographic crayon. The stone is then transferred to the press and proofs taken in the usual way. It is said that excellent pictures have been obtained from the stone after 900 copies had been pulled.

The process of M. Charles Nègre, which has excited much attention in Paris, is more complicated than the preceding, but yields superior results. His process appears to be not unlike that of M. Fizeau. He employs acids to eat the lines into the plate, and at a certain stage of the process it is submitted to the action of a galvanic bath which plates it with copper, silver, or gold, according to circumstances. By his process the half-tones are produced with much delicacy.

Mr. Fox Talbot's process of *Photoglyphic Engraving* has been thus described by himself:—

"I employ plates of steel, copper, or zinc, such as are commonly used by engravers. Before using a plate its surface should be well cleaned; it should then be rubbed with a linen cloth dipped in a mixture of caustic soda and whiting, in order to remove any remaining trace of greasiness. The plate is then to be rubbed dry with another linen cloth. This process is then to be repeated; after which, the plate is in general sufficiently clean.

"In order to engrave a plate, I first cover it with a substance which is sensitive to light. This is prepared as follows:—About a quarter of an ounce of gelatine is dissolved in eight or ten ounces of water, by the aid of heat. To this solution is added about one ounce, by measure, of a saturated solution of bichromate of potash in water, and the mixture is strained through a linen cloth. The best sort of gelatine for the purpose is that used by cooks and confectioners, and commonly sold under the name of gelatine In default of this, isinglass may be used, but it does not answer so well.

Some specimens of isinglass have an acidity which slightly corrodes and injures the metal plates. If this accident occurs, ammonia should be added to the mixture, which will be found to correct it. This mixture of gelatine and bichromate of potash keeps good for several months, owing to the antiseptic and preserving power of the bichromate. It remains liquid and ready for use at any time during the summer months; but in cold weather it becomes a jelly, and has to be warmed before using it: it should be kept in a cupboard or dark place. The proportions given above are convenient, but they may be considerably varied without injuring the result. The engraving process should be carried on in a partially darkened room, and is performed as follows:—A little of this prepared gelatine is poured on the plate to be engraved, which is then held vertical, and the superfluous liquid allowed to drain off at one of the corners of the plate. It is held in a horizontal position over a spirit lamp, which soon dries the gelatine, which is left as a thin film, of a pale yellow colour, covering the metallic surface, and generally bordered with several narrow bands of prismatic colours. These colours are of use to the operator, by enabling him to judge of the thinness of the film: when it is very thin, the prismatic colours are seen over the whole surface of the plate. Such plates often make excellent engravings; nevertheless, is is perhaps safer to use gelatine films which are a little thicker. Experience alone can guide the operator to the best result. The object to be engraved is then laid on the metal plate, and screwed down upon it in a photographic copying frame. Such objects may be either material substances, as lace, the leaves of plants, &c., or they may be engravings, or writings, or photographs, &c. &c. The plate bearing the object upon it is then to be placed in the sunshine, for a space of time varying from one to several minutes according to circumstances; or else, it may be placed in common daylight, but of course for a long time. As in other photographic processes, the judgment of the operator is here called into play, and his experience guides him as to the proper time of exposure to the light. When the frame is withdrawn from the light, and the object removed from the plate, a faint image is seen upon it—the yellow colour of the gelatine having turned brown wherever the light has acted.

"The novelty of the present invention consists in the improved method by which the photographic image, obtained in the manner above described, is engraved upon the metal plate. The first of these improvements is as follows:—I formerly supposed that it was necessary to wash the plate, bearing the photographic image, in water, or in a mixture of water and alcohol, which dissolves only those portions of the gelatine on which the light has not acted: and I believe that all other persons who have employed this method of engraving, by means of gelatine and bichromate of potash, have followed the same method, viz., that of washing the photographic image. But however carefully this process is conducted, it is frequently found, when the plate is again dry, that a slight disturbance of the image has occurred, which, of course, is injurious to the beauty of the result; and I have now ascertained that it is not at all necessary to wash the photographic image; on the contrary, much more beautiful engravings are obtained upon plates which have not been washed, because the more delicate lines and details of the picture have not been at all disturbed. The process which I now employ is as follows:—When the plate, bearing the photographic image, is removed from the copying frame, I spread over its surface, carefully and very evenly, a little finely-powdered gum copal (in default of which common resin may be employed). It is much easier to spread this resinous powder evenly upon the surface of the gelatine, than it is to do so upon the naked surface of a metal plate. The chief error the operator has to guard against is, that of putting on too much of the powder: the best results are obtained by using a very thin layer of it, provided it is uniformly distributed. If too much of the powder is laid on it impedes the action of the etching liquid. When the plate has been thus very thinly powdered with copal, it is held horizontally over a spirit lamp in order to melt the copal; this requires a considerable heat. It might be supposed that this heating of the plate, after the formation of a delicate photographic image upon it, would disturb and injure that image; but it has no such effect. The melting of the copal is known by the change of colour. The plate should then be withdrawn from the lamp, and suffered to cool. This process may be called the laying an aquatint ground upon the gelatine, and I believe it to be a new process. In the common mode of laying an aquatint ground, the resinous particles are laid upon the naked surface of the metal, before the engraving is commenced. The gelatine being thus covered with a layer of copal, disseminated uniformly and in minute particles, the etching liquid is to be poured on. This is prepared as follows:—Muriatic acid, otherwise called hydrochloric acid, is saturated with peroxide of iron, as much as it will dissolve with the aid of heat. After straining the solution, to remove impurities, it is evaporated till it is considerably reduced in volume, and is then poured off into bottles of a convenient capacity; as it cools it solidifies into a brown semi-crystalline mass. The bottles are then well-corked up, and kept for use. I shall call this preparation of iron by the name of perchloride of iron in the present specification, as I believe it to be identical with the substance described by chemical authors under that name — for example, see *Turner's Chemistry*, fifth edition, page 537; and by others called permuriate of iron —for example, see *Brand's Manual of Chemistry*, second edition, vol. ii. page 117.

"It is a substance very attractive of moisture. When a little of it is taken from a bottle, in the form of a dry powder, and laid upon a plate, it quickly deliquesces, absorbing the atmospheric moisture. In solution in water, it forms a yellow liquid in small thicknesses, but chestnut-brown in greater thicknesses. In order to render its mode of action in photographic engraving more intelligible, I will first state, that it can be very usefully employed in common etching; that is to say, that if a plate of copper, steel, or zinc is covered with an etching ground, and lines are traced on it with a needle's point, so as to form any artistic subject; then, if the solution of perchloride of iron is poured on, it quickly effects an etching, and does this without disengaging bubbles of gas, or causing any smell; for which reason it is much more convenient to use than aquafortis, and also because it does not injure the operator's hands or his clothes if spilt upon them. It may be employed of various strengths for common etching, but requires peculiar management for photoglyphic engraving; and, as the success of that mode of engraving chiefly turns upon this point, it should be well attended to.

"Water dissolves an extraordinary quantity of perchloride of iron, sometimes evolving much heat during the solution. I find that the following is a convenient way of proceeding:—

"A bottle (No. 1) is filled with a saturated solution of perchloride of iron in water.

"A bottle (No. 2) with a mixture, consisting of five or six parts of the saturated solution and one part of water.

"And a bottle (No. 3) with a weaker liquid, consisting of equal parts of water and the saturated solution. Before attempting an engraving of importance, it is almost essential to make preliminary trials, in order to ascertain that these liquids are of the proper strengths. These trials I shall therefore now proceed to point out. I have already explained how the photographic image is made on the surface of the gelatine, and covered with a thin layer of powdered copal or resin, which is then melted by holding the plate over a lamp. When the plate has become perfectly cold, it is ready for the etching process, which is performed as follows:— A small quantity of the solution in bottle No. 2, viz. that consisting of five or six parts of saturated solution to one of water, is poured upon the plate, and spread with a camel-hair brush evenly all over it. It is not necessary to make a wall of wax round the plate, because the quantity of liquid employed is so small that it has no tendency to run off the plate. The liquid penetrates the gelatine wherever the light has not acted on it, but it refuses to penetrate those parts upon which the light has sufficiently acted. It is upon this remarkable fact that the art of photoglyphic engraving is mainly founded. In about a minute the etching is seen to begin, which is known by the parts etched turning dark brown or black, and then it spreads over the whole plate — the details of the picture appearing with great rapidity in every quarter of it. It is not desirable that this rapidity should be too great, for, in that case, it is necessary to stop the process before the etching has acquired sufficient depth (which requires an action of some minutes' duration). If, therefore, the etching, on trial, is found to proceed too rapidly, the strength of the liquid in bottle No. 2 must be altered (by adding some of the saturated solution to it before it is employed for another engraving); but if, on the contrary, the etching fails to occur after the lapse of some minutes, or if it begins, but proceeds too slowly, this is a sign that the liquid in bottle No. 2 is too strong, and too nearly approaching saturation. To correct this, a little water must be added to it before it is employed for another engraving. But, in doing this, the operator must take notice, that a very minute quantity of water added often makes a great difference and causes the liquid to etch very rapidly. He will therefore be careful in adding water, not to do so too freely. When the proper strength of the solution in bottle No. 2 has thus been adjusted, which generally requires three or four experimental trials, it can be employed with security. Supposing, then, that it has been ascertained to be of the right strength, the etching is commenced as above mentioned, and proceeds till all the details of the picture have become visible, and present a satisfactory appearance to the eye of the operator, which generally occurs in two or three minutes; the operator stirring the liquid all the time with a camel-hair brush, and thus slightly rubbing the surface of the gelatine, which has a good effect. When it seems likely that the etching will improve no further, it must be stopped. This is done by wiping off the liquid with cotton wool, and then rapidly pouring a stream of cold water over the plate, which carries off all the remainder of it. The plate is then wiped with a clean linen cloth, and then rubbed with soft whiting and water to remove the gelatine. The etching is then found to be completed.

PHOTOGRAPHY. (From *photo*, light; *graphê*, a writing or a description.) The art of producing pictures by the agency of sunshine, acting upon chemically prepared papers. The name appears unfortunate, since we are persuaded that it is not LIGHT — that is, the *luminous principle* of the sunshine, which effects the chemical change, but a peculiar principle or power which is associated with light in the sunbeam. In the metaphysical refinements of our modern philosophy, which endeavours to refer every physical phenomenon to some peculiar mode of motion, we are apt to lose sight of the stern facts, which in spite of the enormous amount of talent which has been brought to bear on the whole series of undulatory hypotheses, still stand out as unreconcilable with any of these views. If *light* is motion, and *shadow* degrees of repose, it remains unexplained how the most intense *motion, yellow light*, not only produces no chemical change, but actually prevents it; or how the *deep shadow* of the *non-luminous* rays produces the most active chemical decomposition. M. Nièpce, in 1827, called his interesting discovery HELIOGRAPHY, or *sun-writing*. This name, as involving no hypothesis, was an exceedingly happy one, and it is to be regretted that it was not adopted. See ACTINISM.

In this dictionary it is our purpose only to deal with the chief principles involved in this very interesting art, and to give brief descriptions of some of the more remarkable and interesting of the processes which have been introduced. There are certain chemical compounds, and especially some of the salts of silver, which are rapidly decomposed by the influence of the sunshine, and even, though more slowly, by ordinary daylight, or powerful artificial light. As the extent to which the decomposition is carried on, depends upon the intensity of radiation proceeding from the object, or passing through it, accordingly as we are employing the reflected or the transmitted rays, it will be obvious that we shall obtain very delicate gradations of darkening, and thus the photograph will represent in a very refined manner all those details which are rendered visible to the eye by light and shadow.

There are two methods by which photographs can be taken: the first and simplest is by *super-position*, but this is applicable only to the copying of engravings of such botanical specimens as can be spread out upon paper, and objects which are entirely or in part transparent. The other method is by throwing upon the prepared paper the image obtained by the use of a lens fitted into a dark box — the *camera obscura*.

To carry out either of those methods certain sensitive surfaces must be produced; these therefore claim our first attention: — The artist requires

1. Nitrate of silver.
2. Ammonia nitrate of silver.
3. Chloride of silver.
4. Iodide of silver.
5. Bromide of silver.

Those five chemical compounds may be regarded as the agents most essential in the preparation of photographic surfaces.

1. NITRATE OF SILVER. The crystallised salt should, if possible, always be procured. The fused nitrate, which is sold in cylindrical sticks, is more liable to contamination, and the paper in which each stick of two drachms is wrapped being weighed with the silver, renders it less economical. A preparation is sometimes sold for nitrate of silver, at from 6*d.* to 9*d.* the ounce less than the ordinary price, which may induce the unwary to purchase it. This reduction of price is effected by fusing with the salt of silver a proportion of some cupreous salt, generally the nitrate, or nitrate of potash. This fraud is readily detected by observing if the salt becomes moist on exposure to the air,—a very small admixture of copper rendering the nitrate of silver deliquescent. The evils to the photographer are, want of sensibility upon exposure, and the perishability (even in the dark) of the finished drawing.

The most simple kind of photographic paper which is prepared, is that washed with the nitrate of silver only; and for many purposes it answers remarkably well, particularly for copying lace or feathers; and it has this advantage over every other kind, that it is perfectly fixed by well soaking in *pure* warm water.

The best proportions in which this salt can be used are 60 grains of it dissolved in a fluid ounce of water. Care must be taken to apply it equally, with a quick but steady motion, over every part of the paper. It will be found the best practice to pin the sheet by its four corners to a flat board, and then, holding it with the left hand a little inclined, to sweep the brush from the upper outside corner, over the whole of the sheet, removing it as seldom as possible.

The nitrated paper not being very sensitive to luminous agency, it is desirable to increase its power. This may be done to some extent by simple methods.

By soaking the paper in a solution of isinglass or parchment size, or by rubbing it over with the white of egg, and drying it prior to the application of the sensitive wash, it will be found to blacken much more readily, and assume different tones of colour, which may be varied at the taste of the operator.

By dissolving the nitrate of silver in common rectified spirits of wine instead of water, we produce a tolerably sensitive nitrated paper, which darkens to a very beautiful chocolate brown; but this wash must not be used on any sheets prepared with isinglass, parchment, or albumen, as these substances are coagulated by alcohol.

2. Ammonia Nitrate of Silver. Liquid ammonia is to be dropped carefully into nitrate of silver; a dark oxide of silver is thrown down; if the ammonia liquor is added in excess, this precipitate is redissolved, and we obtain a perfectly colourless solution. Paper washed with this solution is more sensitive than that prepared with the ordinary nitrate.

3. Chloride of Silver. This salt is obtained most readily by pouring a solution of common salt, *chloride of sodium*, into a solution of nitrate of silver. It then falls as a pure white precipitate, which rapidly changes colour even in diffused daylight.

Chloridated papers, as they are termed, are formed by producing a chloride of silver on their surface, by washing the paper with the solution of chloride of sodium, or any other chloride, and when the paper is dry, with the silver solution.

It is a very instructive practice to prepare small quantities of solutions of common salt and nitrate of silver of different strengths, to cover slips of paper with them in various ways, and then to expose them all to the same radiations. A curious variety in the degrees of sensibility, and in the intensity of colour, will be detected, showing the importance of a very close attention to proportions, and also to the mode of manipulating.

A knowledge of these preliminary but important points having been obtained, the preparation of the paper should be proceeded with; and the following method is recommended: —

Taking some flat deal boards, perfectly clean, pin upon them, by their four corners, the paper to be prepared; observing the two sides of the paper, and selecting that side to receive the preparation which presents the hardest and most uniform surface. Then, dipping a sponge brush into the solution of chloride of sodium, a sufficient quantity is taken up by it to moisten the surface of the paper without any hard rubbing; and this is to be applied with great regularity. The papers being "salted," are allowed to dry. A great number of these may be prepared at a time, and kept in a portfolio for use. To render these sensitive, the papers being pinned on the boards, or carefully laid upon folds of white blotting paper, are to be washed over with the nitrate of silver, applied by means of a camel-hair pencil, observing the instructions previously given as to the method of moving the brush upon the paper. After the first wash is applied, the paper is to be dried, and then subjected to a second application of the silver solution. Thus prepared, it will be sufficiently sensitive for all purposes of copying by application.

The most sensitive paper. — Chloride of sodium, 30 grains to an ounce of water; nitrate of silver, 120 grains to an ounce of distilled water.

The paper is first soaked in the saline solution, and after being carefully wiped with linen, or pressed between folds of blotting paper and dried, it is to be washed twice with the solution of silver, drying it by a warm fire between each washing. This paper is very liable to become brown in the dark. Although images may be obtained in the camera obscura on this paper by about half an hour's exposure, they are never very distinct, and may be regarded as rather curious than useful.

Less sensitive paper for copies of engravings or botanical specimens. — Chloride of sodium, 25 grains to an ounce of water; nitrate of silver, 99 grains to an ounce of distilled water.

Common sensitive paper, for copying lace-work, feathers, &c. — Chloride of sodium, 20 grains to an ounce of water; nitrate of silver, 60 grains to an ounce of distilled water.

This paper keeps tolerably well, and, if carefully prepared, may always be depended upon for darkening equally.

4. Iodide of Silver. This salt was employed very early by Talbot (see Calotype), Herschel, and others, and it enters as the principal agent into Mr. Talbot's calotype paper. Paper is washed with a solution of the iodide of potassium, and then with nitrate of silver. By this means papers may be prepared which are exquisitely sensitive to luminous influence, provided the right proportions are hit; but, at the same time, nothing can be more insensible to the same agency than the pure iodide of silver. A singular difference in precipitates to all appearance the same led to the belief that more than one definite compound of iodine and silver existed; but it is now proved that pure iodide of silver will not change colour in the sunshine, and that the quantity of nitrate of silver in excess regulate the degree of sensibility. Experiment has proved that the blackening of one variety of iodated paper, and the

preservation of another, depends on the simple admixture of a very minute excess of the nitrate of silver. The papers prepared with the iodide of silver have all the peculiarities of those prepared with the chloride, and although, in some instances, they seem to exhibit a much higher order of sensitiveness, they cannot be recommended for general purposes with that confidence which experience has given to the chloride.

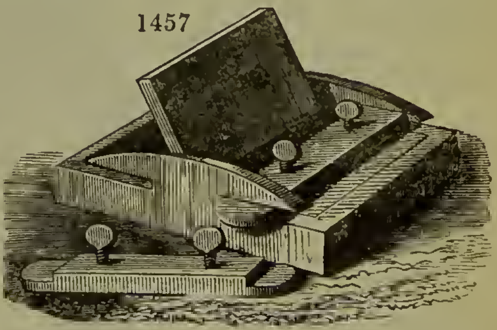
5. Bromide of Silver. In many of the works on chemistry, it is stated that the chloride is the most sensitive to light of all the salts of silver; and, when they are exposed in a perfectly formed and pure state to solar influence, it will be found that this is nearly correct. Modern discovery has, however, shown that these salts may exist in peculiar conditions, in which the affinities are so delicately balanced as to be disturbed by the faintest gleam; and it is singular that, as it regards the chloride, iodide, and bromide of silver, when in this condition, the order of sensibility is reversed, and the most decided action is evident on the bromide before the eye can detect any change in the chloride.

To prepare a highly sensitive paper of this kind, select some sheets of very superior glazed post, and wash it on one side only with bromide of potassium — 40 grains to 1 ounce of distilled water, over which, when dry, pass a solution of 100 grains of nitrate of silver in the same quantity of water. The paper must be dried as quickly as possible without exposing it to too much heat; then again washed with the silver solution, and dried in the dark. Such are the preparations of an ordinary kind, with which the photographer will proceed to work.

The most simple method of obtaining sun-pictures, is that of placing the objects to be copied on a piece of prepared paper, pressing them close by a piece of glass, and exposing the arrangement to sunshine: all the parts exposed darken, while those covered are protected from change, the resulting picture being *white* upon a *dark ground.*

For the multiplication of photographic drawings, it is necessary to be provided with a frame and glass, called a *copying frame.* The glass must be of such thickness as to resist considerable pressure, and it should be selected as colourless as possible, great care being taken to avoid such as have a tint of yellow or red, these colours preventing the permeation of the most efficient rays; *fig.* 1457 represents the frame, showing the back, with its adjustments for securing the close contact of the paper with every part of the object to be copied.

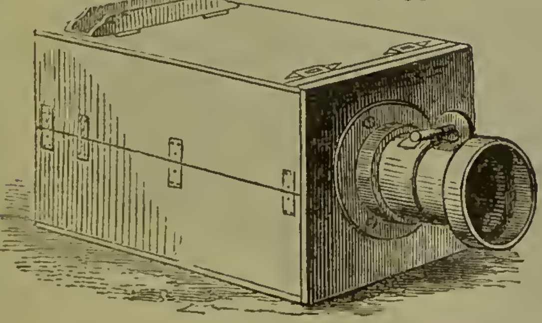
1457



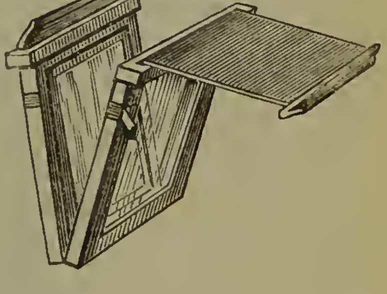
Having placed the frame face downwards, carefully lay out on the glass the object to be copied, on which place the photographic paper very smoothly. Having covered this with the cushion, which may be either of flannel or velvet, fix the back, and adjust it by the bar, until every part of the object and paper are in the closest possible contact; then turn up the frame and expose to sunshine.

It should be here stated, once for all, that such pictures, howsoever obtained, are called *negative photographs;*—and those which have their lights and shadows correct as

1458



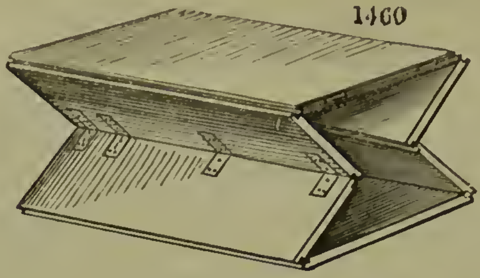
1459



in nature—dark upon a light ground—are *positive photographs.* The mode of effecting the production of a *positive* is, having by fixing, given permanence to the negative picture, it is placed, face down, on another piece of sensitive paper, when all the parts which are white on the first, admitting light freely, cause a dark impression to be made on the second, and the resulting image is correct in its lights and shadows, and also as it regards right and left.

For obtaining pictures of external nature the Camera Obscura of Baptista Porta is employed.

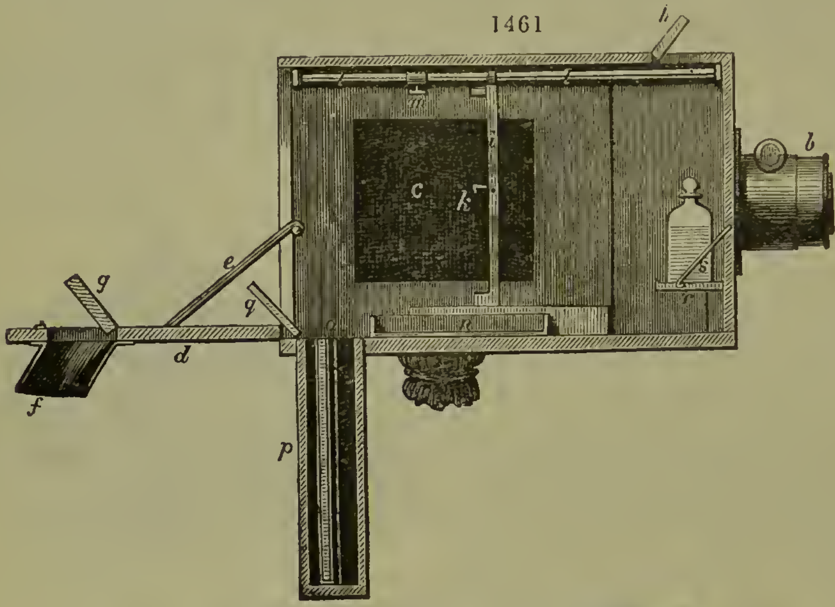
1460



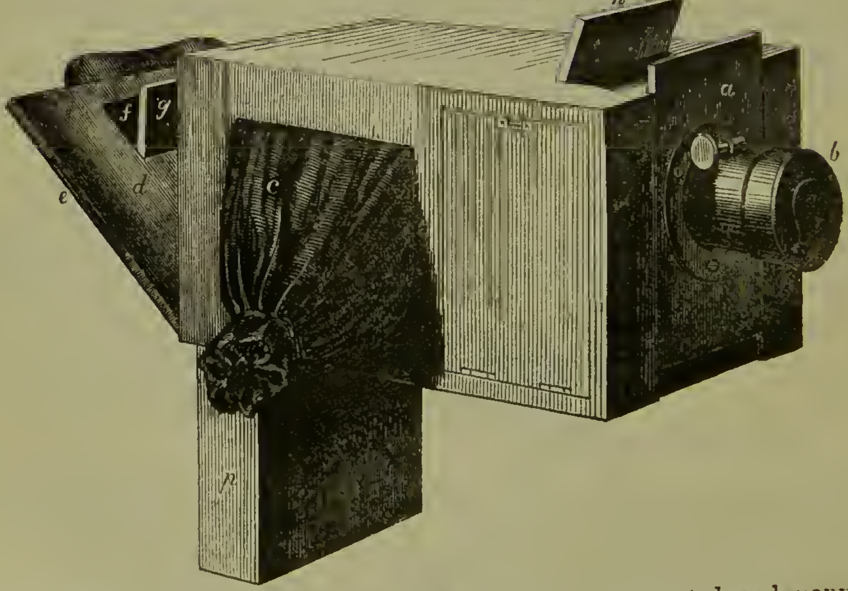
The figures (*figs.* 1458, 1459, 1460) represent a perfect arrangement, and, at the same time, one which is not essentially expensive. Its conveniences are those of folding (*fig.* 1460), and thus packing into a very small compass, for the convenience of travellers.

Fig. 1458 exhibits the instrument complete. *Fig.* 1459 shows the screen in which the sensitive paper is placed, the shutter being up and the frame open that its construction may be seen.

1461



1462



Camera Obscuras of a more elaborate character are constructed, and many of exceeding ingenuity, which give every facility for carrying on the manipulations for the *collodion process*, to be presently described, out of doors. The preceding is a Camera Obscura of this kind, manufactured by Mr. John Joseph Griffin, of Bunhill Row.

This is really Mr. Scott Archer's Camera Obscura improved upon. *Fig.* 1461 is a section of the instrument, and *fig.* 1462 its external form. With a view to its portability it is constructed so as to serve as a packing case for all the apparatus required. *a* is a sliding door which supports the lens. *b*, *c*, *c* are side openings fitted with cloth sleeves to admit the operator's arms. *d* is a hinged door at the back of the camera, which can be supported like a table by the hook *e*. *f* is the opening for looking into the camera during an operation. This opening is closed when necessary by the door *g*, which can be opened by the hand passed into the camera through the sleeves *c*. The yellow glass window which admits light into the camera during an operation is under the door, *h*. *i* is the sliding frame for holding the focusing glass, or the frame with the prepared glass, either of which is fastened to the sliding frame by the check *k*. The frame slides along the rod *l l*, and can be fitted to the proper focus by means of the step, *m*. *n* is the gutta-percha washing-tray. *o* is an opening in the bottom of the instrument near the door, to admit the well *p*, and which is closed when the well is removed by the door. The well is divided into two cells, one of which contains the focusing glass, and the other the glass trough, each in a frame adapted to the sliding frame, *i*. On each side of the sliding door that supports the lens, *a*, there is within the camera a small hinged table, *r*, supported by a bracket, *s*. These two tables serve to support the bottles that contain the solutions necessary to be applied to the glass plate after its exposure to the lens.

For supporting any of these camera obscuras, tripod stands are employed; these are now made in an exceedingly convenient form, being light, at the same time that they are sufficiently firm to secure the instrument from any motion during the operation of taking a picture.

The true photographic artist, however, will not be content with a camera obscura of this or any other kind. He will provide himself with a tent, in which he may be able to prepare his plates, and subsequently to develop and to fix his pictures. Many kinds of tent have been brought forward, but we have not seen any one which unites so perfectly all that can be desired, within a limited space, and which shall have the great recommendation of lightness. *Fig.* 1463 represents Smartt's new photographic tent, which appears to meet nearly all the conditions required.

In this tent an endeavour has been made to obviate many of the inconveniences complained of, especially as to working space, firmness, simplicity, and portability. Usually, in the various forms of tent, the upper part, where space is most required, is the most contracted, while at the lower part, where it is of little importance, a great amount of room is provided.

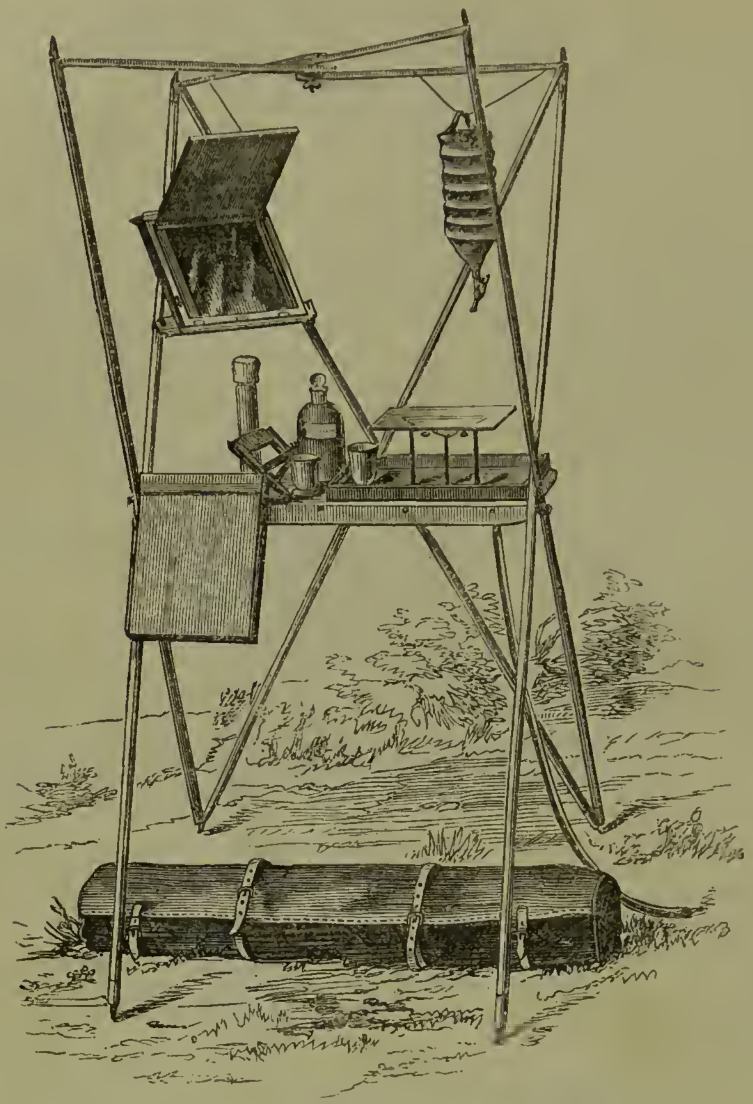
Smartt's tent, made by Murray and Heath, is rectangular in form, is 6 feet high in the clear, and 3 feet square, affording table space equal to 36 inches by 18 inches, and ample room for the operator to manipulate with perfect ease and convenience. The chief feature in its construction is the peculiarity of its framework, which constitutes, when erected, a system of triangles, so disposed as to strengthen and support each other: it thus combines the two important qualities of lightness and rigidity. The table is made to fold up when not in use; and in place of the ordinary dish for developing, a very efficient and portable tray is provided, made of india-rubber cloth, having its two sides fixed and rigid and its two ends movable; it thus folds up into a space but little larger than one of its sides. The working space of the table is economised thus:— a portion of it is occupied by the tray just described; the silver-bath (which is one of Murray and Heath's new glass baths, with glass water-tight top) is suspended from the *front* of the table, and rests upon a portion of the framework of the tent; a contrivance is devised for disposing of the plate-slide of the camera, in order to reserve the space it would require if placed on the table. The bath and plate-holder, in their places as described, are shown in the wood-cut. This arrangement leaves ample space on the table for manipulating the largest sized plates. The entire weight of the tent is 20 lbs., and it is easily erected or taken down by one person.

The collodion pourer, the plate-developing holder, the developing cups, and the water-bottle (the latter is suspended over the tray as in the wood-cut), have all special points in construction.

The object of the inventor has been completely realised, the operator being insured the means of working the wet-collodion process in the open air with ease, comfort, and convenience. Hitherto this has not been possible, in consequence of the great weight and bulk of the contrivances used, and to which may be traced the existence of the many expedients for retaining, more or less, the sensitiveness of the prepared plate.

The object of the inventor has been to make a tent which shall be so efficient as to ensure to the operator the means of working the wet collodion process in the open air, with ease, comfort, and convenience.

1463



The processes of most importance may be divided as follows:

1. The *copying* process, already described.

2. The *Daguerreotype*, the earliest method successfully employed for obtaining pictures by means of the camera obscura. See Daguerreotype.

3. The *Calotype* of Mr. H. Fox Talbot, in which the sensibility of the iodide of silver is exalted by the agency of that peculiar organic compound, gallic acid. See Calotype.

4. The *Collodion* process, which must be succinctly described hereafter.

In addition to the ordinary form of the calotype process as devised by Mr. Fox Talbot, and of which an account has been given under the proper head, the *Wax-paper* process demands some attention. The following directions are those given by Mr. Wm. Crookes, who has devoted much attention to, and who has been eminently successful with, the wax-paper.

The first operation to be performed is to make a slight pencil mark on that side of the paper which is to receive the sensitive coating. If a sheet of Canson's paper be examined in a good light, one of the sides will be found to present a finely reticulated appearance, while the other will be perfectly smooth; this latter is the one that should be marked. Fifty or a hundred sheets may be marked at once, by holding a pile of them firmly by one end, and then bending the packet round, until the loose ends separate one from another like a fan: generally all the sheets lie in the same direction, therefore it is only necessary to ascertain that the smooth side of one of them is uppermost, and then draw a pencil once or twice along the exposed edges.

The paper has now to be saturated with white wax. The wax is to be made perfectly liquid, and then the sheets of paper, taken up singly and held by one end, are gradually lowered on to the fluid. As soon as the wax is absorbed, which takes place almost directly, they are to be lifted up with rather a quick movement, held by one corner, and allowed to drain until the wax, ceasing to run off, congeals on the surface. When the sheets are first taken up for this operation, they should be briefly examined, and such as show the water-mark, contain any black spots, or have anything unusual about their appearance, should be rejected.

The paper in this stage will contain far more wax than necessary; the excess may be removed by placing the sheets singly between blotting-paper, and ironing them; but this is wasteful, and the loss may be avoided by placing on each side of the waxed sheet two or three sheets of unwaxed photographic paper, and then ironing the whole between blotting-paper; there will generally be enough wax on the centre sheet to saturate fully those next to it on each side, and partially, if not entirely, the others. Those that are imperfectly waxed may be made the outer sheets of the succeeding set. Finally, each sheet must be separately ironed between blotting-paper, until the glistening patches of wax are absorbed.

It is of the utmost consequence that the temperature of the iron should not exceed that of boiling water. Before using, always dip it into water until the hissing entirely ceases. This is one of the most important points in the whole process, but one which it is very difficult to make beginners properly appreciate. The disadvantages of having too hot an iron are not apparent until an after stage, while the saving of time and trouble is a great temptation to beginners.

A well waxed sheet of paper, when viewed by obliquely reflected light, ought to present a perfectly uniform glazed appearance on one side, while the other should be rather duller; there must be no shining patches on any part of the surface, nor should any irregularities be observed on examining the paper with a black ground placed behind; seen by transmitted light, it will appear opalescent, but there should be no approach to a granular structure. The colour of a pile of waxed sheets is slightly bluish.

The paper, having undergone this preparatory operation, is ready for *iodising;* this is effected by completely immersing it in an aqueous solution of an alkaline iodide, either pure or mixed with some analogous salt.

Bromide of potassium is sometimes added, and with much advantage in many cases, to the iodising bath. The addition of a chloride has been found to produce a somewhat similar effect to that of a bromide, but in a less marked degree. No particular advantage, however, can be traced to it.

The best results are obtained when the iodide and bromide are mixed in the proportion of their atomic weights, the strength being as follows: —

Iodide of potassium - - - - -	582·5 grains.
Bromide of potassium - - - -	417·5 grains.
Distilled water - - - - -	40 ounces.

When the two salts have dissolved in the water, the mixture should be filtered; the bath will then be fit for use.

At first a slight difficulty will be felt in immersing the waxed sheets in the liquid without enclosing air bubbles, the greasy nature of the surface causing the solution to run off. The best way is to hold the paper by one end, and gradually to bring it down on to the liquid, commencing at the other end; the paper ought not to slant towards the surface of the bath, or there will be danger of enclosing air bubbles; but while it is being laid down, the part out of the liquid should be kept as nearly as possible perpendicular to the surface of the liquid; any curling up of the sheet when first laid down may be prevented by breathing on it gently. In about ten minutes the sheet ought to be lifted up by one corner, and turned over in the same manner; a slight agitation of the dish will then throw the liquid entirely over that sheet, and another can be treated in like manner.

These sheets must remain soaking in this bath for about three hours; several times during that interval (and especially if there be many sheets in the same bath) they ought to be moved about and turned over singly, to allow of the liquid penetrating between them, and coming perfectly in contact with every part of the surface. After they have soaked for a sufficient time, the sheets should be taken out and hung up to dry; this is conveniently effected by stretching a string across the room, and hooking the papers on to this by means of a pin bent into the shape of the letter S. After a sheet has been hung up for a few minutes, a piece of blotting-paper, about one inch square, should be stuck to the bottom corner to absorb the drop, and prevent its drying on the sheet, or it would cause a stain in the picture.

While the sheets are drying, they should be looked at occasionally, and the way in which the liquid on the surface dries noticed; if it collect in drops all over the surface, it is a sign that the sheets have not been sufficiently acted on by the iodising bath, owing to their having been removed from the latter too soon. The sheets will usually during drying assume a dirty pink appearance, owing probably to the liberation of iodine by ozone in the air, and its subsequent combination with the starch and wax in the paper. This is by no means a bad sign, if the colour be at all uniform; but if it appear in patches and spots, it shows that there has been some irregular absorption of the wax, or defect in the iodising, and it will be as well to reject sheets so marked.

As soon as the sheets are quite dry, they can be put aside in a box for use at a future time. There is a great deal of uncertainty as regards the length of time the sheets may be kept in this state without spoiling. Mr. Crookes speaks from experience as to there being no sensible deterioration after a lapse of ten months.

Up to this stage, it is immaterial whether the operations have been performed by daylight or not; but the subsequent treatment, until the fixing of the picture, must be done by yellow light.

The next step consists in rendering the iodised paper sensitive to light. Although, when extreme care is taken in this operation, it is hardly of any consequence when this is performed; yet in practice, it will not be found convenient to *excite* the paper earlier than about a fortnight before its being required for use. The materials for the exciting bath are nitrate of silver, glacial acetic acid. and water.

The following bath is recommended:—

Nitrate of silver - - - - - -	300 grains.
Glacial acetic acid - - - - - -	2 drachms.
Distilled water - - - - - -	20 ounces.

The nitrate of silver and acetic acid are to be added to the water, and when dissolved, filtered into a clean dish, taking care that the bottom of the dish be flat, and that the liquid cover it to the depth of at least half an inch all over; by the side of this, two similar dishes must be placed, each containing distilled water.

A sheet of iodised paper is to be taken by one end, and gradually lowered, the marked side downwards, on to the exciting solution, taking care that no liquid gets on to the back, and no air bubbles are enclosed.

It will be necessary for the sheet to remain on this bath from five to ten minutes; but it can generally be known when the operation is completed by the change in appearance, the pink colour entirely disappearing, and the sheet assuming a pure homogeneous straw colour. When this is the case, one corner of it must be raised up by the platinum spatula, lifted out of the dish with rather a quick movement, allowed to drain for about half a minute, and then floated on the surface of the water in the second dish, while another iodised sheet is placed on the nitrate of silver solution; when this has remained on for a sufficient time, it must be in like manner transferred to the dish of distilled water, having removed the previous sheet to the next dish.

A third iodised sheet can now be excited, and when this is completed, the one first excited must be rubbed perfectly dry between folds of clean blotting-paper, wrapped up in clean paper, and preserved in a portfolio until required for use; and the others can be transferred a dish forward, as before, taking care that each sheet be washed twice in distilled water, and that at every fourth sheet the dishes of washing water be emptied and replenished with clean distilled water; this water should not be thrown away, but preserved in a bottle for a subsequent operation.

The above quantity of the exciting bath will be found quite enough to excite about fifty sheets of the size here employed, or 3,000 square inches of paper.

Of course these sensitive sheets must be kept in perfect darkness. Generally, sufficient attention is not paid to this point. It should be borne in mind, that an amount of white light, quite harmless if the paper were only exposed to its action for a few minutes, will infallibly destroy it if it be allowed to have access to it for any length of time; therefore, the longer the sheets are required to be kept, the more carefully must the light, even from gas, be excluded; they must likewise be kept away from any fumes or vapour.

Experience alone can tell the proper time to expose the sensitive paper to the action of light, in order to obtain the best effects. However, it will be useful to remember, that it is almost always possible, however short the time of exposure, to obtain some trace of effect by prolonged development. Varying the time of exposure, within certain limits, makes very little difference on the finished picture; its principal effect being to shorten or prolong the time of development.

Unless the exposure to light has been extremely long (much longer than can take place under the circumstances we are contemplating), nothing will be visible on the sheet after its removal from the instrument more than there was previous to exposure; the action of the light merely producing a latent impression, which requires to be developed to render it visible.

The developing solution in nearly every case consists of an aqueous solution of gallic acid, with the addition, more or less, of a solution of nitrate of silver.

An improvement on the ordinary method of developing with gallic acid, formed the subject of a communication from Mr. Crookes to the *Philosophical Magazine* for March 1855, who recommends the employment of a strong alcoholic solution of gallic acid, to be diluted with water when required for use, as being more economical both of time and trouble than the preparation of a great quantity of an aqueous solution for each operation.

The solution is thus made: put two ounces of crystallised gallic acid into a dry flask with a narrow neck; over this pour six ounces of good alcohol (60° over proof), and place the flask in hot water until the acid is dissolved, or nearly so. This will not take long, especially if it be well shaken once or twice. Allow it to cool, then add half a drachm of glacial acetic acid, and filter the whole into a stoppered bottle.

The developing solution for one set of sheets, or 180 square inches, is prepared by mixing together ten ounces of the water that has been previously used for washing the excited papers, and 4 drachms of the exhausted exciting bath; the mixture is then filtered into a perfectly clean dish, and half a drachm of the above alcoholic solution of gallic acid poured into it. The dish must be shaken about until the greasy appearance is quite gone from the surface; and then the sheets of paper may be laid down on the solution in the ordinary manner with the marked side downwards, taking particular care that none of the solution gets on the back of the paper, or it will cause a stain. Should this happen, either dry it with blotting paper, or immerse the sheet entirely in the liquid.

If the paper has been exposed to a moderate light, the picture will begin to appear within five minutes of its being laid on the solution, and will be finished in a few hours. It may, however, sometimes be requisite, if the light has been feeble, to prolong the development for a day or more. If the dish be perfectly clean, the developing solution will remain active for the whole of this time, and when used only for a few hours, will be quite clear and colourless, or with the faintest tinge of brown; a darker appearance indicates the presence of dirt. The progress of the development may be watched, by gently raising one corner with the platinum spatula, and lifting the sheet up by the fingers. This should not be done too often, as there is always a risk of producing stains on the surface of the picture.

As soon as the picture is judged to be sufficiently intense, it must be removed from the gallo-nitrate, and laid on a dish of water (not necessarily distilled). In this state it may remain until the final operation of fixing, which need not be performed immediately, if inconvenient. After being washed once or twice, and dried between clean blotting paper, the picture will remain unharmed for weeks, if kept in a dark place.

Some general remarks on the *fixing processes* will be found towards the end of this article.

The Collodion Process.

The difficulty with which we are met in any attempt to describe this photographic process is, that it is almost hopeless to find two photographers who adopt precisely the same order of manipulation; and books almost without number have been published, each one recommending some special system.

By general consent the discovery of the collodion process, as now employed, is given to the late Mr. Scott Archer. It will, therefore, be considered quite sufficient to give the details of his process, which has really been but little improved on since its first introduction.

To prepare the collodion. Thirty grains of gun cotton should be taken and placed in 18 fluid ounces of rectified sulphuric ether, and then 2 ounces of alcohol should be added, making thus one imperial pint of the solution. The cotton, if properly made, will dissolve entirely; but any small fibre which may be floating about should be allowed to deposit and the clear solution poured off.

To iodise the collodion. Prepare a saturated solution of iodide of potassium in alcohol—say one ounce, and add to it as much iodide of silver, recently precipitated and well washed, as it will take up: this solution is to be added to the collodion, the quantity depending on the proportion of alcohol which has been used in the preparation of the collodion.

Coating the plate. A plate of perfectly smooth glass, free from air bubble or striæ, should be cleaned very perfectly with a few drops of ammonia on cotton, and then wiped in a very clean cotton cloth.

The plate must be held by the left hand perfectly horizontal, and then with the right a sufficient quantity of iodised collodion should be poured into the centre, so as to diffuse itself equally over the surface. This should be done coolly and steadily, allowing it to flow to each corner in succession, taking care that the edges are well covered; then gently tilt the plate, that the superfluous fluid may return to the bottle from the opposite corner to that by which the plate is held. At this moment the plate should be brought into a vertical position, when the diagonal lines caused by the fluid running to the corner, will fall one into the other, and give a clear flat surface. To do this neatly and effectually some little practice is necessary, as in most things, but the operator should by no means hurry the operation, but do it systematically, at the same time not being longer over it than is actually necessary, for collodion being an ethereal compound evaporates rapidly. Many operators waste their collodion by imagining it is necessary to perform this operation in great haste; but such is not the case, for an even coating can seldom be obtained if the fluid is poured on and off again too rapidly; it is better to do it steadily, and submit to a small loss from evaporation. If the collodion becomes too thick, thin it with the addition of a little fresh and good ether.

Exciting the plate. Previous to the last operation it is necessary to have the bath ready, which is made as follows:—

Nitrate of silver - - - - -	30 grains.
Distilled water - - - - -	1 ounce.

Dissolve and filter.

The quantity of this fluid *necessary* to be made must depend upon the *form of trough to be used*, whether horizontal or vertical, and also upon the size of the plate. With the vertical trough a glass dipper is provided, upon which the plate rests, preventing the necessity of any handle or the fingers going into the liquid. If, however, the glass used is a little larger than required, this is not necessary. Having then obtained one or other of these two and filtered the liquid previously, the plate, free from any particle of dust, &c., is to be *immersed steadily and without hesitation*; for if a pause should be made in any part, a line is sure to be formed, which will print in a subsequent part of the process.

The plate being immersed in the solution must be kept there a sufficient time for the liquid to act freely upon the surface, particularly if a negative picture is to be obtained. *As a general rule, it will take about two minutes, but this will vary with the temperature of the air at the time of operating, and the condition of the collodion.* In cold weather, or indeed anything below 50° F., the bath should be placed in a warm situation, or a proper decomposition is not obtained under a very long time. Above 60° the plate will be certain to have obtained its maximum of sensibility by two minutes' immersion, but below this temperature it is better to *give a little extra time.*

To facilitate the action, let the temperature be what it may, the plate must be lifted out of the liquid two or three times, which also assists in getting rid of the ether from the surface, for without this is thoroughly done a uniform coating cannot be obtained; *but on no account should it be removed until the plate has been immersed about half a minute*, as marks are apt to be produced if removed sooner.

The plate is now ready to receive its impression in the camera obscura. This having been done, the picture is to be developed.

The development of image. To effect this the plate must be taken again into the dark room, and with care removed from the slide to the levelling stand.

It will be well to caution the operator respecting the removal of the plate. Glass, as before observed, is a bad conductor of heat; therefore, if in taking it out we allow it to rest on the fingers at any one spot too long, that portion will be warmed through to the face, and as this is not done until the developing solution is ready to go over, the action will be more energetic at those parts than at others, and consequently destroy the evenness of the picture. We should, therefore, handle the plate with care, as if it already possessed too much heat to be comfortable to the fingers, and that we must therefore get it on the stand as soon as possible.

Having then got it there we must next cover the face with the developing solution. This should be made as follows:

Pyrogallic acid - - - - - -	5 grains.
Glacial acetic acid - - - - -	40 minims.
Distilled water - - - - - -	10 oz.

Dissolve and filter.

Mr. Delamotte employs

Pyrogallic acid - - - - - -	9 grains.
Glacial acetic acid - - - - -	2 drachms.
Distilled water - - - - - -	3 ounces.

Now, in developing a plate, the quantity of liquid taken must be in proportion to its size. A plate measuring 5 inches by 4 will require half an ounce; less may be used, but it is at the risk of stains; therefore we would recommend that half an ounce of the above be measured out, into *a perfectly clean measure*, and to this from 8 to 12 drops of a 50-grain solution of nitrate of silver be added.

Pour this quickly over the surface, taking care not to hold the measure too high, and not to pour all on one spot, but having taken the measure properly in the fingers, begin at one end, and carry the hand forward; immediately blow upon the face of the plate, which has the effect not only of diffusing it over the surface, but causes the solution to combine more equally with the damp surface of the plate: it also has the effect of keeping any deposit that may form in motion, which, if allowed to settle, causes the picture to come out mottled. A piece of white paper may now be held under the plate, to observe the development of the picture: if the light of the room is adapted for viewing it in this manner, well; if not, a light must be held below, but in either case arrangements should be made to view the plate easily whilst under the operation: a successful result depending so much upon obtaining sufficient development without carrying it too far.

As soon as the necessary development has been obtained, the liquor must be poured off, and the surface washed with a little water, which is easily done by holding the plate over a dish, and pouring water on it; taking care, both in this and a subsequent part of the process, to hold the plate horizontally, and not vertically, so as to prevent the coating being torn by the force and weight of water.

Protosulphate of iron, which was first introduced as a photographic agent in 1840 by Robert Hunt, may be employed instead of the pyrogallic acid with much advantage. The beautiful collodion portraits obtained by Mr. Tunny of Edinburgh are all developed by the iron salt. The following are the best proportions:

Protosulphate of iron - - - - -	1 ounce.
Acetic acid - - - - - - -	12 minims.
Distilled water - - - - - - -	1 pint.

This is used in the same manner as the former solutions.

Fixing of image. This is simply the removal of iodide of silver from the surface of the plate, and is effected by pouring over it, after it has been dipped into water, a solution of hyposulphite of soda, made of the strength of 4 ounces to a pint of water. At this point daylight may be admitted into the room, and, indeed, we cannot judge well of its removal without it. We then see by tilting the plate to and fro the iodide gradually dissolve away, and the different parts left more or less transparent, according to the action of light upon them.

It then only remains to thoroughly wash away every trace of the hyposulphite of soda, for should any salt be left, it gradually destroys the picture. The plate should therefore either be immersed with great care in a vessel of clean water, or what is better, water poured gently and carefully over the surface. After this it must be placed upright to dry, or held before a fire.

The fixing processes. The most important part of Photography, and one to which the least attention has been paid, is the process of rendering permanent the beautiful images which have been obtained. Nearly all the fine photographs with which we are now familiar are not permanent. This is deeply to be regretted, especially as there appears to be no necessity for their fading away. In nearly all cases the fading of a photograph may be referred to carelessness, and it is not a little startling and certainly very annoying, to hear a very large dealer in photographic pictures declare that the finest pictures by the best photographers are the first to fade. This is, no doubt, to be accounted for by the demand which there is for their pictures, leading to a fatal rapidity in the necessary manipulatory details.

There is no necessity for a photograph to fade if kept with ordinary care. It should be at all events as permanent as a sepia drawing. The hyposulphite of soda is the true fixing agent for any of the photographic processes, be they Daguerreotype, calotype, collodion, or the ordinary process for producing positive prints. It should be understood, whichever of the salts of silver are employed, that by the action of the solar rays either oxide of silver or metallic silver is produced, and the unchanged chloride, iodide, or bromide can be dissolved out by the use of the *hyposulphite of soda*.

The photographic picture on paper, on metal, or on glass, is washed with a strong solution of the hyposulphite of soda, and the silver salt employed combines with it, forming a peculiarly sweet compound, the hyposulphite of silver; this is soluble in water, and hence we have only to remove it by copious ablutions. The usual practice is to place the pictures in trays of water and to change the fluid frequently. In this is the danger, and to it may be traced the fading of nine-tenths of the pictures prepared on paper.

Paper is a mass of linen or cotton fibre; howsoever fine the pulp may be prepared, it is still full of capillary pores, which, by virtue of the force called capillarity, hold with enormous force a large portion of the solid contents of the water. If we make a solution of a known strength of the hyposulphite of soda, and dip a piece of paper into it, it will be found to have lost more of the salt than belongs to the small quantity of water abstracted by the paper. Solid matter in excess has been withdrawn from the solution. So a photographic picture on paper holds with great tenacity one or other of the hyposulphites. By soaking there is of course a certain portion removed, but it is not possible by any system of soaking to remove it all.

The picture is, however, prepared in this manner, and slowly, but surely, under the combined influences of the solar rays and atmospheric moisture, the metallic silver loses colour, *i. e.* the photograph fades.

The only process to be relied on demands that every picture should be treated separately. First, any number may be soaked in water, and the water changed; by this means the excess of the hyposulphite of silver is removed. Then each picture must be taken out and placed upon a slab of porcelain or glass, and being fixed at a small angle, water should be allowed to flow freely over and off it. Beyond this, the operator should be furnished with a piece of soft sponge, and he should maintain for a long time a dabbing motion. By this mechanical means he disturbs the solid matter held in the capillary tubes, and eventually removes it. The labour thus bestowed is rewarded by the production of a permanent picture, not to be secured by any other means.

In this article those processes only which have become of commercial value have been noted. The Carbon process of printing, which promises well, can scarcely be said to be as yet in a perfect state; and for the other curious but less important processes, and for a full examination of the philosophy of the subject, see *Hunt's Researches on Light*, 2nd edition.

PHOTOMETRY. The measurement of light, or of illuminating power. See ILLUMINATION.

PHOTOZINCOGRAPHY. This is the name given by Colonel James, R. E., Director of the Ordnance Survey, to a process which he has lately introduced, and which has been carried out, to some extent experimentally, in the Ordnance Map Office at Southampton, for the purpose of copying ancient documents. In a report just made to the House of Commons (March, 1860), Colonel James thus describes the process. After speaking of some experiments made with the carbon printing process, he continues:—

"We have also tried a method, which is still more valuable, and by which the reduced print is in a state to be at once transferred to stone or zinc, from which any number of copies can be taken, as in ordinary lithographic or zincographic printing, or for transfer to the waxed surface of the copper plates. To effect this, the paper, after being washed over with the solution of the bichromate of potash and gum, and dried, is placed in the printing frame under the collodion negative, and after exposure to the light, the whole surface is coated over with lithographic ink, and a stream of hot water then poured over it; and as the portion which was exposed to the light is insoluble, whilst the composition in all other parts being soluble is easily washed off, we obtain at once the outline of the map in a state ready for being transferred either to stone, zinc, or the copper plate, or we can take the photograph on the zinc at once.

"This new method of printing from a negative is extremely simple and inexpensive, and promises to be of great use to us. Sheet 96, of Northumberland, has been transferred to the copper plate from impressions taken by this process, and from the perfect manner in which we are able to transfer the impressions to zinc, we can, if required, print any number of faithful copies of the ancient records of the kingdom, such as *Doomsday Book*, the *Pipe Rolls*, &c., at a comparatively speaking very trifling cost. (See specimen at the end of this Report). I have called this new method Photozincography, and anticipate that it will become very generally useful, not only to Government, but to the public at large, for producing perfectly accurate copies of documents of any kind."

PHTHALIC ACID. A crystallised substance produced by the action of nitric acid on rubian. See MADDER.

PHYTOGRAPHY. See NATURE PRINTING.

PICAMARE. Colourless oil in wood tar, discovered by Reichenbach. See DISTILLATION, DESTRUCTIVE; NAPHTHA; PYROXILIC SPIRIT.

PICKLES are various kinds of vegetables and fruits preserved in vinegar. The preparation of pickles belongs rather to a book on cookery. The peculiar and beautiful green colour which has been frequently imparted to pickles, is due in nearly all cases to the use of a salt of copper. This is in the highest degree injurious, and cannot be too strongly deprecated. The presence of copper may be detected by putting the blade of a perfectly clean knife, or, still better, a polished piece of soft iron, into the suspected pickle; it will, if copper be present, become coated in a short time with a cupreous film. It is satisfactory to find that most of our large pickle manufacturers are content to sacrifice the colour, at one time so much looked to; and they now furnish the public with pickles which are free from any metallic contamination.

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.—C. G. W.

PICOLINE, $C^{12}H^{7}N$. A nitryle base, isomeric with aniline, discovered by Anderson in coal naphtha and bone oil. It is also contained in the shale naphtha and crude chinoline.—C. G. W.

PICROTOXIN (*Picrotoxic acid*) is an intensely bitter poisonous vegetable principle, extracted from the seeds of the *Menispermum cocculus*, (Cocculus Indicus). It crystallises in small white needles, dissolves in boiling water and in alcohol. It does not combine with acids, but forms combinations with alkalies. Its formula is $C^{12}H^{7}O^{5}$.—C. G. W.

PIETRA DURA. Ornamental work, executed in coloured stones, representing flowers, fruits, birds, and the like. The Florentine work and the inlaid marble work of Derbyshire are of this character.

PIGMENTS. See Colours, Paints.

PIMENTO. (*Myrtus pimenta*, Linn., *Eugenia pimenta*, De Candolle.) Allspice, or Jamaica pepper. This plant is cultivated in Jamaica in regular *Pimento walks*. The full sized fruit is gathered green and sun-dried, during which process it is frequently immersed. It is sent to the English market in bags of 1 cwt. each. This fruit consists, according to Bonastre's complicated analysis, of:—

	Shells or Capsules.	Kernels.
Volatile oil	10·0	5·0
Green oil	8·4	2·5
Concrete oil	0·9	1·2
Extract containing tannin	11·4	39·8
Gummy extract	3·0	7·2
Brown matter dissolved in potash	4·0	8·0
Resinous matter	1·2	3·2
Sugar, uncrystallised	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

Our *imports* and *exports* were as follows in 1858:—

Imports, almost all from Jamaica	42,310 cwts.
Exports	24,015 „

PINANG, or Betel Nut. See Areca.

PINCHBECK. A yellow metal, composed of 3 ounces of zinc to 1 lb. of copper. See Alloy; Brass.

PINE-APPLE YARN and CLOTH. In Mr. Zincke's process, patented in December, 1836, for preparing the filaments of this plant, the *Bromelia ananas*, 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 is 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.

PINES. A numerous family of cone-bearing timber trees. The wood, which is extensively used, is imported under the names of American, Baltic, Dantzic, Memel, Norway, and Riga timber, Swiss deals, &c. The New Zealand pine, called also the Cowdie or Kaurie (the *Dammara Australis*), is not a true pine.

The Pinus sylvestris. The wild pine, or Scotch fir, yields the yellow deal.

The Abies excelsa. The Norway spruce fir, the white deal.

The Abies picea. The silver fir, a whitish deal, much used for flooring.

The Larix Europea. The Larch. This wood is much employed in Switzerland.

The Pinus Strobus. The Weymouth pine, is much used in the Northern United States.

The Pinus Australis. The southern pine, yellow pine, or pitch pine. Of this wood nearly all the houses of the southern United States are built. It is imported into Liverpool as the Georgia pitch pine.

There are numerous others, as the American larch, the balm of Gilead fir, the spruce firs, &c., which are employed in various districts for ship and house building, but they scarcely require any special notice here.

Our *imports*, in 1858, were: —

	Loads.	Computed real value.
Not sawn or split, or otherwise dressed except hewn - -	971,826	£2,776,808
Deals, battens, boards, &c., sawn or split - - - - -	1,255,430	£3,187,200

The duty from 10th October, 1842, on timber of British possessions, 2*s.* $1\frac{2}{10}$*d.*; and from 15th April, 1851, on foreign timber, 10*s.* per load.

PINEY TALLOW is a concrete fat obtained by boiling with water the fruit of the *Vateria 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 97½° F., is white or yellowish, has a spec. grav. of 0·926; is saponified by alkalies, 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. See OIL.

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 red-hot 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 cleaning 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 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. A detailed description of it will be found in the 9th volume of *Newton's London Journal.* The following outline will give the reader an idea of the structure of Mr. L. W. Wright's ingenious machine for pin making.

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 die 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.

The following is a further detail of this very interesting manufacture: —

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."

An improved pin has been introduced, in which iron or steel wires have been employed. 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.

The following is the process adopted with those: — 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 $9\frac{1}{2}$ gallons, but should not contain more than about $1\frac{1}{2}$ gallons of water, with about 2 ounces of soap dissolved therein, as this quantity will be sufficient for the treatment of about $13\frac{1}{2}$ 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 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.

Into a glass or stone vase, there are put about $1\frac{1}{2}$ gallons of soft water, $\frac{7}{10}$ of a pound of sulphuric acid, $\frac{6}{100}$ lb. of salt of tin, $\frac{8}{100}$ lb. of crystallised sulphate of zinc, and 108 grs. of pure sulphate of copper. This mixture is left to work for about 24 hours, so that the salts and sulphates may be properly dissolved.

The mixture, prepared as directed, is introduced into another revolving cylinder, and pins about $13\frac{1}{2}$ 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 grs. of crystallised sulphate of copper in coarse powder, and 150 grs. of crystallised 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 $4\frac{2}{5}$ lbs. of crude tartar or cream of tartar, in about 22 gallons 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.

PIPERIDINE, $C^{10}H^{11}N$. A volatile base, discovered by Anderson, by acting with potash on the product of the action of nitric acid on piperine. It may also be procured by treating piperine with potash. It has been chiefly studied by Cahours.—C. G. W.

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, which see.

PITCH *of wood-tar* (*Poix*, Fr.; *Pech*, Germ.) is obtained by boiling tar in an open iron pot, or in a still, till the volatile matters are driven off. Pitch contains pyroligneous resin, along with colophany (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. See TAR.

PIPECLAY. A silicate of alumina, found in Devonshire and some other parts, much used in the manufacture of tobacco pipes. See PORCELAIN CLAY.

PITCH BLENDE. An ore of URANIUM, which see.

PITCH-STONE. A glassy trappean rock, similar to, and often classed with obsidian.

PITCOAL. See COAL.

PITTACAL, from two Greek words, signifying *fine pitch*, is one of the principles detected in wood-tar by Reichenbach. It is obtained by adding barytes water to a solution of *picamar*, or of oil of tar deprived of its acid, when the pittacal falls. It is a dark-blue solid substance, somewhat like indigo, and assumes a metallic lustre on friction. It is void of taste and smell, not volatile; carbonises 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 alkalies, and in alcohol and ether. It dyes a fast blue upon linen and cotton goods with tin and aluminous mordants.

PLANE TREE. Maple or Plane. (*Erable*, Fr.; *Ahorn*, Germ.) The *Platanus occidentalis*, about the largest of the American trees. The wood of the plane tree is much used in this country for quays. It is also employed for musical instruments, and for other works requiring a clean light coloured wood.

PLASMA. A translucent chalcedony, of a greenish colour, and a glittering lustre.

PLASTER. See MORTAR.

PLASTER OF PARIS. See ALABASTER and GYPSUM.

PLASTIC CLAY. Any clay which, when in a moist state, may be kneaded between the fingers, and admits of being moulded into a definite form, so as to be converted into pottery.

Hence plastic clay is not confined to any particular strata, and is found in secondary and tertiary formations, and also in deposits derived from the decomposition of other rocks.

In geological nomenclature, however, the term Plastic Clay is applied to those portions of the Lower Tertiary or Eocene strata which intervene between the Chalk and the London clay, in consequence of some of the beds of clay of which they are composed being of a plastic nature. Some of the earliest pottery made in this country was manufactured from these clays, dug up at Crendle Common, near Cranborne, in Dorsetshire, where, as well as at Newport in the Isle of Wight, Fareham in Hants, &c., the clay is still dug up and converted into pottery. The clay from the Plastic Clay series is generally of a bright brick-red colour, frequently mottled with white, but sometimes (as at Crendle) it is dark purple or nearly black towards the lower part, and this clay is said to be the best as regards quality. The clays of the plastic clay burn to a red colour, and are manufactured into bricks, tiles, flower-pots, and other coarse pottery.—H. W. B.

PLATE-CLEANING. Boil 30 grms. of finely powdered 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 black lead 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 oxidise 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.

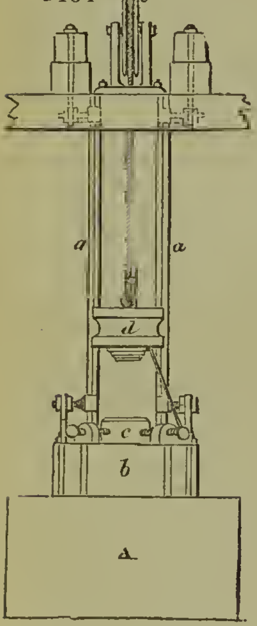
The ingot is next cleaned, and rolled to the proper thinness between cylinders, as described under MINT; being in its progress of lamination frequently annealed on a small reverberatory hearth. After the last annealing, the sheets are immersed in hot dilute sulphuric acid, and scoured with fine Calais 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 redhot 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 redhot, 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. 1464 and 1465 are two views of the stamp: A is a large stone, the more massy

1464



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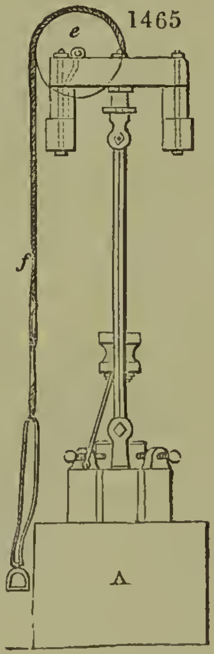
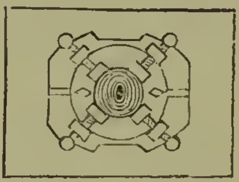
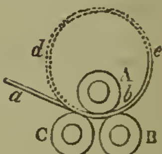


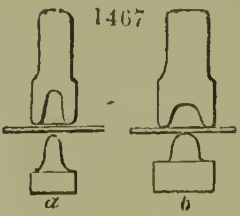
1466



1469



1467



1468

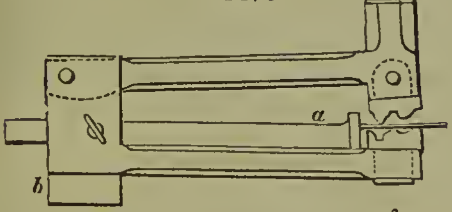
the better; *b*, the anvil on which the die *c* is secured by four screws, as shown in the ground plan, *fig.* 1466. In *fig.* 1464, *a a* are two upright square prisms, set diagonally with the angles opposed to each other; between which the hammer or drop *d* slides truly, by means of nicely fitted 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.* 1467. 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.

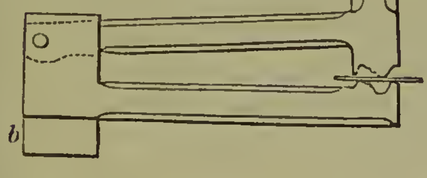
Cylindrical and conical vessels are mostly formed by bending and soldering. The bending is performed on blocks of wood, with wooden mallets; but the machine so much used by the tin-smiths, to form their tubes and cylindric vessels (see the end sections *figs.* 1468, 1469), might be employed with advantage. 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.* 1470, 1471. The part A lifts up by a joint, and

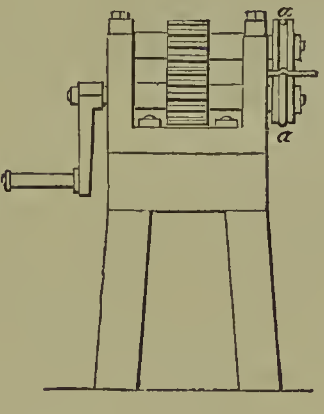
1470



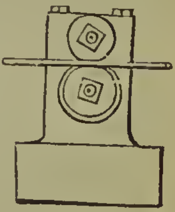
1471



1472



1474



1473

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.* 1470, 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.* 1472, 1474. *Fig.* 1473 is a section to show the form of the bead. The two wheels *a, a, fig.* 1472, 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. See Electro-Metallurgy.

PLATINUM is a metal of a greyish-white colour. 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 nitro-muriatic.

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 882½ grains, or more than 2 oz. avoirdupois. A lump of native platinum is 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 11,641 grains. In 1827 a specimen was found in the Ural Mountains which weighed 11·57 pounds troy; the largest yet obtained being in the Demidoff Cabinet, weighing 21 pounds.

The colour of the grains of native platinum is generally a greyish 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 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 recognised 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.

4. Platinum is largely produced 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. It also occurs at Nische, Tagilsk, and Goroblagodat in the Ural in alluvial and drift material.

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-grey grains, which were taken for a mixture of osmium and iridium, are merely an alloy of platinum, containing 25 per cent. of these metals. In Russia platinum has been formed into coins of eleven and twenty-two rubles each; and this country affords annually about 800 cwt. of platinum, which is nearly ten times the amount from Brazil, Colombia, St. Domingo, and Borneo.

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. The same thing has not again been met with, even in other specimens from Guadalcanal.

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 8lbs., 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 is 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.

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 beaten out into leaves of such thinness as to be blown about with the breath. Dr. Wollaston succeeded in obtaining a wire not exceeding the two-thousandth of an inch in diameter. A wire of this metal of $\frac{1}{8}$ inch in diameter will support a weight of 361 lbs.

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 nitro-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; 2nd, by the absence of the lightning, fulguration, or coruscation; 3rd, by the dull white colour of the button and its crystallised surface; 4th, by the straw-yellow colour which platinum communicates to the aquafortis in the parting; 5th, 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 the processes 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.

Production of Platinum in the Ural.

From 1822 to 1827 inclusively,	52 poods*	and 22½	pounds Russian.
1828	94 ,,		
1829	78 ,,	31½	,,
1830	105 ,,	1	,,
1831 to 1833	348 ,,	15	,,

Analyses of the Platinum Ores of the Ural, and of that from Barbacoas on the Pacific between the 2nd and 6th degrees of northern latitude.

	From Nischne-Tagilsk. Berzelius. Magnetic.	From Nischne-Tagilsk. Berzelius. Not Magnetic.	Goroblagodat. Osann.	Goroblagodat. Osann.	Barbacoas. Berzelius.
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 iridium	2·38	1·96	1·80	1·40	
Osmium	- -	- -	- -	- -	1·03
Quartz	- -	- -	- -	- -	0·60
Lime	- -	- -	- -	- -	0·12
	97·86	98·75	99·72	98·92	98·08

The value of the platinum *imported* in 1858 was 8,285*l.*

PLATINUM, ALLOYS OF. This metal will alloy with iron; the alloy is malleable and possesses much lustre.

Copper and platinum in certain proportions form a brilliant alloy.

* The Russian pood is 36 lbs. 1 oz. 11 drs. Troy. The pood contains 40 Russian pounds; 63 poods make a ton.

Silver is much hardened by platinum: although platinum is not soluble in nitric acid, it will, when alloyed with silver, dissolve in that acid.

Some other alloys are known, but none of them are employed.

PLATINUM BLACK. This interesting preparation, which so rapidly oxidises 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. Bœttger:—the insoluble powder of potassa-chloride or ammonia-chloride 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 hydrochloric 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 black will be also very fine, and proportionally powerful as a chemical agent.

The following method of preparing igniferous black platinum, proposed by Descotil, has been recommended by M. Dobereiner:—

Melt platinum 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 oxidise 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-grey powder contains some osmiuret of iridium, united with the crude platinum. This compound acts like simple platinum black, after it has been purified by digestion in potash lye, and washing with water. Its oxidising 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 platinum black 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.

A yet more simple method of preparing the platinum black than either of those is the following:—Protochloride of platinum is dissolved in a concentrated solution of potash with the aid of heat; then alcohol is added by degrees, constantly stirring the solution. The platinum is precipitated as a black powder, which is boiled successively with alcohol, hydrochloric acid, and potash water.

PLATINUM, SALTS OF. The salts of platinum being rarely employed in the arts or manufactures, the reader is referred for them to *Ure's Dictionary of Chemistry.*

PLATINUM YELLOW. A pigment prepared from platina, by oxidation with acids, is sold under this name.

PLUMBAGO, commonly called Black Lead; the name *plumbago*, and its common one, being derived from the fact of this mineral resembling lead in its external appearance. See Graphite, for its mineralogical and chemical characters. In this country plumbago has been found most abundantly in Cumberland. The mountain at Borrowdale, in which the black lead is mined, is nearly 2,000 feet high, and the entrance to the mine is about 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 was then protected by a 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 could enter the interior of the mountain. In this apartment, called the dressing-room, the miners change their ordinary clothes for their mining dress. At one time as much as 100,000*l.* was realised from the Borrowdale mine in a year, the Cumberland plumbago selling at 45*s.* per pound. This mine has not, however, been worked for many years. The last great discovery, stated to have been about 30,000*l.*'s worth, has been hoarded by the proprietors, a small quantity only being sold every year; but it is now generally understood to be nearly exhausted. Some few years since the Borrowdale Black Lead Mine was inspected by three experienced miners, but their report was far from encouraging; notwithstanding which a new company has been recently (1859) formed to work this mine.

This plumbago in Borrowdale is found in "nests" in a trap rock, partially decomposed, which runs through the clay slate. In Glenstrathfarrar in Inverness, it is found in gneiss, and at Craigman in Ayrshire it occurs in coal beds which have been formed in contact with trap. In Cornwall plumbago has been discovered in small lumps in the Elvan courses (see Elvan); and on the northern coast of that country, small pieces are picked out of the clay slate rocks, where it has been exposed by the wearing down of the cliffs. At Arendal, in Norway, it occurs with quartz. Plumbago is sometimes formed in considerable quantities in the beds of blast furnaces, especially at Cleator Moor.

Plumbago occurs in Finland. Large quantities are brought from Ceylon and the East Indies. Some considerable portions are obtained from the mines of the United States.

Mr. Brodie purifies plumbago by mixing it in coarse powder, in an iron vessel, with twice its own weight of commercial sulphuric acid, and seven per cent. of chlorate of potash, and heats the whole over a water bath until chloric oxide ceases to be evolved. By this means the compounds of iron, lime, and alumina present, are rendered for the most part soluble, and the subsequent addition of a little fluoride of sodium to the acid mixture, will decompose any silicates which may remain, and volatilise the silica present. The mass is now washed with abundance of water, dried, and heated to redness. This last operation causes the grains of the plumbago to exfoliate. The mass swells up in a surprising manner, and is reduced to a state of very minute division. It is then levigated, and obtained in a state of great purity, ready to be compressed by the method of Brockedon.—T. S. H.

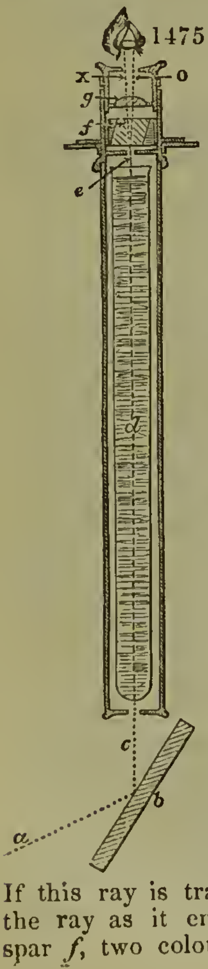
PLUSH (*Panne*, *Peluche*, Fr.; *Wollsammet*, *Plüsch*, Germ.) is a textile fabric, having a sort of velvet nap or shag upon one side. It is composed regularly of a woof of a single woollen thread, and a two-fold warp, the one, wool of two threads twisted, the other, goat's or camel's hair. There are 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 woof 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 broach, 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.

POAKE. A name amongst peltmongers for the collected waste arising in the preparation of skins; it is used for manure.

POINT NET is a style of lace formerly much in vogue, but now superseded by the bobbin-net manufacture.

POLARISATION OF LIGHT. It is not the purpose of the present work to deal with any of the peculiar phenomena of the physical powers, except so far as they are involved in any of the processes of manufacture. Polarised light is employed in the sugar refinery; it therefore is necessary that some short account should be given of the phenomena so called, and of the methods of rendering it available to useful ends.

1475



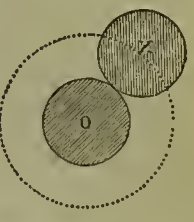
Under the term *Polarisation of Light* is comprehended a variety of very singular phenomena, which it is exceedingly difficult to explain within the space which can be devoted to this article. For anything like an exact description of these peculiar and striking phenomena, the reader is referred to works devoted specially to this branch of science. For our purpose it will be sufficient to state that if a ray of light is reflected from a plate of glass placed at an angle of about 56 degrees, it will be found to have undergone a remarkable change. If the reflected ray of light is looked at through a thin slice of *Tourmaline*, it will be found that while the ray is seen, while the reflecting plate is in one position, it can no longer be seen through the transparent crystal if the glass plate is turned round 90°, or if the crystal is turned to the same extent; although an ordinary ray of light is seen with equal intensity in whatever position the crystal may be held.

The ray of light by reflection, at or about the above-named angle, appears to have assumed the position of a polar body, *i. e.*, a body having dissimilar sides. or it may be, that the mode of motion has been altered by the reflection at the polarising angle. Light can be polarised by refraction, equally as well as by reflection.

Under some circumstances, the condition of *Circular Polarisation* is produced. (See Pereira's *Lectures on Polarised Light*). We do not attempt to explain this. The phenomena alone is all we have now to deal with. An instrument called a Polariscope is constructed upon the principles shown in the accompanying figure (*fig.* 1475).

If a ray of common light *a*, be polarised by falling upon a glass *b*, at an angle of 56° 45′, the plane polarised ray *c* is obtained. If this ray is transmitted through a pure solution of crystallisable cane sugar, and the ray as it emerges, *e*, be analysed by a double refracting rhomb of Iceland spar *f*, two coloured images are perceived, as shown in *fig.* 1476. One, *o*, is caused by ordinary refraction, and the other, *x*, by extraordinary refraction. *y* is a lens to produce a well-defined image. The colours of these images are complementary, that is, when one is *red* the other is *green*, when one is *yellow* the other is *violet*, when one is *blue* the other is *orange*. By rotating the "analyser,"—the rhomb of Iceland spar,—the colours change. If the rotation be right handed, that is, as we turn a screw or cork-screw to make it enter, the sequence of colour is *red, orange, yellow, green, blue, indigo,* and *violet red.* It will be understood that by rotating the rhomb of Iceland spar, the extraordinary ray revolves around the ordinary ray, each undergoing a change of colour. The sequence of the ordinary image being given above, and the complementary colours named, it will be seen that the sequence of colours on the extraordinary image will be *green, blue, indigo,* and *violet, red, orange, yellow, green.* In one complete revolution of the analyser, each of the colours of the spectrum occurs twice for each image. The polariscope is now used for both the qualitative and quantitative analysis of sugar. Indeed, the minutest difference in chemical character and physical constitution can be readily detected by this instrument. See SUGAR.

1476



POLISHING SLATE. A grey or yellow slate composed of microscopic infusoria. It is found abundantly in the coal measures of Bohemia, and in the Auvergne.

POLYCHROMATE. (*Æsculine.*) A compound from which a variety of colours may be prepared.

A great many vegetables give, when treated with hot water, a solution which appears yellow by transmitted light, but blue by reflected light. The inner bark of the horse-chestnut is a peculiar example of this. See FLUORESCENCE.

POPLAR. (*Peuplier*, Fr.; *Pappel*, Germ.) The wooden polishing wheels of the glass grinder are made from horizontal sections of the stem of this tree. It is used in the manufacture of toys, but not for many other purposes.

POPPY OIL. Much used in painting. See OIL.

PORCELAIN. See POTTERY.

PORCELAIN CLAY. (*Kaolin.*) Nature has, up to a certain point, provided the article which man requires for the elaboration of the most perfect production of the potter's art. The clay — China clay, as it is commonly called, or *kaolin*, as the Chinese have it — is quarried from amidst the granitic masses of Dartmoor and of Cornwall. We are not at all satisfied with any of the theories which have been put forward to account for the formation of porcelain clay. It is commonly stated to be a decomposed granite; this rock, as is well known, consisting of mica, quartz, and felspar, with sometimes shorl and hornblende. The felspar is supposed to have decomposed; and, as this forms the largest portion of the mass, the granite is disintegrated by this process. We have, therefore, the mica, quartz, and the clay, forming together a soft mass, lying but a short distance below the surface, but extending to a considerable depth. It is quite evident that this stratum is not *deposited;* had it been so, the particles constituting the mass would have arranged themselves in obedience to the law of gravity, towards which there is not the slightest attempt. But we do not know by what process the decomposition of the solid granite could have been effected to a depth from the surface of upwards of one hundred feet, and then, as it often does, suddenly to cease. This, however, is a question into which we cannot at present enter. The largest quantity of porcelain or China clay is manufactured in Cornwall, especially about St. Austell and St. Stepheus; from which, in 1859, about 60,000 tons were sent away to the potteries, and for paper-making and bleaching.

A spot being discovered where this substance abounds, the operation is commenced by removing the vegetable soil and substratum, called by the workmen the *overburden*, which varies in depth from about three to ten feet. The lowest part of the ground is then selected, in order to secure an outlet for the water used in washing the clay. The *overburden* being removed, the clay is dug up in *stopes*: that is, in successive layers or courses, and each one being excavated to a greater extent than the one immediately below it, the *stopes* resemble a flight of irregular stairs. The depth of the *china clay pits* is various, extending from twenty feet to fifty feet.

The clay when first raised has the appearance and consistence of mortar; it contains numerous grains of quartz, which are disseminated throughout in the same manner as in granite. In some parts the clay is stained of a rusty colour, from the presence of veins and imbedded portions of shorl and quartz; these are called by the workmen *weed, caple,* and *shell*, which are carefully separated. The clay is next conveyed to the floor of the washing place, and is then ready for the first operation of the process.

A heap of the clay being placed on an inclined platform, on which a little stream of water falls from the height of about six feet, the workman constantly moves it and turns it over with a *piggle* and shovel, by which means the whole is gradually carried down into an oblong trench beneath, which is also inclined, and which ends in a covered channel that leads to the *catch-pits* about to be described. In the trench the grains of quartz are deposited, but the other parts of the clay, in consequence of their greater levity, are carried away in a state of suspension.

This water is conducted into a series of pits, each of which is about eight feet long, four in breadth and in depth, and is lined on the sides and bottom with cut moorstone, laid in a waterproof cement. In these pits the porcelain earth is gradually deposited. In the first pit the grosser particles collect; and being of a mixed nature, are always rejected at the end of each day's work by an opening provided for that purpose at the bottom of the pit. When the water has filled the first pit, it overflows into the second, and in like manner into the third; and in these pits, particularly in the second, a deposit also takes place, which is often preserved, and is called by the workmen *mica.* The water, still holding in suspension the finer and purer particles of porcelain clay, next overflows into larger pits, called *ponds*, which are of the same depth as the first pits, but about three times as long and wide. Here the clay is gradually deposited, and the clear supernatant water is from time to time discharged by plug-holes on one side of the pond. This process is continued until, by successive accumulations, the ponds are filled. At this stage the clay is in the state of a thick paste; and to complete the process it only remains to be consolidated by drying, and then it is fit for the market.

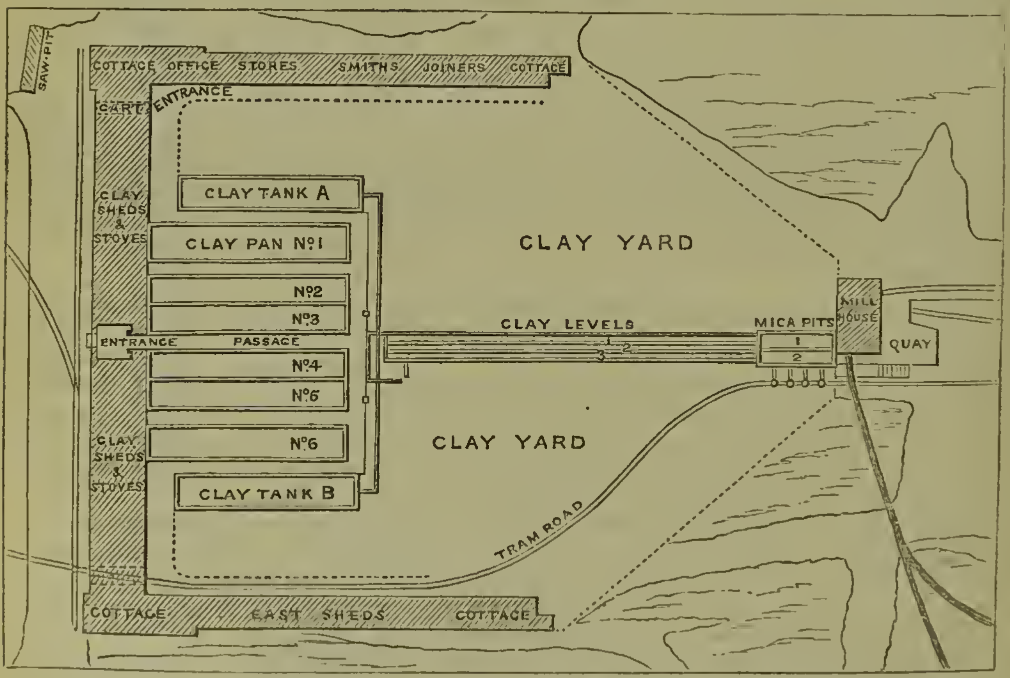
This, however, is a tedious operation in our damp climate, and is effected as follows:—The moist clay is removed in hand-barrows into *pans*, which are constructed like the *pits* and *ponds*, but are much larger, being about forty feet long, fifteen wide, and a foot and a half in depth. The above dimensions may not be quite correct, for I did not actually measure the pits; they are, however, very near the truth. When the pans are nearly filled, the clay is levelled, and is then allowed to remain undisturbed until it is nearly dry. The time required for this part of the process must depend in a great measure on the state of the weather and the season of the year, because the pans are exposed to the air. During the winter at least eight months are necessary, whilst during the summer less than half the time is sufficient.

When the clay is in a fit state, it is cut into oblong masses, and carried to the drying house,—an oblong shed, the sides of which are open wooden frames, constructed in the usual way for keeping off the rain, but admitting the free passage of the air.

The clay thus dried is next scraped perfectly clean, and is then packed up into casks, and carried to one of the adjacent ports, to be shipped for the potteries.

The porcelain earth thus prepared is of a beautiful and uniform whiteness, and is perfectly smooth and soft to the touch.—*Dr. Boase's Geology of Cornwall.*

1477



The works at Lee Moor, on the borders of Dartmoor, being, however, far more complete, we have selected them as the best for our description. See *fig.* 1477.

Here we see a quarry of this decomposed granite, shining white in the sunshine, and at the bottom of this quarry are numerous workmen employed in filling trucks placed upon a tramway. This native material is now carried off to a house, distinguished by the powerful water-wheel which revolves on one side of it, and here it undergoes its first process in manufacture. The trucks are lifted, and the contents discharged into a hopper, from which the clay falls into inclined troughs, through which a strong current of water passes, and the clay is separated from the large particles of quartz and mica, these being discharged *over* a grating, *through which* flows the water charged with the clay and the finer matter, the coarser portion sliding off the grating, and falling in a heap outside the building. The water contains not only the pure clay, but the finer particles of silica, mica, shorl, or of any other matters which may be mixed with the mass. To separate these from the clay, very complete arrangements are made. Large and deep stone tanks receive the water as it comes from the mill, in these the heavier particles settle; and when each tank becomes full, the mica, &c., is discharged through openings in the bottom, into trucks placed to receive it on a railway, and this, the refuse material of the clay works elsewhere, is here preserved for other uses, to be by-and-by described. The water, charged with its clay, now flows slowly and quietly through a great length of stone channel, and during its progress nearly all the micaceous and other particles subside; the water eventually flowing into very large pits, in which the clay is allowed slowly to deposit. The water enters in a thin sheet at one end, and gradually diffuses itself over the large area. The clay, in an impalpable powder, falls down, and perfectly clear water passes away at the other end. From the clay tanks marked A and B in the plan, the semi-fluid clay is pumped into the clay-pans, beneath which there circulates hot-water pipes, and in these the clay is finally dried. When a thickness of about eighteen inches is obtained, evaporation is promoted by the graduated artificial temperature produced by the water pipes. After a little time, the clay is sufficiently hard to be cut out, and subjected to its final drying. The clay is cut out in squares of about eight inches, so that they form parallelograms when removed from the bed. These are then placed in heated rooms, and being still further dried, are fit for the market.

The clay found near Newton in Devonshire is a clay prepared from the same source by nature, instead of by art. Of this about 20,000 tons are annually exported from Teignmouth. See Clay.

PORCELAIN JASPER. Beds of clay which have been vitrefied by the igneous rocks.

PORCELLANOUS SHELLS. See Shells.

PORPOISE OIL. See Oils.

PORPORINO. An Italian glass.

PORTER is a malt liquor, so called from being for a long period the favourite beverage of the porters of London, and indeed confined exclusively to this class of the workpeople of the metropolis. It is characterised by its dark-brown colour, its transparency, its moderately bitter taste, and peculiar aromatic flavour. 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. Porter is now brewed in large quantities in other cities besides London, especially in Dublin. See Beer.

PORTLAND ARROWROOT. See Arrowroot.

PORTLAND CEMENT is so called because it resembles in colour the Portland stone. It is prepared by calcining a mixture of the clayey mud of the Thames with a proper proportion of chalk. They make equally good cement in other parts of England and France by mixing chalk or marl with other clays. The materials are reduced to fine powder, and intimately mixed, with the addition of water. The resulting paste is moulded into bricks, which are dried and burned. It is of importance that the heat in calcining be sufficiently elevated, otherwise the carbonic acid and water may be expelled, without that reaction between the lime and clay which is required for the production of a cement. It is necessary to employ a white heat, which shall agglutinate and frit the mixture. After this operation the material is assorted, and the portions which are scorified by too much heat, as well as those insufficiently calcined, being set aside, the cement is pulverised for use. It is often advantageous to grind to powder the native mixtures of limestone and clay before burning them, in order to ensure homogeneousness. It will also be seen that a calcination at a very high temperature is frequently required to develop the hydraulic character of limestones; the greater the temperature employed, the more slow is the solidification of the cement, but the harder does it become.

PORTLAND STONE. An oolitic limestone, immediately underlying the Purbeck strata; so called in consequence of its development in the island of Portland, situated off the southern coast of Dorsetshire.

St. Paul's Cathedral, and many of the public buildings of this country, have been built of stone from Portland, and it is still obtained from numerous quarries on the island for transmission to other places, and for the breakwater now in course of construction there.

The quarries from which the stone used for building St. Paul's Cathedral was obtained, were situated at the northern extremity of the island, but have been long abandoned in consequence of the stone being somewhat harder and more difficult to work than that met with in other parts of the island. The principal beds of stone quarried in the Isle of Portland are called, in descending order, *roach* or *roche*, *rubbly bed*, and *whit* (*i. e.* white) or *best* bed. These beds vary much in thickness, but they may be stated to average five, and six feet, respectively; some reaching fifteen feet.

The roach affords large blocks of a hard and durable white stone, particularly adapted for foundations of buildings, docks, breakwaters, and other constructions where great strength is required; but, owing to the numerous cavities it contains (produced by the empty casts of shells), it will not receive a close, even face, and is therefore not so well adapted for many other purposes of a more ornamental description. The rubbly bed is not much worked; but the white or best bed, when accessible, is always quarried, and affords a white oolitic freestone, which takes a smooth, even face, and works freely in all directions.

The following analysis by Professor Daniell, gives the chemical composition of this stone: —

Silica	1·20
Carbonate of lime	95·16
Carbonate of magnesia	1·20
Iron, alumina	0·50
Water and loss	1·94
Bitumen	trace
	100·00

The other principal localities where the Portland stone is quarried are the Isle of Purbeck, in Dorsetshire, where it is called Purbeck-Portland; and the Vale of Wardour, where (as at Chilmark and other places) it affords a freestone of a very superior description.

In the year 1858, about 40,000 tons of stone were raised in the Isle of Portland. See *Mineral Statistics* for 1858, by Robert Hunt.—H. W. B.

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 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, sulphides, 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 grey 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.

Dr. Ure says the best pink Canadian potashes, as imported in casks containing about 5 cwts., contain pretty uniformly 60 per cent. of absolute potassa; and the best pearlashes 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 (*Anthemis cotula*, L.)	19·6
Poplar	0·75	Flax stems	5·00	Sunflower stalks	20·00
Trefoil	0·75	Small rushes	5·08	Common nettle	25·03
Beechwood	1·45	Vine shoots	5·50	Vetch plant	27·50
Oak	1·53	Barley straw	5·80	Thistles in full growth	35·37
Boxwood	2·26	Dry beech bark	6·00	Dry straw of wheat before earing	47·0
Willow	2·85	Fern	6·26	Wormwood	73·0
Elm and maple	3·90	Large rush	7·22	Fumitory	79·0
Wheat straw	3·90	Stalk of maize	17·5		
Barb of oak twigs	4·20	Bean stalks	20·0		

Stalks of tobacco, potatoes, chestnuts, chestnut 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 siphon. 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 pearlash 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 potash chemically pure, recourse must be had to the bicarbonate, nitrate, or tartrate of potash, salts which, when carefully crystallised, are exempt from anything to render the potash 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 siphon, 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 red-hot. Let the fused potash 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 potash, being composed of 1 atom of potassa 48, + 1 atom of water 9 = 57.

A pure carbonate of potash 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 red-hot 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 potash 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 potash, 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 potash, or the oxide free from water, can be obtained only by the combustion of potassium in the open air. It is composed of 83⅓ of metal, and 16⅔ of oxygen. Berzelius's numbers are, 83·05 and 16·95.

Caustic potash may be crystallised; 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 potash 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	1·33	34·74	1·26	26·34	1·14	15·38	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 potash in any solid or liquid is from the quantity of a dilute acid of known strength which it can saturate.

The hydrate of potash 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.

Carbonate of potash 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 potash, 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.

We *imported* of pearlash and potash, in 1858, 150,432 cwts., of the computed real value of 233,724*l.*

POTASH, BICARBONATE, is prepared by passing carbonic acid through a solution of the carbonate of potash. See BICARBONATES.

POTASH, BICHROMATE OF. See CHROMATES OF POTASH.

POTASH, BINOXALATE. *Salt of wood sorrel; Salt of sorrel; Sal acetosella.* (*Sel d'oseille*, Fr.)

The *Oxalis acetosella* is an odourless plant, but in taste it is agreeably acidulous. In some parts of Germany the binoxalate of potash is obtained in large quantities from this plant by evaporating the expressed juice. Five hundred parts of the plant yield four parts of the crystallised salt; its composition is, oxalic acid two parts, potash one part, water two parts.

The salt sold under this name is however usually made by neutralising one part of oxalic acid, with carbonate of potash, and then adding three parts more of acid to it. This is a *quadroxalate* of potash.

It is sold under the name of *salt of lemons*, sometimes in a pure state, but more frequently mixed with *cream of tartar*, and is used for the removal of iron stains.

POTASH, BITARTRATE. *Cream of tartar.* This salt is a constituent of many vegetable juices, especially of the juice of the grape. All the salt of commerce is obtained during the vinous fermentation; it deposits during the process of the formation of alcohol, and accordingly as it is obtained from white or red wine it is known by the name of *white or red argol.* The acid tartar is thus prepared in the wine-making districts of France.

Argol, which occurs in crystalline cakes, and is composed of the bitartrate of potash, tartrate of lime, and colouring matter, is boiled in water; and the solution allowed to cool, by which a deposit of crystals is obtained. These are washed with cold water, and then dissolved in boiling water, in which is diffused clay and charcoal, which as they fall down receive the colouring matter. The clear liquor is allowed to cool slowly, and crystals form.

This salt consists of

Potash	25·00
Tartaric acid	70·21
Water	4·79
	100·00

If cream of tartar is heated it is decomposed, swells up, evolves gaseous products, and is converted into Black Flux, which see.

The bitartrate of potash is used in many processes of manufacture.

POTASH, CARBONATE. Salt of tartar, potashes, pearlashes. If land plants are burnt their ashes will be found to contain a considerable quantity of the carbonate of potash. See Potash.

POTASH, CHLORATE OF. See Chlorate of Potash.

POTASH, CITRATE OF. This salt is formed by neutralising citric acid with carbonate of potash. Under the names of *lemon and kali*, *effervescing lemonade*, and the like, mixtures of dry citric acid in powder and carbonate of potash, with very dry sugar, are sold. These form very agreeable and healthful beverages.

POTASH, HYDRATE OF, CAUSTIC. (*Potasse*, Fr.; *Kali*, Germ.) An oxide of potassium. It may be obtained thus:—Mix a solution of 1 part of the dry carbonate of potash with 1 part freshly prepared dry hydrate of lime, and allow it to stand in a closed vessel for 24 hours at a temperature of 68° to 78° F., frequently shaking it. The potash salt should be dissolved in 12 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, HYDRIODATE OF. See Potassium, Iodide of.

POTASH, NITRATE OF, KO,NO^5. Syn. *Nitre*, *Saltpetre*, *Prismatic nitre*. (*Nitrate de potasse*, Fr.; *Salpetersaures Kali*, Germ.) For the mode of purification, see Gunpowder. This well known and useful salt is found native in various parts of the world, more especially in tropical climates. The formation of nitre in the earth appears to be much facilitated by warmth.

Preparation. 1. By lixiviation of earth impregnated with the salt. The earth is heated with water in tanks or tubs with false bottoms, and after sufficient digestion the solution is run off and evaporated to crystallisation. The nitre procured by the first operation is exceedingly impure, and contains large quantities of chloride of potassium, and some sulphate of potash. By repeated crystallisations the salt may be obtained pure. If the crude product of the lixiviation contains, as is often the case, the nitrates of lime or magnesia, they may be got rid of by the addition of carbonate of potash; the earths are precipitated as carbonates, and may be filtered off, while an equivalent quantity of nitrate of potash is formed and remains in solution, thus:—

$$CaO,NO^5 + KO,CO^2 = CaO,CO^2 + KO,NO^5.$$

2. The second mode of preparing nitre which we shall consider, is from nitrate of soda and chloride of potassium. On dissolving equivalent quantities of these two salts in water, and salting down, double decomposition takes place. The chloride of sodium may be removed from the hot concentrated fluid by means of shovels, while the nitrate of potash, being much more soluble in hot than in cold water, remains in solution, but crystallises out on cooling. The decomposition takes place in accordance with the annexed equation:—

$$NaO,NO^5 + KCl = NaCl + KO,NO^5.$$

The above reaction is one of great interest and importance, inasmuch as it enables us to convert Peruvian or cubic nitre, as nitrate of soda is sometimes called, into the much more valuable salt, nitrate of potash. During the last war with Russia it was found that large quantities of chloride of potassium were exported, and found their way into that country. For some time no notice was taken, because the salt appeared too harmless to be declared contraband of war. Eventually it was found that it was entirely used in Russia for the purpose of affording nitrate of potash, by the process described. It need scarcely be said that the gunpowder made through the medium of our own chloride of potassium, was employed against our troops in the Crimea.

3. Nitre may of course be prepared by neutralising nitric acid by means of carbonate of potash, or the caustic alkali. The process is evidently too expensive to be employed, except for the purpose of experimental illustration, or under other special circumstances.

The formation of nitre in the earth of hot climates is probably in most cases due to the decomposition of nitrogenised organic matters. The subject of nitrification is one upon which some controversy has taken place. It is supposed by some chemists that the chief source of the nitric acid is the ammonia produced during the decay of nitrogenous matters. The presence of bases appears to have a remarkable tendency to increase the production of the acid. It has been asserted that the ammonia which is produced suffers partial oxidation, the acid formed uniting with the undecomposed ammonia to form the nitrate of that alkali. On the other hand, it has been argued that the ammonia does not suffer oxidation, but that the nitrogen produced during the decay of organic matter combines, at the instant of its liberation with oxygen, to form nitric acid, which unites with the bases present. Nitrate of ammonia, no matter how formed, suffers double decomposition in presence of the carbonates of the alkaline earths, the result being the production of the nitrates of lime and magnesia. It is owing to the presence of the two latter salts in the crude liquor obtained by lixiviating nitrified earth, that the addition of carbonate of potash is so important, and causes so great an increase in the produce of nitre. It has been insisted by some observers that the presence of nitrogenous organic matters is not essential to the production of nitre. In support of this it has been shown that large quantities of nitrates are often found where little or no organic matters are present. This has been explained by assuming that porous bodies have the power of absorbing water, oxygen, and nitrogen, and producing nitric acid from them. But it is evident that other forces exist capable of inducing the oxidation of atmospheric nitrogen. It has been experimentally demonstrated that nitric acid is produced during the discharge of atmospheric electricity. It is also probable that ozone plays an important part in the phenomena of nitrification. Perhaps most of the chemists who have investigated the subject, have been too anxious to assign the formation of nitre to one particular cause, whereas the phenomena which have been noticed by different observers are in favour of the idea that several agencies are at work during the production of nitrates in the earth and in artificial nitre beds.

During the time that France was fighting single-handed against the rest of Europe, great difficulty was found in obtaining sufficient nitre for the production of the vast amount of gunpowder necessary to enable her artillery to be effectively supplied with ammunition. This led the French chemists to establish artificial nitre beds in various parts of the country. The success of the process may be judged of from the fact that they yielded 2,000 tons annually.

Chemical and physical properties.—Nitre crystallises in colourless six-sided prisms. The crystals are anhydrous; large specimens when broken, however, generally show the presence of a little moisture mechanically adhering to the interstices. If wanted in fine powder, it must therefore be first coarsely bruised, and then dried, after which it may be finely pulverised and sifted, without that tendency to adhere into lumps which would otherwise be observed.

By the careful application of heat, nitrate of potash may be melted without undergoing any decomposition or loss of weight. But if the heat be raised to redness it begins to decompose, the degree to which the change takes place depending on the amount of heat and the time of exposure. By carefully heating for some time, a large quantity of nitrite of potash is formed, oxygen gas being evolved. If the heat be raised, or the exposure to a high temperature be continued, a large quantity of nitrogen accompanies the oxygen, and the nitre becomes more and more changed, until finally, a mixture of potash with peroxide of potassium is attained. If copper filings, clippings, or shreds be mixed with the nitre, the decomposition proceeds much more readily, and Wöhler has proposed to prepare pure potash by this means. At high temperatures nitre is a potent agent of oxidation, so much so, that the diamond itself is attacked and converted into carbonic acid, which unites with the potash. It was in this manner that Smithson Tennant first showed the diamond to consist of pure carbon. His mode of operating was to fuse the nitre with fragments of diamond in a tube of gold. Crystallised boron, which is said to equal if not exceed the diamond in hardness, is not attacked by fused nitre. A very striking experiment for the lecture table consists in pouring charcoal in powder into melted nitre retained at a red heat over a lamp. A violent deflagration takes place, and a considerable quantity of carbonate of potash is formed. The presence of the latter substance may be shown as soon as the capsule has become cold, by adding an acid to its contents, when a strong effervescence will take place. The oxidising power of nitre is made use of in the arts in order to obtain bichromate of potash from chrome iron ore.

Nitrate of potash is sometimes used as a source of nitric acid, but nitrate of soda is in every way more economical. This will be evident when it is considered that it takes 101 parts of nitrate of potash to yield one equivalent of dry nitric acid (54 parts), whereas 85 parts of nitrate of soda yield the same amount of acid. Moreover, if nitrate of potash be used, it is essential to employ two equivalents of sulphuric acid to decompose one equivalent of the salt, for if only one were used the residue of sulphate of potash being hard, and not very readily removable by water, considerable chances would be incurred of injuring the still; it is usual, therefore, to so adjust the proportions that the readily soluble bisulphate should be the residue. If, on the other hand, nitrate of soda be employed, the residue in the still being sulphate of soda, no difficulty is found in its removal.

Nitrate of potash is employed in blow-pipe experiments, in order to assist in the production of the green reaction characteristic of the presence of manganese. It often happens where the quantity of manganese is exceedingly small, as in rose quartz, that the green coloration with soda or platinum foil cannot be obtained; if, however, a little nitre be added, and the testing be repeated, the reaction generally appears without any trouble.

Nitrate of potash is greatly employed in the preparation of pyrotechnic mixtures. It ought always to be well dried and reduced to fine powder before being used.

Solubility of nitre in water at various temperatures.

1 part of nitre dissolves in	13,320	parts of water at	32°·0
"	4·000	"	61°·0
"	3·450	"	64°·4
"	1·340	"	113°·0
"	0·424	"	206°·6
"	0·250	"	212°·0

From the above table it is evident that the solubility of nitre in water increases very rapidly with the temperature. Nitre is not unfrequently employed by the chemist for determining the percentage of sulphur in coals. For this purpose the coal, reduced to fine powder, is mixed with nitre and carbonate of soda, and projected by small portions into a silver crucible, maintained at a red heat. A platinum crucible must not be employed, as it is attacked by nitre in a state of fusion. The sulphur in the coal is converted, by the oxidising agency of the nitre, into sulphuric acid; the latter can then be converted into sulphate of baryta, and the percentage of sulphur ascertained from its weight.

Estimation of the value of nitre.—A great number of proeesses have been devised for the determination of the percentage of pure nitrate of potash in samples of the crude salt. All these processes are more or less incorrect, and a really accurate mode of determining the value of nitre has long been felt as a want by chemists. This want has only quite recently been supplied by Messrs. Abel and Bloxam of the Woolwich Arsenal, who have devoted much labour and skill to the subject, the importance of which, in connection with the art of war, can scarcely be over-estimated. Before detailing the new and successful process of the latter chemists, we will take a brief glance at the other methods commonly used for the purpose. The French process depends upon the principle that a solution, when saturated with one salt, is still capable of dissolving a considerable quantity of saline matter differing in its nature from the first. If, therefore, a saturated solution of nitre be poured upon pure nitre, no more is dissolved if the temperature remains the same as it was when the original solution was prepared. But if, on the other hand, the saturated solution of nitre be digested with an impure sample containing the chlorides of sodium, potassium, &c., the latter salts will be dissolved, and the pure nitre remaining can, after proper draining, &c., be dried and weighed. The loss of weight obviously represents the impurities removed. This process is subject to so many sources of error that the practical details need not be entered into.

Another mode of valuing nitre consists in fusing the salt, and, after cooling, breaking the cake: the fineness or coarseness and general characters of the fracture are the means whereby the greater or less value of the salt are ascertained. This process, which is known as the Swedish or Swartz's method, is far too dependent on the individual experience and dexterity of the operator to be of any value in the hands of the chemist whose attention is only now and then directed to the valuation of saltpetre. Moreover, although those who are in the habit of using it possess some confidence in its correctness, is quite evident that it is impossible for such an operation to yield results of analytical accuracy.

The Austrian method has also been used by some, but it is quite inadmissible as a general working process. It consists in ascertaining the temperature at which the solution crystallises.

Gossart's method consists in determining the value of the nitre by measuring its power of oxidation. The latter is accomplished by finding the quantity of protoxide of iron which it can convert into peroxide. If to an acid solution of protosulphate of iron nitric acid or a nitrate be added, the proto is converted into a persalt at the expense of a portion of the oxygen of the nitric acid, thus:—

$$2(FeO,SO^3) + NO^5 + SO^3 = Fe^2O^3, 3SO^3 + NO^4.$$

Theoretically this process is unexceptionable, but in practice it is liable to great errors.

M. Pelouze endeavoured to improve the above process by using such an excess of the protosalt of iron that the nitre added should be able to convert only a portion of it into a persalt. The remaining protoxide was then converted into persalt by means of a solution of permanganate of potash of known strength. The data so obtained enabled the value of the nitre to be estimated. But even this process is liable to variations, so much so, indeed, that Messrs. Abel and Bloxam obtained the following results in eleven experiments made with pure nitre:—

Exp.	Nitre taken.	Nitre found.	Per-centage.
1	18·53	18·12	99·40
2	18·50	Result somewhat higher.	
3	20·10	17·58	87·46
4	20·16	17·81	88·33
5	20·05	17·78	88·67
6	20·18	18·45	91·42
7	20·26	19·95	98·48
8	17·83	19 71	110·55
9	17·80	19·09	107·20
10	17·64	19·33	109 50
11	14·56	16·41	112·70

In the above experiments the conditions were somewhat varied, but the results showed that very slight variations in the modes of manipulating created such enormous differences in the values obtained, that it was quite impossible to rely on the method.

The next process which we shall notice is that which the chemists alluded to have finally settled upon as yielding the best results. It is that of M. Gay-Lussac. It depends on the fact that if nitrate of potash be heated with charcoal, or, in fact, any carbonaceous matters in excess, the nitrate is converted into carbonate of potash, the amount of which may be accurately estimated by means of a standard solution of sulphuric acid. The chlorides which may be present are unacted upon by the charcoal, and do not, therefore, influence the result; but if sulphates be present they are reduced by the earbon to sulphides, which, in consequenee of being decomposed by the sulphuric acid, may cause serious errors. Fortunately the amount of sulphuric acid present in nitre is seldom sufficient to cause any great error. Any nitrate of soda present would come out in the final result as nitrate of potash, and thus become another source of error; in practice this is seldom likely to occur. The original process consists in weighing out 20 grammes (308·69 grains) of crude saltpetre, and mixing it with 5 grammes (77·17 grains) of charcoal, and 80 grammes (1234·7 grains) of chloride of sodium. The mixture is thrown little by little into a red-hot crucible, and, when the decomposition is over, allowed to cool. The residual mass is dissolved in water, filtered, and water passed through the filter until it amounts to 200 cubic centimetres (12·2 cubic inches). The amount of alkali is then ascertained with a burette and standard sulphuric acid. (See ALKALIMETER.) Messrs. Abel and Bloxam have minutely and laboriously studied this operation, and deteeted its sources of difficulty and error. Their researches have led them to employ the following modification.

Twenty grains of the sample are to be well mixed in a platinum crucible with 30 grains of finely-powdered resin, and 80 grains of pure dry common salt. The heat of a wire gauze flame is then applied, until no more vapour is given off. The crucible is then allowed to cool down a little, and 25 grains of chlorate of potash are added. A gentle heat is then applied uutil most of the chlorate is decomposed; the heat is then raised to bright redness for two or three minutes. The mass should be fluid, and free from floating charcoal. The mass, when cool, is removed to a funnel, and the crucible, &c., washed with boiling water. The mass is then dissolved in hot water, and the entire solution, coloured by litmus, is neutralised with the standard acid. In the annexed table 20 grains of pure nitre were taken for each experiment:—

Exp.	Nitre found.	Nitre per cent.
1.	20·00	100·00
2.	20·00	100·00
3.	19·97	99·85
4.	19·97	99·85
5.	20·08	100·40
6.	20·08	100·40
7.	20·08	100·40

The authors, not yet satisfied, made 53 more experiments by this method. The mean result with pure nitre was 99·7 per cent.

The mean of 25 of the above experiments was 98·7 per cent.

The mean of the remainder was 100·7 per cent.

Subsequent experiments showed that greater accuracy might be obtained by substituting for the resin, pure ignited finely divided graphite, prepared by Professor Brodie's patented process. To perform the process 20 grains of the nitre are to be mixed with 5 grains of ignited graphite and 80 grains of salt. The general process is conducted in the manner described in the operation with resin. The results are very exact, and apparently quite sufficient for all practical purposes.—C. G. W.

POTASH, NITRITE OF, KO,NO^3. When ordinary saltpetre, or nitrate of potash, is heated with sulphuric acid, in the cold, no special reaction becomes evident, as far as any evolution of gas is concerned; but if, previous to the addition of the acid, the nitre be strongly fused, it will be found, as soon as the admixture takes place, that red fumes are evolved. This arises from the fact, that nitrate of potash, when subjected to strong ignition, is decomposed with evolution of oxygen, the nitrate becoming gradually converted into the nitrite of potash, thus:—

$$KO,NO^5 = KO,NO^3 + 2O.$$

This reaction acquires great interest from the circumstance, that to its correct explanation was owing the commencement of the fame of the illustrious Swedish chemist Scheele. A pharmaceutist, at Upsala, having heated some saltpetre to redness in a crucible, happened, when it became cold, to pour vinegar over it, when, to his surprise, red fumes were evolved. Ghan was applied to for an explanation; but, unable to comprehend the matter, he applied to Bergmann; but even he was as much in the dark as Gahn. The explanation which these eminent chemists were unable to give, was supplied by the pharmaceutist's apprentice, the young Scheele. Bergmann, when informed by Gahn of Scheele's explanation, felt a strong desire to make his acquaintance, and ultimately they were introduced to each other.

Nitrite of potash has acquired some importance of late years, owing to the valuable properties, as a decomposing agent, which have been found by chemists to reside in nitrous acid.

Preparation.—Nitrate of potash is to be fused at a red heat for a considerable time. When cold, the contents of the crucible are to be dissolved out with boiling water, and the nitrate of potash remaining is to be removed as far as possible by crystallisation. The nitrite of potash may be obtained from the mother liquor by evaporation and subsequent crystallisation. It is a neutral salt, which deliquesces on exposure to the air. If a piece of strongly-fused nitre be put, when cold, into a solution of sulphate of copper, a very beautiful apple-green colour is produced, of a tint which is seldom observed except in solutions containing the nitrite of that metal.—C. G. W.

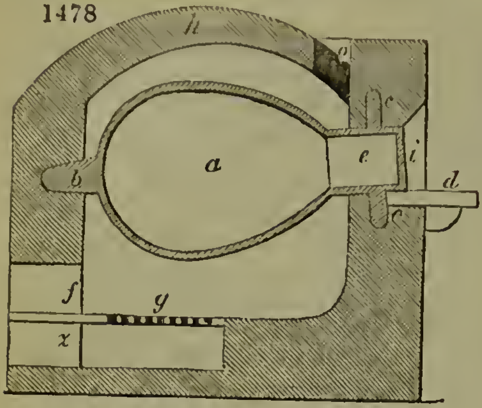
POTASH, PRUSSIATE OF. *Ferrocyanide of potassium. Yellow prussiate of potash.* $K^2FeCy^3 + 3HO$.

This salt occurs in a state of great purity in commerce, and is thus manufactured on the large scale.

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 azotised matter in the smallest bulk. Dried funguses have been also prescribed. These animal matters may either be first carbonised in cast-iron cylinders, and the residual charcoal may be then taken for making the ferroprussiate; 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 two 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.* 1478, 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*, *c*, 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 arched top *h* 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.

1478



The calcining process is different, according as the animal substances are fresh or carbonised. 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 carbonised 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 with the other materials, to the amount of one or two hundredths of the potash.

The above lixivium is not a solution of pure ferroprussiate ; 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 crystallised ferroprussiate of potash. The mother-water is again evaporated and crystallised, whereby a somewhat inferior ferroprussiate 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 prussiate 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, neutralising any carbonate and cyanide of potash that may be present with acetic acid, then precipitating the ferroprussiate of potash by the addition of a sufficient quantity of alcohol, and finally crystallising the precipitated salt twice over in water. The sulphate of potash may be decomposed by acetate of baryta, and the resulting acetate of potassa removed by alcohol.

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.* 1479, 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 E F, of the ellipsoid. *a a*, represents the grating or bars of the furnace to be heated with coal or coke; I I, is the pot or retort shown in *figs.* 1480, 1481, 1482.

This pot or retort is placed in a separate compartment, as seen in *fig.* 1479, which is a vertical section, taken through *fig.* 1482 at the line G, H. K, is a connecting tube, from the retort and the elliptical pipes W.

In the section, *fig.* 1480, the shape of the tube K will be better seen; also its cocks *u*, 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; M, an inclined plane behind the fire bars.

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 N.

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.* 1481 is represented the junction-tubes, which connect the four pipes with their gas-burners Z, Z, and the cocks *m m′*. *r*, *r*, *fig.* 1482, are covers, closing the pipes, and having holes formed in them; these holes are shut by the stoppers *e*.

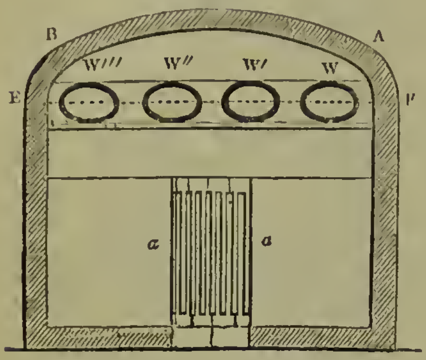
Whether the pipes are placed in the vertical or horizontal position, it is always proper to be able to change the direction of the current of gas; this is easily done by closing, during one hour (if the operation is to last two hours), the cocks *u*, *m′*, and opening those, *u′*, *m*; then the gas passes through *u′*, into the branch K, and entering W‴, passes through V, into W″, through *g*, into W′, and through 2nd *g*, 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 K, 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.

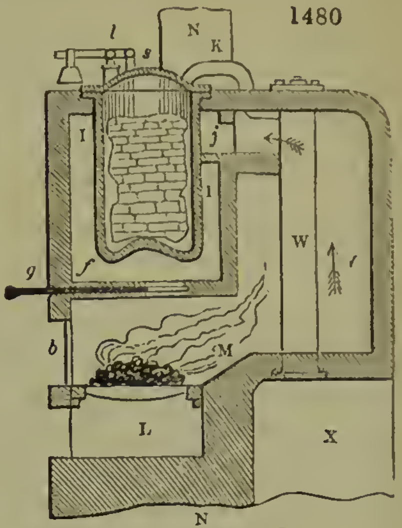
The patentee remarks, that although this operation is only described with reference to potash, for obtaining prussiate of potash, it is evident that the same process is applicable to soda; and when the above-mentioned ingredients are employed, soda being substituted for potash, the result will be prussiate of soda.

The process employed in the manufacture of *Kalium Eisen Cyanure*, by Hoffmayr and Prükner, is as follows:—The potash must be free from sulphate, for each atom of sulphur destroys an atom of the cyanide of potash. 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 in fusing. A reverberatory furnace is recommended; but the flame must not beat too much upon the materials for fear of oxidising them. When the smoky

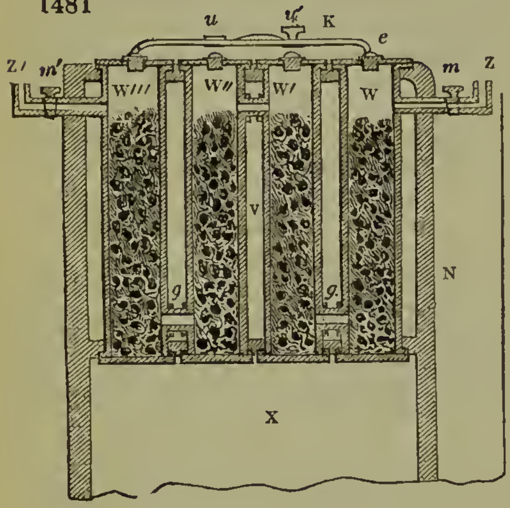
1479



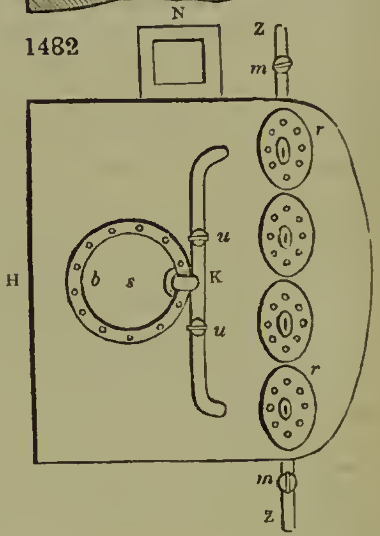
1480



1481



1482



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. 2nd. 100 parts of horns or hoofs; from 33 to 35 potash; 2 to 4 iron. 3rd. 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.

Dr. Ure, in the former editions of this Dictionary, discussed the chemical questions involved in the manufacture of this very important salt. As *Ure's Dictionary of Chemistry*, from which, originally, the article was derived, is again in course of publication, this subject is restored to its original place.

POTASH, RED PRUSSIATE OF. Ferridcyanide of potassium, prepared by passing chlorine gas through a solution of the ferrocyanide of potassium until it ceases to give a precipitate of prussian blue, with a persalt of iron, and no longer. Its formula is $K^3Fe^2Cy^6$.

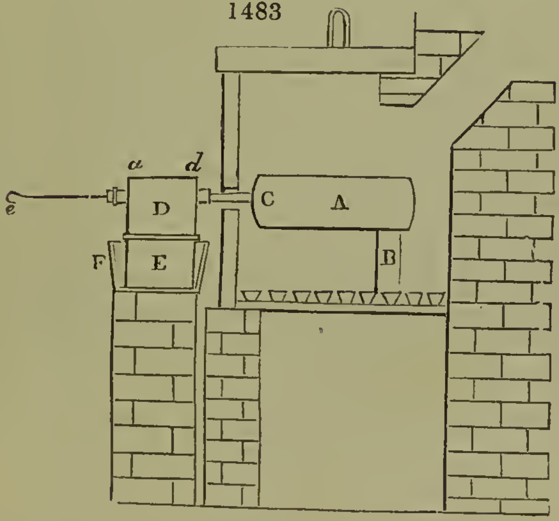
POTASSIUM (Eng. and Fr.; *Kalium*, Germ.) is a metal deeply interesting, not only from its own marvellous properties, but from its having been the first link in the chain of discovery which conducted Sir H. Davy through many of the formerly mysterious and untrodden labyrinths of chemistry. It is the metallic base of potash.

The easiest mode of obtaining this elementary substance is that contrived by Brunner. Into the orifice of one of the iron bottles, as A, *fig.* 1483 in which mercury is imported, adapt, by screwing, a piece of gun-barrel tube, 9 inches long; having brazed into its side, about three 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 brick-work, 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 potassuretted 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 PHOSPHORUS. 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.

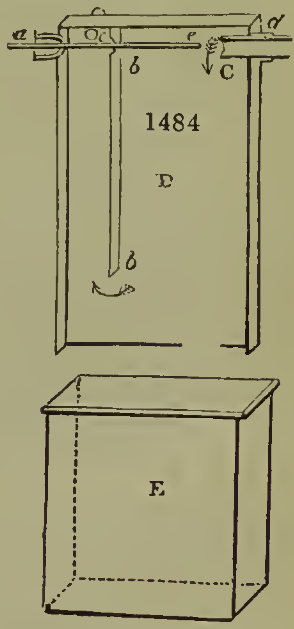
Tartar skilfully treated in this way will afford 3 per cent. of potassium; and when it is observed to send forth green fumes, it has commenced the production of the metal. Instead of the construction above described, the following form of apparatus may be employed.

A, *fig.* 1483 represents the iron bottle, charged with the incinerated tartar; and B is a fire-brick support. A piece of fire-tile should also be placed between the bottom of

1483



1484



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*, D, E, shown in a large scale in *fig.* 1484.

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 *c*, 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. E, 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.

For an account of the chemical action by which potassa is reduced, see *Ure's Chemical Dictionary*.

Pure potassium, as procured in Sir H. Davy's original method, by acting upon fused potash under a film of naphtha, with the negative wire of a powerful voltaic battery, is a soft metal, which can be cut like wax with a knife, and its newly cut surface possesses great brilliancy. It is fluid at 120° F. 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 volatilised, 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 oxygenised 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 potash. When thrown upon a cake of ice, it likewise kindles, and melts a hole in it. If a globule of it be laid upon wet turmeric paper, it takes fire, and runs about, marking its desultory paths 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, potassuretted hydrogen being formed.

POTASSIUM, IODIDE OF. Iodide of potassium is usually prepared by digesting 2 parts of iodine, and 1 part of pure iron filings, in 10 parts of water, till they have combined to form a solution of a pale green colour, which is a solution of the iodide of iron.

This solution is decomposed with exactly the requisite quantity of carbonate of potash, and iodide of potassium is held in solution, the iron salt being precipitated. The iodide is then crystallised out. *Iodide of potassium* is much used in photography to obtain the iodide of silver; and for this purpose its purity is of great importance. The iodide of potassium of commerce frequently contains carbonate of potash, caustic potash, and the bromide and chloride of potassium. In the *Chemical Gazette*, Mr. Penny gives the following method of detecting these adulterations. His plan consists in ascertaining the amount of a solution containing a known weight of the iodide which is required to decompose a given quantity of bichromate of potash, dissolved in water acidulated with hydrochloric acid. The point at which the chromic acid is completely reduced is indicated by dipping a glass rod into the solution, and touching a drop of a solution of protosulphate of iron and sulphocyanide of potassium placed upon a white plate; when a red colour is no longer produced the decomposition is complete; 10 grains of KO^2CrO correspond to 33 grains of KI. For other methods, see *Ure's Chemical Dictionary*.

POST. A north of England term for any bed of firm rock. It is generally applied to sandstone.

POTATO. (*Pomme de terre*, Fr.; *Kartoffel*, Germ.) 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 STARCH.

POTATO STARCH. *English arrowroot*. See STARCH.

POTATO SUGAR. See SUGAR.

POTSTONE, a magnesian mineral of the character of steatite and serpentine. It is used in Germany for ornamental purposes.—H. W. B.

POT METAL, an inferior metal composed of lead and copper, used for making large vessels. See ALLOY.

POTTERY, PORCELAIN. EARTHENWARE, STONEWARE. (Engl. and Fr.; *Steingut, Porcellan*, 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 true porcelain or china-ware; which is also called *hard* and *genuine*, or *tender* and *spurious*, according to the quality and quantity of the fusible ingredients. The *tender* porcelain is an earthy body which is covered with and penetrated by a transparent glaze. 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 glazed bricks from Babylon,—the enamelled tiles from the ruined cities of the desert,—and the glazed coffins from those Assyrian cities of the dead discovered by Mr. Kennet Loftus, prove, contrary to the received ideas, that the earliest attempts to make a compact earthenware, with a painted glaze, did not originate with the Arabians in Spain about the ninth century; but it is certain that the art 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 manufactory of this ware 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, aud the glaze was opaque, being formed of the oxides of lead and tin, along with potash and sand, which glaze was in all probability the discovery of Luca della Robbia, which he had found "after experiments innumerable." Bernard Palissy, about the middle of the 16th century, manufactured the Palissy ware,—which is remarkable for its beautiful glaze, and the imitation of plants and animals,—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 earthenware.

The English East India Company was formed in 1600, and in 1631 they imported China ware into England. The Dutch, however, in 1586, appear to have traded in this true porcelain. There was naturally a desire to imitate this beautiful manufacture. In this Böttcher made the first advance in 1709. Böttcher was working in the laboratory of Tschirnhaus, an alchemist, at Dresden, and it is stated that some crucibles prepared by him assumed the character of Chinese porcelain. Böttcher made first a red ware, but eventually, by employing white clays (*Kaolin*) which were found near Schneeberg in the Erzgebirge, he made a true porcelain at Meissen. Eventually the manufacture spread to Dresden, Munich, and other places, and the celebrated Sèvres Pottery was established.

Coarse ware was manufactured in Staffordshire as early, if not earlier, than 1500. Dr. Shaw says, "there exist documents which imply that during many centuries considerable quantities of common culinary articles were manufactured of red, brown, and mottled pottery."—*History of Staffordshire Potteries.*

It was in 1670 that a work for making earthenware of a coarse description, coated with a common lead glaze (butter pots), was formed at Burslem, which may be considered as the germ of the vast potteries now established Staffordshire. The manufacture was improved about the year 1690, by two Dutchmen, the brothers Elers, who were compelled to leave the Potteries in 1710, and it is said they settled in Chelsea. The introduction of the use of salt for glazing took place in 1690 at Palmer's pottery at Bagnall. It is to the late Josiah Wedgewood 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, and especially by the late Herbert Minton, 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. The discovery of the Cornish China clay by Cookworthy must be considered as the primary cause which advanced the art.

Of the Materials of Pottery, and their Preparation.

Clay.—The best clay from which the Staffordshire ware is made comes from Pool in Dorsetshire, and a second quality from near Newton in 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. For the manufacture of porcelain, and of the finer kinds of earthenware, the China clay is used. See Porcelain Clay. In the factory 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 *blunging*. 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 everything 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.

Flints.—These are obtained in great quantities from the chalk formations.

Chert, which is a flinty substance, found in the Mountain Limestone, is also employed. These are calcined and ground.

Felspar.

Bone.—Bone ashes, phosphate of lime, also enters into the composition of pottery.

Steatite, or *Soap stone,* is occasionally employed.

China stone.—A decomposed granite.

These may be regarded as the substances which enter into the body of the ware. See Porcelain Clay.

Clay alone cannot form a proper material for pottery, on account of its great contractility 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 redhot in a kiln, like that for burning lime, and thrown in this state into water, by which treatment they lose their translucency, and become exceedingly brittle. They are then reduced to a coarse powder in a stamping-mill or a crushing-mill. 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. 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 plughole 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 grey 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 earthenware 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.

Although we have abundant evidence proving to us the importance of the so-called fermenting process, of the treading operation, and of the slapping, we are not in possession of any explanation, which is in the slightest degree reliable, as to any one of the changes which may be effected in the mass by these manipulations.

The basis of the English earthenware is a 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 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 Wedgewood's invention, and of the tender porcelain.

The constituents of the stoneware are, Dorsetshire clay, the powder of calcined flints, and of the decomposed granite 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 *cream colour*,	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 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 porcelain 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 Teignmouth clay-cream there are added,

13	measures of	flint liquor.
12	—	porcelain clay ditto.
1	—	Cornish stone ditto.

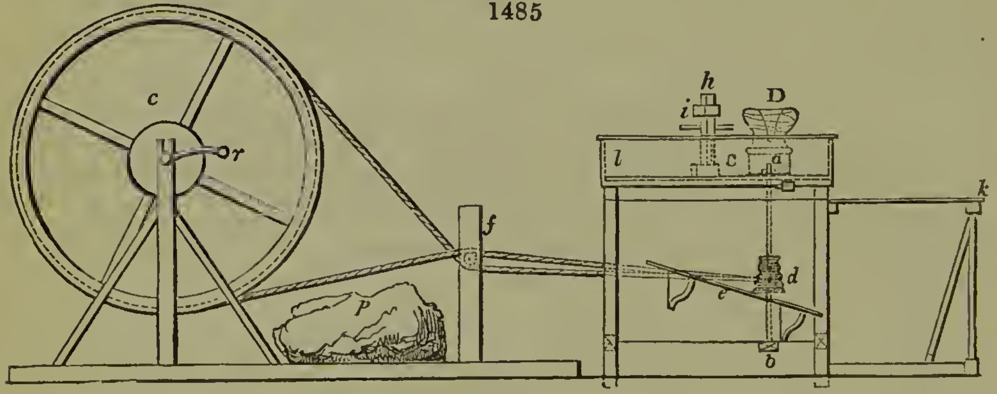
The whole are well mixed by proper agitation, half dried in the *troughs* of the slip-kiln, and then subjected to the machine for cutting up the clay into junks. The above paste, when baked, is very white, hard, sonorous, and susceptible of receiving all sorts of impressions from the paper engravings. 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.

We must now proceed to a consideration of the manufacture. The clay being prepared is submitted to the potter, who employs at the present day a wheel of the same description as that used in the days of Moses.

Throwing is performed upon a tool called the potter's lathe. 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.

Fig. 1485 is the profile of the ordinary 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*,

1485



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, for catching the shavings of clay which fly off from the lathe; *h* is an instrument, with a slide-nut *i*, for measuring the objects in the blocking out; *c* 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.

D 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, 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 versâ.*

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 to finish 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.*

At a certain stage of the drying, called the *green state*, the ware 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. 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 tea-pots, 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 temperature of the various rooms in a pottery is as follows:—

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.

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 desiccated 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 saggers 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 saggers. 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 saggers during the intervals of their work; or if there be a relay of hands, the man who is not firing makes the saggers.

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 saggers is called a *bung*.

Plan of an English Pottery.

A pottery 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 *pisé*, 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.

A, *fig.* 1486, 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 saggers; Z, 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, saggers, &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 articles; *m*, room for putting the biscuit into the saggers; 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.

Pottery Kiln of Staffordshire.

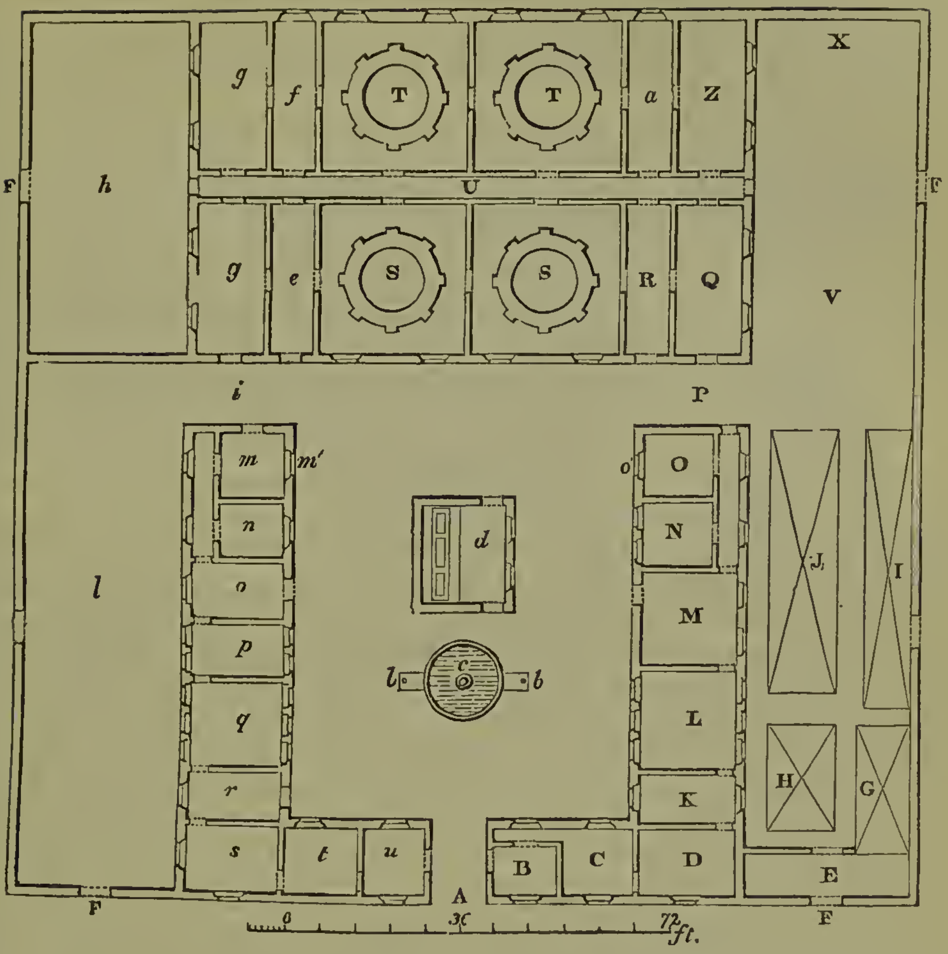
Figs. 1487, 1488, 1489, 1490, 1491, represent the kiln for baking the biscuit, and also for running the glaze, in the English potteries.

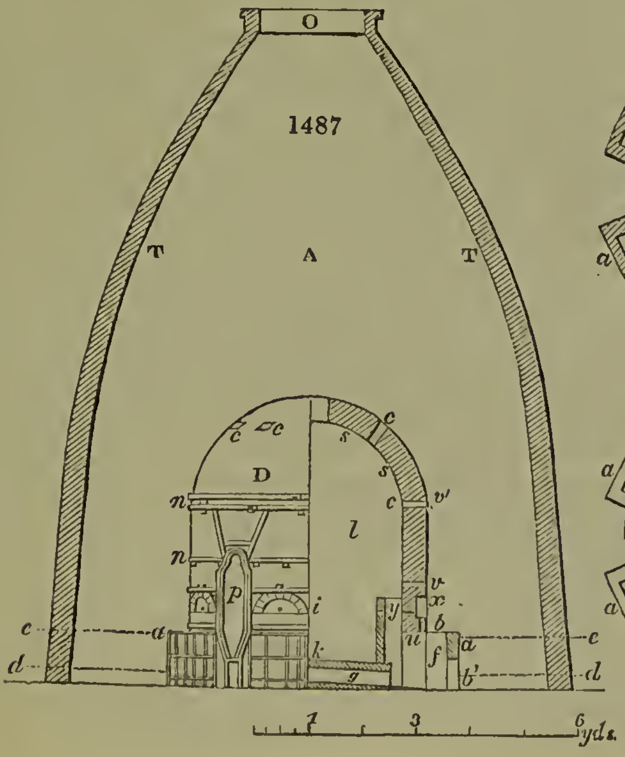
a, *a*, *figs.* 1487, 1488, 1489, are the furnaces which heat the kiln; of which *b*, in *fig.* 1487, are the upper mouths, and b' the lower; the former being closed more or less by the fire-tile *z*, shown in *fig.* 1491.

f is one fireplace; for the manner of distributing the fuel in it, see *fig.* 1491.

g, *y*, *figs.* 1487, 1491, 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*, *u*, 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

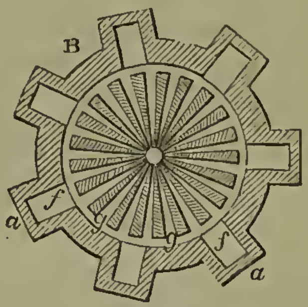
1486



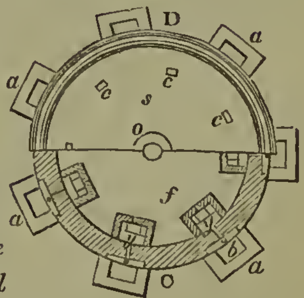


1487

1488

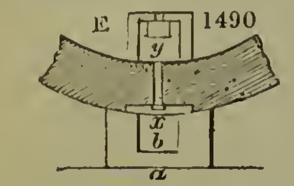


1489

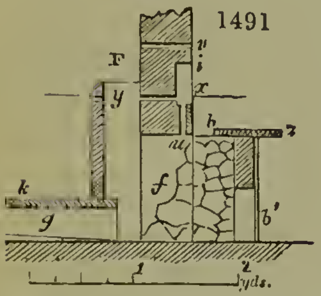


the kiln; *i* is an arch which supports the walls of the kiln, when the furnace is under repair; *c*, *c*, are small flues in the vault *s* of the laboratory. *h*, *fig.* 1488, is the central flue, called *lunette*, of the laboratory.

T, T, 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.



1490



1491

A, is the complete kiln and *howell*, with all its appurtenances.

B, *fig.* 1488, 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.* 1489, 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.* 1489, 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.* 1490, is a detailed plan at the level *c*, *c*, of one furnace and its dependencies.

F, *fig.* 1491, is a transverse section, in detail, of one furnace and its dependencies.

The same letters indicate the same objects in all the figures.

Charging of the kiln.—The saggers 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 saggers, 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 saggers, 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 saggers. 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 saggers 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 saggers, four in number, above the level of the flue-tops. They are taken hastily out of the saggers, 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.

Whenever 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, *z*, *fig.* 1491, 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 *z*, 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 kiln.—The kiln is allowed to cool very slowly. On taking the ware out of the saggers, 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.

Of Porcelain.

Porcelain is a kind of pottery ware whose paste is fine grained, compact, very hard, and faintly translucid; 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.

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 Yrieux-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 sulphide. It is calcined to make it crushable, under stamp-pestles driven by machinery, then ground fine in hornstone (chert) mills. 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 pulverised, moistened a little, 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 aspen 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.

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 the 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 three 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, aspen 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. Everything 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 grey-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 earthenware. Each porcelain plate requires a separate sagger; so that 12 occupy in the kiln a space sufficient for at least 38 earthenware plates. The temperature of a hard porcelain kiln being very high, involves a proportionate consumption of fuel and waste of saggers. With 40 cubic metres of wood, 12,000 earthenware 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.

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 beehives. 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 fireplaces 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 $4\frac{1}{2}$ 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."

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 pulverised, 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 saggers 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 everywhere; 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.

The best English porcelain is made from a mixture of the Cornish and Devonshire 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 saggers.

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 fire-powder and potash, the biscuit ware is dipped, as already described. The pieces are then fired in the glaze-kiln, care being taken, before putting them into their saggers, to remove the glaze powder from their bottom parts, to prevent their adhesion to the fire-clay vessel.

Mortar body, is a paste composed of 6 parts of clay, 3 of felspar, 2 of silex, and 1 of china clay.

Ironstone China. Some of the English porcelain has been called ironstone china. This is composed usually of 60 parts of Cornish stone, 40 of china clay, and 2 of flint glass; or 42 of 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	107

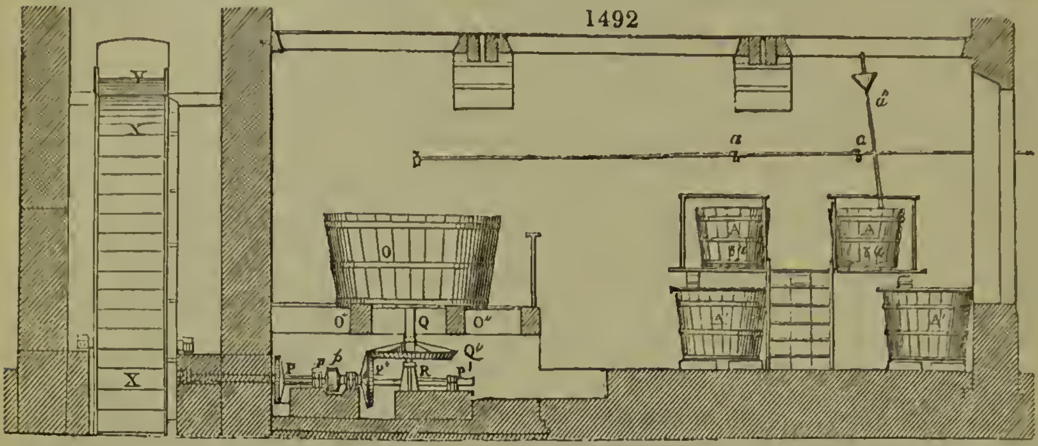
The glaze for the first two of the preceding compositions consists of, felspar 45, flints 9, borax 21, flint glass 20, nickel 4. After fritting that mixture, add 12 parts of red lead. For the third composition, which is the most fusible, the glaze must receive 12 parts of ground flints, instead of 9; and there should be only 15 parts of borax, instead of 21.

Description of the Porcelain Mill.

1. The following figures of a felspar and flint mill (*figs.* 1492, 1493) 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, 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.

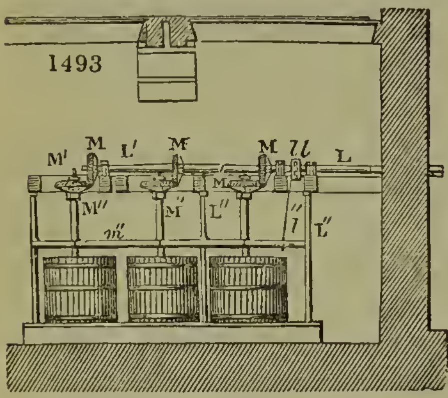
1492



After the clay has subsided, the water is drawn off from its surface by a zinc siphon. 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.

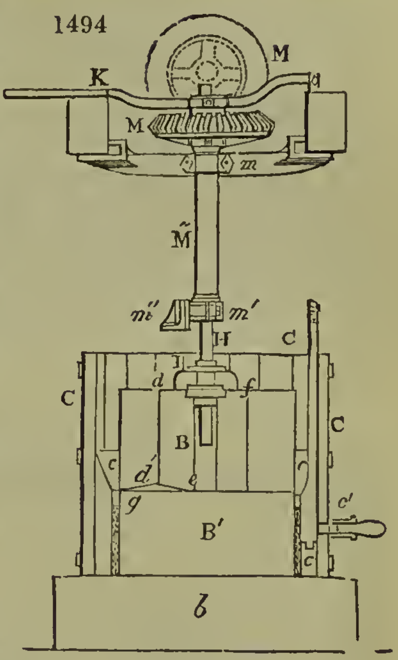
The small triturating mill is represented in *fig.* 1493. There are three similar grinding-tubs on the same line. The details of the construction are shown in *fig.* 1494, where it is seen to consist principally of a revolving millstone, B (*fig.* 1495), of a fast or sleeper millstone, B′, and of a vat, 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 by means of a peg put into the holes at its top; the spigot is then drawn, and the thin paste is run out into vats. The upper grindstone, B *d*, 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.* 1495; 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.

1493



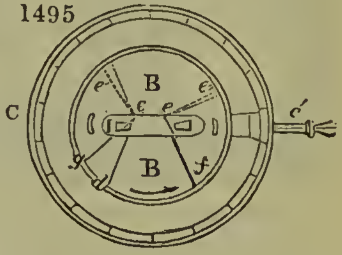
The turning hornstone-block is set in motion by the vertical shaft H, which is fixed by the clamp-iron cross I to the top of the stone. When the stone is new, its thickness is about 14 inches, and it is made to answer for grinding till it be reduced to about 8 inches, by lowering the clamp I upon the 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.* 1493, 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 open. 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 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.* 1494. 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.* 1493. 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 agoing, 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 K, 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 K is lowered or lifted up. Thus each millstone may be thrown out of or into gear at pleasure.

1494



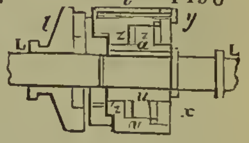
These stones make upon an average 11 or 12 turns in a minute, corresponding to 3 revolutions of the water-wheel, which moves through a space of 3 feet 4 inches in the second, its outer circumference being 66 feet. The weight of the upper stone, with its iron mountings, is about 6 cwt. when new. The charge 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 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.* 1493, is not a locking crab, fixed in the common way, upon the shaft L; but it is composed, as shown in *figs.* 1496, 1497, 1498, 1499, 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.* 1497 represents the collar v seen in front; that is, by the face which carries the clutch teeth; and *fig.* 1498 represents its other face, which receives the flat ring x, *fig.* 1499, in four notches corresponding to the four projections of the washer-ring. Since the ring u is fixed upon the shaft L, 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 L′ 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 z, z', *fig.* 1496; 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

1495

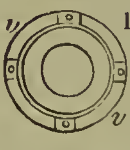


1497

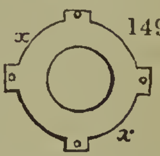
1496



1498



1499



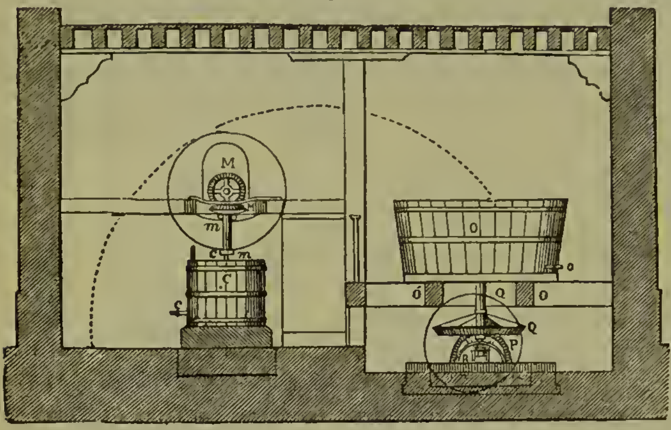
become as it were a lateral brake, to tighten more or less the bearing of the ring *u*, to which they are applied: by regulating this pressure, everything may be easily adjusted. When the resistance becomes too great, the leather washers, pressed upon one side by the collar *v*, of the washer *x*, and rubbed upon the other side by the prominence of the ring *u*, get heated to such a degree, that they are apt to become carbonised, and require replacement.

This safety clutch may be recommended to the notice of mechanicians, 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 a spigot and faucet at the side, for drawing off the liquid paste. The whole system of the mechanism is ver y substantial, and is supported by wooden beams.

The following is the manner of turning the upper blocks. In *fig.* 1492 the main horizontal shaft P bears at one of its extremities a toothed wheel, usually mounted upon the periphery of the great water-wheel (*fig.* 1500 shows this toothed wheel by a dotted line) at its other end; P 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 P, there is a second shaft P′, which bears the movable portion of that box, and an upright bevel wheel P″. Lastly, in *figs.* 1492 and 1500, 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.* 1494. At the lower end of the shaft Q, there is the bevel wheel Q″, which receives motion from the wheel P″, *fig.* 1492.

1500



The shaft P always revolves with the water-wheel; but transmits its motion to the shaft P′ only when the latter is thrown into gear with the coupling-box *p*′, by means of its forked lever. Then the bevel wheel P′ turns round with the shaft P′, 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 R, which is supported upon a cast-iron arch Q′, seen in profile in *fig.* 1492; its base is solidly fixed by four strong bolts. Four set screws above R, *fig.* 1492, serve to set the shaft Q truly perpendicular: thus supported, and held securely at its lower end, in the step at R, *figs.* 1492 and 1500, 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 cut 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.* 1492 and 1500, 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 141⅓ 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.

STONEWARE.

It is with great difficulty that any satisfactory distinction can be made between the different kinds of ware; they slide by nice degrees into one another. Stoneware of the ordinary kind, such as we see in jars, drain-pipes, and the variety of chemical utensils which are made in the Lambeth potteries, is constituted of the plastic clay, united in various proportions with some felspathic mineral, sands of different kinds, and in some cases with cement—stone, or chalk; these mixtures being subjected to a heat which is sufficient to produce a partial fusion of the mass,—this condition of semi-fusion being the distinguishing character of stoneware. The finer varieties of stoneware are made from well-selected clays, which when burnt will not have much colour. These are united with some fluxing material, by which that condition of semi-fusion is obtained which is necessary to the production of stoneware. The glaze of stoneware was always a salt glaze; it has, however, recently been the practice to glaze with a mixture of Cornish stone, flint, &c., as for earthenware.

EARTHENWARE.

This ware is exemplified in the Majolica ware, the Fayence of the French, the Dutch or Delf ware, and by the common varieties of pottery which are at present in general use in this country.

All the varieties of earthenware — and they are many — consist of clay bodies, coated with an easily-fusible glaze, containing lead or borax.

Poole clay, Devonshire clay, Cornish clay, and many of the clays from the coal measures, and other geological formations, enter into the composition of earthenware. These are combined with certain proportions of ground flint. Porous vessels for cooling water and wine, now made extensively in many parts of this country, are similar to the ancient Spanish cooling vessels.

The Spanish *alcarazzas*, 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 alcarazzas; 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 portion of sand, and very moderately fired.

With what has been already said in reference to the modes of manufacture, added to the remarks on printing, glazing, &c., which are to follow, the general principles which obtain in the manufacture of pottery, will, we think, be sufficiently understood.

PRINTING AND PAINTING.

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 transferrer 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 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 "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.

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 leathern 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 volatilising 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 *tournas n*, 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.

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.

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, and 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 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 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.

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.

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.

An iron lustre is obtained by dissolving a bit of steel or iron in muriatic acid, mixing the 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 ochreous 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.

Enamel colours for painting on porcelain 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 tones 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 than is actually required, 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.

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."

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-consistenced 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 saggers 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 saggers. 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 saggers 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 saggers of the columns. The bottom of the kiln, where the glazed ware is not baked, is occupied by printed biscuit ware.

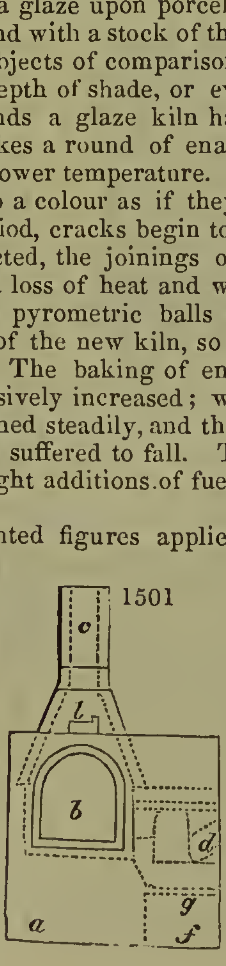
Pyrometric balls of red clay, coated with a very fusible lead enamel, are employed in the English potteries to ascertain the temperature of the glaze kilns. This enamel is so rich, and the clay upon which it is spread is so fine-grained and compact, that even when exposed for three hours to the briskest 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 pipe-clay 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.

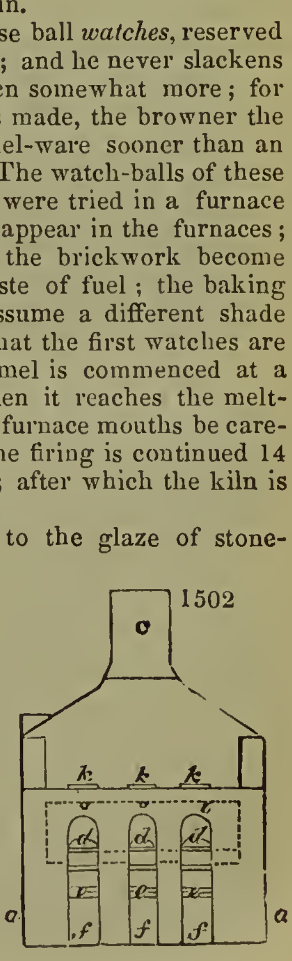
Muffles.—The paintings and the printed figures applied to the glaze of stoneware and porcelain are baked in muffles of a peculiar form. *Fig.* 1501 is a lateral elevation of one of these muffles; *fig.* 1502 is a front view. The same letters denote the same parts in the two figures.

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

1501



1502

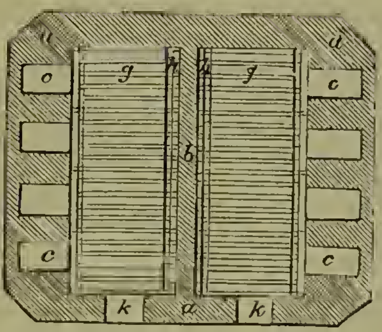


furnace to facilitate the passage of the flame beneath the muffle; *g* is a lateral hole which makes a communication across the furnace in the muffle, enabling the kiln man to ascertain what is passing within; *k*, *k*, are the lateral chinks for observing the progress of the firing or flame; *l* is an opening scooped out in the front of the chimney to modify its draught.

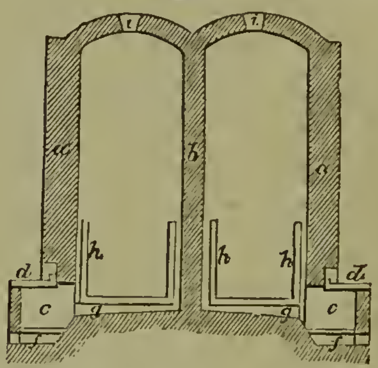
The articles which are printed or painted upon the glaze are placed in the muffle without saggers, upon tripods, or movable supports furnished with feet. The muffle being charged, its mouth is closed with a fire-tile well luted round its edges. The fuel is then kindled in the fire-places *d*, *d*, and 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, envelopes the muffle on all sides, and thence rises up the chimney.

A patent was obtained 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 saggers 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.* 1503 and 1504, *a* represents the square walls or body of the oven; *b*, the partition wall; *c*, the fire-places or

1503



1504



furnaces 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.

Before this article is concluded it is necessary that we should notice the attempts which have been made, with various degrees of success, to employ porcelain as a means for multiplying the productions of high art in a cheap form. Under the various terms of Statuary Porcelain, Parian, Carrara, &c., are produced numerous works of art, many of which are distinguished by their beauty. As the most direct method of illustrating the process of making these figures, 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 of the most perfect character, is mixed with flint, as in the case of manufacturing the finest stoneware china, and it is used in a semi-liquid state about the consistency of cream: this 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. 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. 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 realise 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. Indeed the difficulties which surround the manufacture of Parian, prevent its being rendered to the public at such a price as those would desire who wish to secure the introduction, amongst the people, of all examples which are calculated to refine their tastes. A biscuit china is, by a somewhat similar process, employed in several of the porcelain manufactories on the continent for the production of statuettes, busts, &c., but in colour and character they are all inferior to the English Parian. See Bricks; Clay; Porcelain Clay; Tiles; Stone, Artificial, &c.

The value of *exports* of British manufacture, in 1857 was £1,492,236, and in 1858 £1,153,579.

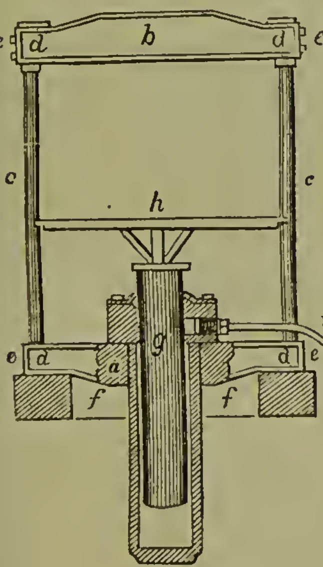
PRECIPITATE is any matter separated in minute particles from a fluid holding matter in solution, which subsides to the bottom of the vessel in a pulverulent form.

PRECIPITATION is the actual subsidence of a precipitate.

PRESERVED MEATS. See Meats, Preserved.

PRESS, HYDRAULIC. Though the explanation of the principles of this powerful machine belongs to a work upon mechanical engineering, rather than to one upon

1505



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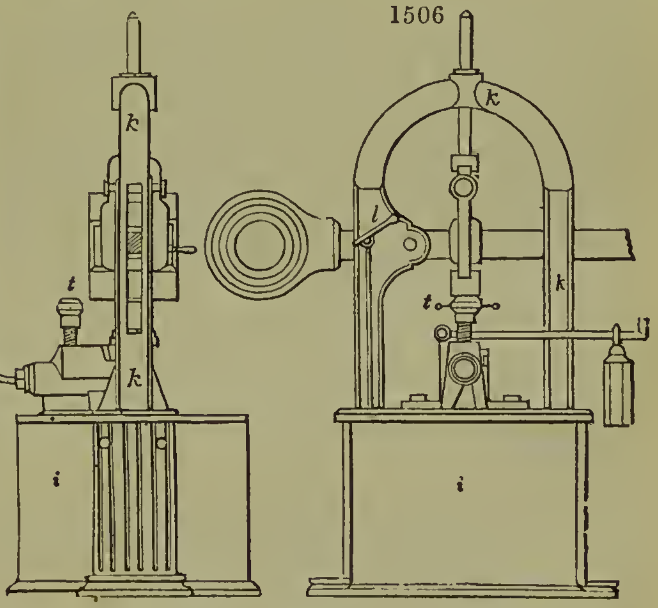
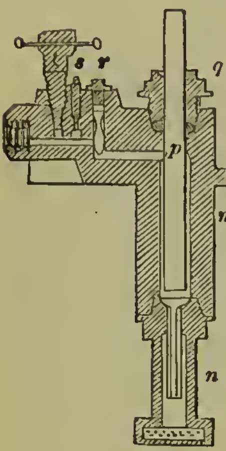


manufactures, yet as it is often referred to in this volume, a brief description of it cannot be unacceptable to many of our readers.

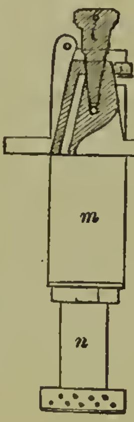
The framing consists of two stout cast-iron plates, *a*, *b*, which are strengthened by projecting ribs, not seen in the section, *fig.* 1505. The top or crown plate *b*, and the base-plate *a*, *a*, are bound most firmly together by 4 cylinders of the best wrought iron, *c*, *c*, which pass up through 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, aud 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.

1507



1508



h, *h*, *figs.* 1505 and 1506, 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.* 1507 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.* 1506, 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.* 1508, *u* is the tube which conveys the water from the pump into the press-cylinder. In *fig.* 1506, 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 Water Pressure Machine.

PRINCE'S METAL, or Prince Rupert's metal, is a modification of brass.

PRINTING. (*Imprimerie*, *typographie*, Fr.; *Buchdrückerkunst*, Germ.) The art of taking impressions from types and engravings in relief.

History.—The art itself is of comparatively modern origin, only 400 years having elapsed since the first book, properly so called, issued from the press; but we cannot doubt that its essence was known to the ancients. It has certainly been practised in the East from a very early period, and in a manner similar to our own first attempts. That a rude kiud of printing was known to the Babylonians is evident from the undecayed bricks of that city which have been found stamped with various symbolical and hieroglyphic characters; but, as the stamp itself was in one piece or block, it was inapplicable to the propagation of knowledge, from its cost and tediousness of production.

The Chinese are the only people who have continued this primitive mode of printing to the present time. Their earliest attempts are stated in the chronicles to have been made about 50 years before the Christian era; but it was not till the reign of the Emperor Ming-tsong (927—934 A.D.) that any great advance was made in printing large numbers of comparatively cheap books. The name of the Chinese Caxton was Tong-tao. He obtained permission of the emperor in 932 to print and circulate copies of the "Classical Works," as they are called, by taking impressions from stone plates, the letters cut into them, so that the impression ou the paper was black, and the letters themselves left white. This is still the case in all Chinese lithographic printing. Tong-tao, however, subsequently obtained the emperor's sanction to cut in wood and print an edition of the nine "King," or classical books, for the use of the Imperial College in Pekin. This was completed in 952; and, although intended only for the pupils of the college, it was made purchasable by any person in the empire. The process pursued in the printing of this work is precisely the same as at the present day; the following being the *modus operandi*:—The work intended to be printed is handed to a caligraphist, who writes the separate pages on fine tracing paper; these are given to the engraver, who glues them face downwards upon a thin plate of hard wood, called *li*, resembling that of the pear tree, and he cuts away with a sharp instrument all those parts of the wood on which nothing is traced, leaving the transcribed characters in relief and ready for printing. The Chinese printer then, having no notion of the printing-press, makes use of two fine brushes, both held in the right hand, one of which contains ink, the other dry. With the former he blackens the letters; the latter he passes gently over the paper which has been laid on them. By this means an expert workman can take a large number of impressions in one day. As the Chinese paper is thin and transparent, it is printed on one side only, two pages side by side, and the sheet has a black line down the middle, as a guide to the binder, who folds it double, and fastens the open leaves together. Various attempts have been made in the Celestial Empire to substitute movable types for the wooden blocks, but they have always terminated in a return to the old method.

The ancient Romans made use of metal stamps, with characters engraved in relief, to mark their articles of trade and commerce; and Cicero, in his "De Naturâ Deorum," has a passage from which Toland imagines the moderns have taken the hint of printing. Cicero orders the types to be made of metal, and calls them *formæ literarum*, the very words used by the first printers to express them. In Virgil's time, too, brands, with letters, were used for marking cattle, &c., with the owner's name. Landseer (*Lectures on the Art of Engraving*, 8vo. 1807) observes, "Had the modern art of making paper been known to the ancients, we had probably never heard the names of Faust and Finiguerra; for with the same kind of stamps which the Romans used for their pottery and packages, books might also have been printed; and the same engraving which adorned the shields and pateras of the more remote ages, with the addition of paper, might have spread the rays of Greek and Etrurian intelligence over the world of antiquity. Of the truth of this assertion I have the satisfaction to lay before you the most decided proofs, by exhibiting engraved Latin inscriptions, both in cameo and intaglio, from the collection of Mr. Douce, with impressions taken from them at Mr. Savage's letter-press but yesterday [1805]. One of them is an intaglio stamp, with which a Roman oculist was used to mark his medicines; the other, which is of metal, and in cameo, is simply the proper name of the tradesman by whom it has probably been used, 'T[itus] Valagini Mauri.'" The following impression (*fig.* 1509) is a facsimile of the latter stamp:—

1509

Books before the invention of printing.—The value of books and the esteem in which they were held before the invention of printing, were such, that notaries were employed to make the conveyance with as much care and attention as if estates were to be transferred. It was then thought the worthy occupation of a life either to copy or collect an amount of reading which modern improvements now present to us for a few shillings. Galen tells us that Ptolemy Philadelphus gave the Athenians 15 talents, with exemption from all tribute, and a great convoy of provisions, for the autographs and originals of the tragedies of Æschylus, Sophocles, and Euripides. "Pisistratus is said to have been the first among the earliest of the Greeks who projected an immense collection of the works of the learned, and is supposed to have been the collector of the scattered works which passed under the name of Homer." (*D'Israeli, Cur. of Lit.*)

Among the Romans the bulk or goodness of a man's library was the distinguishing mark of his excellence and wisdom. Middleton (*Life of Cicero*), speaking of Cicero himself, says, "Nor was he less eager in making a collection of Greek books, and forming a library, by the same opportunity of Atticus's help. This was Atticus's own passion; who, having free access to all the Athenian libraries, was employing his slaves in copying the works of their best writers, not only for his own use, but for sale also, and the common profit both of the slave and the master.

The passion for the enjoyment of books has in all ages led their lovers to cover them with the most costly and ornamental bindings. The ancients commonly adorned them with pendent ornaments of variously coloured cloth, and the covers were stained with scarlet or purple colour: "Hirsutus sparsis ut videare comis" (*Ovid*), and "Purpureo fulgens habitu, radiantibus uncis" (*Martial*). The *unci* were rollers of wood or ivory, round which the books were rolled to prevent injury to their fronts. Ovid and Tibullus call them *cornua*, from the similarity of their ends to horns. Epistles differed from books in this: the leaves were folded together, tied round with linen tape, and sealed with *creta Asiatica*, while books were "bound" as above. If, however, there were more epistles than one, "or if one epistle was to be preserved in the library, it was enclosed and turned round, and not folded: hence the word *volumen*" (*Arts of the Greeks and Romans*). "Video quod agas: tuas quoque epistolas vis referam in volumina." (*Cicero.*)

The orders respecting books in the "Close Rolls" of the Middle Ages are interesting, not only as illustrating the literary taste of the age, but principally because they generally contain some circumstance which shows the scarcity and value of the article. It was not until a period considerably subsequent to the invention of printing that the cost and rarity of books ceased to obstruct the advancement of learning and the diffusion of knowledge.

Incredible difficulties were encountered by those who undertook first to lay open the stores of ancient learning, from the scarcity of MSS.; for the literary treasures of antiquity had suffered from the malice of men as well as from the hand of time.

Block Books.—The time had now come, however, when the world's inheritance of the knowledge of Greece and Rome was to be secured from any further destruction. The art of printing books from engraved blocks of wood was no doubt invented in Holland; and, apart from the great interest created by the object for which the block books were designed, namely, the propagation of the Scriptures (being, as it were, the forerunner of the Reformation), they are extremely valuable as exhibiting the first attempts at engraving on wood in the form of books, many of them having preceded the art of printing by movable types. (*Sotheby's Block Books.*)

But that prints without text, or letterpress as it is termed, were in common use at a period considerably anterior to that of the block books, there is abundant evidence. It is related by Papillon (*Traité Historique et Pratique de la Gravure en Bois*) that the heroic actions of Alexander the Great were engraved on wood by the two Cunio, Alexander Alberic, and his sister Isabella, and impressions printed from the blocks as early as 1285; and his statement has been supported by Ottley (*Early Hist. of Engraving upon Copper and Wood, &c.*, 2 vols. 4to. 1816) and Singer (*Hist. of Playing Cards, &c.*, London, 4to. 1816). But Jackson (*Hist. of Wood Engraving*) takes some trouble to prove that Papillon was excessively credulous, if not deranged. Towards the end of the 14th century, too, playing cards were engraved and printed for the amusement of Charles VI. King of France, who reigned from 1380 to 1421. The print of St. Christopher carrying the infant Saviour on his back across the sea, in the collection of Earl Spencer, bears an inscription and the date 1423 at the bottom of the same block; but one in the possession of Mr. J. A. G. Weigel of Leipsic is supposed to be the work of even an earlier artist.* These circumstances, together with the fact that the government of Venice published a decree, dated October 11, 1441, wherein the art and mystery of making "playing cards and coloured figures printed" are stated to have fallen into decay in consequence of the great quantity which had been made out of that state, and which were now prohibited under pain of forfeiture and fine †, all prove that the knowledge and practice of printing, although not applied to the spread of knowledge and the multiplication of books, had yet an existence in Europe long before the time to which it is usually attributed.

When the substructure had been completed, the work was pursued with the utmost eagerness. Great numbers of books were produced, evidently in the Chinese manner above described; for the diversity of the characters found in block books has been a never-ending puzzle to those who have endeavoured to ascertain the printer by comparison of the formation of the letters used. The workmanship of many of these picture books was of a coarse description, without shadowing or "cross-hatching," tastelessly daubed over with broad colours, especially those printed for circulation amongst the poorer classes. Those best known of this class were called *Biblia Pauperum*, poor men's books, or rather books for poor preachers, and consisted of a series of rude engravings, each occupying a page, but divided into compartments containing pictorial illustrations of the most remarkable incidents mentioned in the books of Moses, the Gospels, and the Apocalypse.

Invention of movable types.—Gutenberg.—About the year 1438, while the learned Italians were eagerly deciphering their recently-discovered MSS., and slowly circulating them from hand to hand, it fell to the lot of a few obscure Germans to perfect the greatest discovery recorded in the annals of mankind. The notion of printing by movable types, and thereby saving the endless labour of cutting new blocks of letters for every page, was reserved for John Gutenberg of Mayence. Born in that city about the beginning of the century, he settled at Strasburg about 1424, and commenced printing in the house of one Dritzehen. But having been

* A copy of Mr. Weigel's print may be seen in Sotheby's "Block Books," vol. ii. p, 161.
† This must be regarded as the earliest authentic document respecting printing.

engaged in a lawsuit connected with Dritzehen's family, and exhausted his means, he returned to Mentz, where he resumed his typographic employment in partnership with a wealthy goldsmith, named John Fust or Faust. After many experiments with his presses and movable types, Gutenberg succeeded in printing an edition of the Vulgate, the Mentz or Mazarin Bible, so called from a copy having been discovered in the library of Cardinal Mazarin in Paris. The work was done between the years 1450 and 1455, and was printed on vellum; but there are several paper copies in England, France, and Germany. The partnership between Gutenberg and Fust having been dissolved, and the former being unable to repay part of the capital advanced by the wealthy goldsmith, the whole of the printing apparatus fell into the hands of Fust, who "printed off a considerable number of copies of the Bible, to imitate those which were commonly sold as MSS.; and he undertook the sale of them at Paris. It was his interest to conceal this discovery, and to pass off his printed copies for MSS. But, enabled to sell his bibles at sixty crowns, while the other scribes demanded five hundred, this raised universal astonishment; and still more when he produced copies as fast as they were wanted, and even lowered his price. The uniformity of the copies increased the wonder. Informations were given in to the magistrates against him as a magician; and in searching his lodgings a great number of copies were found. The red ink, — and Fust's red ink is peculiarly brilliant, — which embellished his copies, was said to be his blood; and it was solemnly adjudged that he was in league with the infernals. Fust at length was obliged, to save himself from a bonfire, to reveal his art to the Parliament of Paris, who discharged him from all prosecution in consideration of the wonderful invention. (*D'Israeli, Cur. of Lit.*)

This Bible was printed with large *cut* metal types; but in 1457 a magnificent edition of the "Psalter" appeared, printed by Fust and his assistant and son-in-law, Peter Schœffer, who had been taken into partnership. In this book the new invention was announced to the world in "a boasting colophon, though certainly not unreasonably bold. Another edition of the 'Psalter,' one of an ecclesiastical book, Durand's account of liturgical offices *, one of the Constitutions of Pope Clement V., and one of a popular treatise on general science, called the Catholicon †, filled up the interval till 1462, when the second Mentz Bible proceeded from the same printers. This, in the opinion of some, is the earliest book in which *cast* metal types were employed; those of the Mazarin Bible having been cut with the hand. But this is a controverted point. In 1465 Fust and Schœffer published an edition of Cicero's 'Offices,' the first tribute of the new art to polite literature." (*Hallam, Europe during the Middle Ages*, vol. iii. p. 470.)

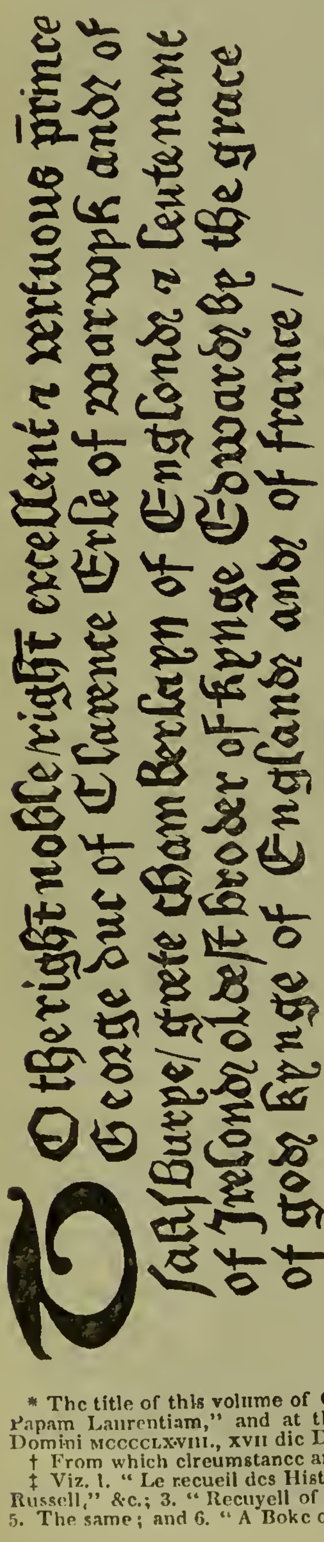
After the lapse of a few years the pupils and workmen of Fust and Schœffer, dispersed into various countries by the sacking of Mentz, under the Archbishop Adolphus, the invention was thereby publicly made known, and the art spread over all parts of Europe. Before the year 1500, printing presses had been set up in 220 places, and a multitude of editions of the classical writers given to the world. Santander ("*Dictionnaire Bibliographique choisi du quinzième Siècle*," &c., Bruxelles 1805, 3 vols.), in his interesting and masterly work, gives at the end of his first volume a chronological table of 200 places where the art was practised during the 15th century, with the names of the printers and of the first productions of their presses. We cannot afford room for this list; but must be content to state that from Mentz the art was transplanted to Haarlem and Strasburg; from Haarlem to Rome, in 1466, by Sweynheym and Pannartz, who were the first to make use of Roman types; to Paris in 1469; to England in 1474; and to Spain in 1475; and spread so rapidly that, between the years 1469 and 1475, most towns in Germany, Italy, and the Netherlands had made successful attempts in the production of printed copies of the most valued authors of the time.

Printing in England. — Until about the period of the Restoration, William Caxton was universally acknowledged to have introduced the art of printing into this country, in or about the year 1471. But, in 1664, a Mr. Richard Atkyns, in a work called "The Original and Growth of Printing," &c., brought before the notice of the curious a little book, printed at Oxford, bearing the date 1468, three years before the period usually assigned to the labours of Caxton. This work took literary men by surprise, and gave rise to the most violent discussions. It is related by Atkyns that a Dutchman of the name of Frederic Corsellis was induced to desert his employers in the Low Countries, and that one Richard Turnour, an agent of King Henry VI., assisted by William Caxton, who was well known in Holland as a merchant, and therefore likely to throw the jealous possessors of the new art off their guard, brought him to England, where at Oxford he was set to work by Archbishop

* "Rationale Divinorum Officiorum" of William Durand, 1459.
† "Catholicon Januensis," 1460, in the King's Library.

Bourchier, ten years before the date of Caxton's first book.* But the silence of Caxton on a subject in which he took the utmost interest, and in which it is stated on this occasion he was an important actor, is a strong argument against the authenticity of the story. Indeed, M. Santander (vol. i. p. 328) does not for a moment entertain the pretensions of Corsellis, and agrees with Dr. Conyers Middleton in considering that the date MCCCCLXVIII. ought to have been MCCCCLXXVIII., an X having been by accident omitted by the compositor:—"Voilà ce que Richard Atkyns imagina, et les moyens dont il se servit, en 1664, pour soutenir contre le corps des libraires de Londres, que l'imprimerie était un droit de la couronne en Angleterre. Mais le docteur Middleton, dans sa 'Dissertation sur l'Origine de l'imprimerie en Angleterre,' imprimée à Cambridge, en 1735, in 4°, a prouvé démonstrativement, que l'impression d'Oxford, de 'l'Expositio S. Jeronimi in simbolum Apostolorum,' est de l'an 1478, le compositeur ayant omis un X dans la date de la souscription (faute typographique dont nous avons plusieurs exemples dans les impressions du XV^e siècle)." Amongst other examples of blunders of this description, the learned doctor observes:—"But whilst I am now writing, an unexpected instance is fallen into my hands, to the support of my opinion; an 'Inauguration Speech of the Woodwardian Professor, Mr. Mason,' just fresh from the press, with its date given ten years earlier than it should have been, by the omission of an X, viz. MDCCXXIV.; and the very blunder exemplified in the last piece printed at Cambridge, which I suppose to have happened in the first from Oxford."

1510



Whether, however, Caxton was or was not the first English printer, it is quite certain that he was the first who made use of cast metal types, the works of Corsellis having been executed with merely wooden ones. During a long residence abroad, he had acquired a practical knowledge of the art; and on his return to England in 1471, set up a press at Westminster Abbey, in an old chapel† adjoining that edifice; and was for many years engaged in translating and printing books on a variety of subjects. His first work is, "Le Recueil des Histoires de Troyes" of Raoul le Fevre, chaplain to the Duchess of Burgundy; but "The Dictes and Sayinges of the Philosophers" is the earliest book known to have issued from his press with the date and place of printing; and we have no proof at all that his six earlier works‡ were printed in this country. Indeed, it is stated in the Life of Caxton, in Ames's "Typ. Antiquities," p. xcv., that the French and English editions of the "Histories of Troy" are justly "admitted to have been printed abroad."

The types used in Caxton's works, as well as in those of most of the early printers, were the Gothic or *black-letter* characters, said to have been invented by Ulphilas, first bishop of the Mœso-Goths. A facsimile of Caxton's types is here annexed, *fig.* 1510, showing the formation of his letters; and proving to our mind that, as compared with the specimens we have seen of the characters used by the Oxford printer Corsellis, they have an undoubted claim to the greater antiquity.

Caxton is said to have printed 64 books; and was followed by his pupils or assistants, Theodore Rood, John Lettou, William Machilinia, and Wynkyn de Worde, all foreigners, and Thomas Hunt, an Englishman. All these pioneers of the art worthily maintained the honour of their master's name; and Wynkyn de Worde is especially remarkable for his improvements and typographical excellence, and as having been the first printer in England who introduced the Roman letter. He printed 410 works.

* The title of this volume of Corsellis is, "Exposicio Sancti Jeronimi in Simbolum Apostolorum ad Papam Laurentiam," and at the end, "Explicit Exposicio, &c. Impressa Oxonie, et finita Anno Domini MCCCCLXVIII., XVII die Decembris."

† From which circumstance an assemblage of printers is to this day called a "chapel."

‡ Viz. 1. "Le recueil des Histoires de Troyes;" 2. "Propositio Clarissimi oratoris Magistri Johannis Russell," &c.; 3. "Recuyell of the Histories of Troye;" 4. "The Game and Playe of the Chesse;" 5. The same; and 6. "A Boke of the hoole Lyf of Jason."

The spirit and taste of the patrons of the first printers are shown in the character of their earliest works, religious books and romances constituting the greater part of the productions of the father of English printing. But the art, although at first countenanced by the clergy, was soon looked upon with extreme jealousy by the church. Efforts were made towards the publication of the Word of God; but for the first 60 or 70 years all copies of the Scriptures were printed in the Latin or some other language, not understood by the generality of the people. A new era had, however, arrived. The doctrines of the Reformation had proclaimed the Bible as man's best guide and teacher, and the people yearned to possess Bibles. Wickliffe's translation was never printed. The part of the Sacred Writings in the English language first produced by the printing press, was the New Testament, translated by William Tindal, assisted by Miles Coverdale, afterwards Bishop of Exeter: it was printed at Antwerp, in 1526; but as it gave offence to Wolsey and the church, the whole impression was bought up and burnt. The first complete English Bible printed by authority, was Tindal's version, revised and compared with the original by Coverdale, and afterwards examined by Cranmer, who wrote a preface for it. Of this edition, hence called " Cranmer's Bible," 500 copies were printed by Grafton and Whitchurch, to whom Henry VIII., in letters patent dated November 13, 1539, granted the sole right of printing the Bible for five years. It was ordered by royal proclamation to be set up in all churches throughout the kingdom, under a penalty of 40*s.* a month in every case of neglect. So great was the demand for copies of the Scriptures in the 16th century, that we have in existence 326 editions of the English Bible, or parts of the Bible, printed between 1526 and 1600.

The progress of the art in the first century of its existence was remarkable ; but the earliest English printers did not attempt what the Continental ones were doing for the ancient classics. " Down to 1540, no Greek book had appeared from an English press; Oxford had only printed a part of Cicero's epistles; Cambridge, no ancient writer whatever. Only three or four old Roman writers had been reprinted, at that period, throughout England. But a great deal was done for public instruction by the course which our early printers took ; for, as one of them says: — 'Divers famous clerks and learned men translated and made many noble works into our English tongue, whereby there was much more plenty and abundance of English used than there was in times past.' The English nobility were, probably, for more than the first half century of English printing, the great encouragers of our press: — They required translations and abridgments of the classics, versions of French and Italian romances, old chronicles, and helps to devout exercises. Caxton and his successors abundantly supplied these wants, and the impulse to most of their exertions was given by the growing demand for literary amusement on the part of the great. Caxton, speaking of his 'Boke Eneydos,' says — 'This present book is not for a rude uplandish man to labour therein, nor read it; but only for a clerk and a noble gentleman, that feeleth and understandeth in feats of arms, in love, and in noble chivalry.' But a great change was working in Europe; the 'rude uplandish man,' if he gave promise of talent, was sent to school. The priests strove with the laity for the education of the people ; and not only in Protestant but in Catholic countries were schools and universities everywhere founded. Here, again, was a new source of employment for the press — A, B, C's, or Absies, Primers, Catechisms, Grammars, Dictionaries, were multiplied in every direction. Books became, also, during this period, the tools of professional men. There were not many works of medicine, but a great many of law. The people, too, required instruction in the ordinances they were called upon to obey ; and thus the statutes, mostly written in French, were translated and abridged by Rastell, our first law-printer.

" After all this rush of the press of England towards the diffusion of existing knowledge, it began to assist in the production of new works, but in very different directions. Much of the poetry of the 16th century, which our press spread around, will last for ever: its controversial divinity has, in great part, perished. Each, however, was a natural supply, arising out of the demand of the people ; as much as the chronicles, and romances, and grammars were a natural supply; and as the almanacks. and mysteries, and ballads, which the people then had, were a natural supply. Taken altogether, the activity of the press of England, during the first period of our enquiry, was very remarkable. Ames and Herbert have recorded the names of 350 printers in England and Scotland, or of foreign printers engaged in producing books for England, that flourished between 1471 and 1600. The same authors have recorded the titles of nearly 10,000 distinct works printed amongst us during the same period. Many of these works, however, were only single sheets, but, on the other hand, there are, doubtless, many not here registered. Dividing the total number of books printed during these 130 years, we find that the average number of distinct works produced each year was 75." (*Penny Magazine.*)

The first book in which Greek types occur is Cicero's "Offices," printed in the year 1465, in which the characters are so imperfect that the words are with difficulty deciphered; but the first work printed wholly with Greek types is a Greek Grammar written by the learned Constantine Lascaris, printed in Milan by Dionysius Paravisinus, in 1476, in 4to. It went through several editions in Italy, France, and Switzerland. One of them, that of Aldus, printed in Venice in 1495, is the first Aldine book printed with a date. One of the most elegant specimens of ancient Greek typography, valued not only for its beauty, but also for its rarity and the accuracy of its text, is the "Argonautica, Flor. ap. Junta, 1500," 4to, editio princeps.

It was not unusual for the early printers of Greek, as well as of other works, to endeavour to imitate the characters of the MSS. of the age. In this they were more or less successful. An exceedingly beautiful specimen of this kind of printing is the editio princeps of Isocrates, "Orat. à Demetrio Chalcondyla, Gr. Mediol. ap. Henr. Germanus et Sebastianus ex Pontremula," 1493, fol. The text of this edition is said to be remarkably accurate. Fabricius considers it more so than that of the Aldine edition of 1513.

The first Greek book printed in Rome was the works of Pindar: "Pindari Opera, Gr. cum Scholiis Callieggi." Rome, 1515, 4to. This is also remarkable as the first edition with the Scholia. The first Greek work printed at Cambridge was Plato's "Menexenus, sive Funebris Oratio, exhortatio ad Patriam amaudam atque defendam. Cantab." Greek types were not introduced into Scotland till after the middle of the 16th century. In a 4to volume printed in Edinburgh in 1563, entitled, "The Confutation of the Abbote of Crosraguel's Masse," there is an Epistle by the Printer to the Reader, apologising for his want of Greek characters, which he was obliged to supply by manuscript.

The first work printed with Roman types was Cicero's "Epistolæ Familiares," by Sweynheym and Pannartz, at Rome, in 1467. Italic type was invented by Aldus Manutius, about 1500.

Italy has the honour also of having printed the first Hebrew Bible, at Soncino, a small city in the Duchy of Milan, in 1488, under the superintendence of two Jewish rabbins, named Joshua and Moses. The edition of Brescia, of 1494, was used by Luther in making his German translation. But Hebrew types were not introduced into England for many years after this period; for we find that in 1524, Dr. Robert Wakefield, chaplain to Henry VIII., complains, in his "Oratio de Laudibus," &c., that he was obliged to omit his whole third part, as the printer (Wynkyn de Worde) had no Hebrew types. Towards the end of the 16th century, various works were printed in Syriac, Arabic, Persian, Armenian, and Coptic, or modern Egyptian types; some to gratify the curiosity of the learned, and others for the liturgic uses of the Christians in the Levant.

In the 16th century the broils consequent on the Reformation, although that event stimulated religious inquiry, did much to impede the progress of the art in England. But the civil wars and the gloomy religious spirit which succeeded to the pedantry and verbal criticism of the reign of James I., and which prevailed till the Restoration, interrupted still more the production of works calculated to cultivate the understanding. Indeed, we cannot but regard this period as the least favourable to the diffusion of knowledge of any period in the history of our literature. In the British Museum is a collection of controversial and quibbling tracts amounting to the enormous number of 30,000*, while the impressions of new books printed during these stormy times were very few. Dr. Johnson has well remarked that the nation, from 1623 to 1664, was satisfied with two editions of Shakspeare's plays, which, probably, together did not amount to a thousand copies. But during this period we must not forget the present authorised version of the Bible, translated by the forty-seven distinguished scholars appointed by James I., and printed in 1611, which is allowed by competent judges to be one of singular merit, and indeed the most perfect ever produced. An unfavourable effect was also produced on our national literature, and on the progress of the press, by the licentiousness introduced by the literary parasites and courtezans of the Restoration. Under such a state of mental depression, Milton could obtain only 15*l.* for the MS. of his immortal "Paradise Lost," and an Act of Parliament was actually in force enacting that only twenty printers should practise their art in the whole kingdom! Burton, who lived near this time, has drawn a miserable picture of the abject condition of literary men when they had such patrons to rely upon: — "Rhetoric only serves them to curse their bad fortunes; and many of them, for want of means, are driven to hard shifts. From grass-hoppers they turn humble-bees and wasps, plain parasites, and make the Muses mules, to satisfy their hunger-starved paunches and get a meal's meat."

In addition to these impediments, the Crown endeavoured, in the reign of Charles II., to destroy the activity of the press; "and in this it had the example not only of all for-

* Tomlinson's Collection.

mer reigns (in which nothing had been legally published without a license), but of the Long Parliament itself, which had laid severe restrictions upon the printing of 'scandalous and unlicensed papers.' At one time, indeed, it was ordered that no printing should be carried on anywhere but in the City of London and the two Universities; and all London printers were to enter into a bond of 300*l.* not to print anything against the Government, or without the name of the author (or at least of the licenser) on the title-page, in addition to their own."—(*Eccleston's Eng. Antiquities*, p. 325.)

It has been ascertained by counting that the whole number of books printed during the fourteen years from 1666 to 1680, was 3550, of which 947 were divinity, 420 law, and 153 physic, so that two-fifths of the whole were professional books; 397 were school-books, and 253 on subjects of geography and navigation, including maps. Taking the average of these fourteen years, the total number of works produced yearly was 253; but deducting the reprints, pamphlets, single sermons, and maps, we may fairly assume that the yearly average of new books was much under 100. Of the number of copies constituting an edition we have no record; we apprehend it must have been small, for the price of a book, so far as we can ascertain it, was considerable.

The period from the accession of George III. to the close of the 18th century is marked by the rapid increase of the demand for popular literature, rather than by any prominent features of originality in literary production. Periodical literature spread on every side; newspapers, magazines, reviews, were multiplied; and the old system of selling books by hawkers was extended to the rural districts and small provincial towns. Of the number-books thus produced, the quality was indifferent, with a few exceptions; and the cost of these works was considerable. The principle, however, was then first developed, of extending the market, by coming into it at regular intervals with fractions of a book, so that the humblest customer might lay by each week in a savings'-bank of knowledge. This was an important step, which has produced great effects, but which is even now capable of a much more universal application than it has ever yet received. Smollet's 'History of England' was one of the most successful number-books; it sold to the extent of 20,000 copies.

We may exhibit the rapid growth of the publication of new books, by examining the catalogues of the latter part of the eighteenth century, passing over the earlier years of the reign of George III. In the 'Modern Catalogue of Books,' from 1792 to the end of 1802, eleven years, we find that 4096 new works were published, exclusive of reprints not altered in price, and also exclusive of pamphlets: deducting one-fifth for reprints, we have an average of 372 new books per year. This is a prodigious stride beyond the average of 93 per year of the previous period. But we are not sure that our literature was in a more healthy condition. From some cause or other, the selling price of books had increased, in most cases 50 per cent., in others, 100 per cent. The 2*s.* 6*d.* duodecimo had become 4*s.*; the 6*s.* octavo, 10*s.* 6*d.*; and the 12*s.* quarto, 1*l.* 1*s.* It would appear from this that the exclusive market was principally sought for new books; that the publishers of novelties did not rely upon the increasing number of readers; and that the periodical works constituted the principal supply of the many. The aggregate increase of the commerce in books must, however, have become enormous, when compared with the previous fifty years; and the effect was highly beneficial to the literary character. The age of patronage was gone. (*Penny Magazine.*)

According to the last census, upwards of 26,000 persons are employed in printing, and 11,000 in bookbinding.

Printing was introduced into Scotland, and begun in Edinburgh about 30 years after Caxton had brought it into England. Mr. Watson, in his 'History of Printing,' says that the art was introduced into Scotland from the Low Countries by the priests who fled thither from the persecutions at home. Be this as it may, we find James IV. granting a patent in 1507 to Walter Chapman, a merchant of Edinburgh, and Andrew Mollar, a workman, to establish a press in that city. According to bibliographers, the most ancient specimen of printing in Scotland extant is a collection, entitled the 'Porteus of Nobleness,' Edinburgh. In 1509, a 'Breviary of the Church of Aberdeen' was printed at Edinburgh; and a second part in the following year. Very few works, however, appear to have issued from the Scottish press for the next 30 years; but from 1541, the date from which we find James V. granting licenses to print, the art has been pursued with success in the metropolis. At present, and from the beginning of the present century, it is perhaps the most distinguished craft in the city, being conducted in all its departments of typefounding, printing, publishing, and, we may add, paper-making at the mills in the vicinity.

Printing was not known in Ireland till about the year 1551, when a book in black letter was issued from a press in Dublin; but till the year 1700, very little printing was executed in Ireland, and even since that period, the country has acquired little celebrity in this department of the arts, although possessing some respectable printing establishments.

The art of printing has readily taken root and flourished among the civilised inhabitants of North America. The first printing-press established in the American colonies was one set up at Cambridge, in Massachusetts, in the year 1638, the era of the foundation of Harvard College of that place. It was only established by the exertions and joint contributions of different individuals in Europe and America; and there is no doubt that the mechanism and types were imported from England. The first work which issued from this press was the 'Freeman's Call,' and the second the 'Almanac for New England,' both in 1639; the first book printed was the New England version of the Psalms, an octavo volume of 300 pages. In 1676, books began to be printed at Boston; in 1686, printing became known in Philadelphia; and in 1693, in New York. In the year 1700 there were only four printing presses in the colonies. Since that period, and especially since the revolution, which removed everything like a censorship of the press, the practice of the art has undergone enormous expansion. Among the occupations enumerated in the census of 1850 were 14,740 printers, and 3414 bookbinders. In their style of typography and bookmaking, the Americans are still inferior to the English, sacrificing beauty and durability to economy and despatch. (*Chambers's Inform.*)

The activity of the French press has very greatly increased since the time of the first Napoleon. Count Daru, in 1827 (*Notions Statistiques sur la Libraire*), estimated the number of printed sheets (exclusive of newspapers) produced by the French press in 1816, at 66,852,883; and it appears that in 1836 the number of printed sheets (exclusive of newspapers) had increased to 118,857,000; so that it may now be fairly estimated at from 130,000,000 to 140,000,000 of sheets. The quality of many of the works which have issued from the French press is also very superior, such as the "Biographie Universelle," the "Art de vérifier les Dates," and "Bayle's Dictionary;" and it is doubted whether such books could have been published in any other country.

The German printing press is always in a state of the greatest activity; and the trade in books is very much facilitated by the book fairs of Leipsic, the Easter fair especially being frequented by all the booksellers of Germany, besides those of France, Switzerland, Denmark, Livonia, &c., in order to settle their mutual concerns and form new connections. In 1814 began a literary deluge, which still continues to increase. For the 5000 works which then sufficed for the annual demand, we have now from 6000 to 8000. Private libraries are diminishing, and the public ones are daily increasing.

In Austria the printing press has made rapid strides of late years. The Imperial printing office in Vienna, under the able management of M. Auer, has become an establishment of the highest interest. At the Exhibition of 1851, he presented to the notice of the public a collection of the Lord's Prayer, printed with Roman type in 608 languages and dialects, the second section of which contained 206 languages and dialects, printed in the characters proper to the language of the respective nation. He has collected together the following founts, many of which are, however, to be found in the British type foundries :—

Hieroglyphic.
Hieratic.
Demotic.
Ethiopic and Amharic.
Himyaritic.
Himyaritic (ornamented).
Cabylic, American inscript, Touaric and Thugga.
Ancient Hebrew.
Samaritan.
Hebrew.
Raschi, or Rabbinic.
German Hebrew.
German Raschi.
Hebrew, Spanish-Levantine.
Aramaic.
Chaldee.
Palmyric.
Estrangelo.
Syriac.
Cufic.
Arabic, Neschi.
Mauritanic.
Phenician.
Phenician (ornamented).
Punic.
Numidian.
Etrurian.
Ancient Italian.
Runic.
Gothic.
Celtic.
Celtic (new shape).
Anglo-Saxon.
Ancient Greek.
Greek.
Coptic.
Ciryllic.
Clryllic (differently shaped).
Russian, Servian, Wallachian.
Glagolitic.
Albanian.
Albanian (differently shaped).
Lycian.
Armenian.
Georgian.
Georgian (ecclesiast. letters).
Persepolitan cuneiform letters.
Pehlvi.
Zend.
Cabool.
Peguan.
Oldest Ind. signs.
Western Grotto inscription.
Açoka inscription.
Inscription of Guzerat.
Dynasty of Gupta (Allahabad).
Bengali.
Ahom.
Tibetan.
Passepa.
Kutila (ten years after Christ).
Devanagari (Sanscr. No. 1).
Devanagari (Sanscr. No. 2).
Kashmerian.
Sikh.
Assam inscript.
Mahratta.
Orissa.
Gujeratee.
Kayti-Nagari.
Randscha.
Bandschin-Mola.
Multan.
Sindhee.
Nerbudda.
Kistna.
Telinga.
Karnata.
Tamul.
Malayalim.
Cingalese.
Maldivian.
Javanese.
Kiousa.
New Pali (No. 1).
New Pali (No. 2).
Siamese.
Kambogo (with joint and without).
Laos.
Birmese.
Shyan.
Bugis.
Bisaya.
Batta.
Tagala.
Mongolese.
Mandschu.
Chinese.
Coreanic.
Formosan.
Japanese (Katakana No. 1).
Japanese (Katakana No. 2).
Japanese (Firokana).
Tschirokisian.

Types.—Although most of the early printers were type-founders themselves, it does not appear in any prologue or colophon to the books printed by Caxton that he lays claim to the title of type-founder. It would appear that he obtained his type, which is precisely of the same character as that of John Brito of Bruges, from that city, or from the same founders who supplied or manufactured it for John Valdener of Utrecht. But as the art extended the workmanship became inferior; "so that while the productions of the first printers were executed in a very superior style, and the embellishments showed a great proficiency both in design and engraving, the productions of their competitors had all the crudeness and imperfection of a new invention; and in the 17th century it had retrograded to a very low state. At the commencement of the 18th century, Caslon made great improvements in types; as also, Baskerville of Birmingham, in 1750, both in types and printing, which were subsequently carried on by Besley, Bulmer, Clowes, Corrall, Davison, McCreery, Spottiswoode, Whittingham, and a few others in London; by the Foulis, in Glasgow; the Ballantynes, in Edinburgh; by Bodoni at Parma; by Didot in Paris;" and by Brockhaus in Leipsic.

Newspapers, &c.—The period of the English Revolution will be ever memorable in the literary history of this country for the establishment in great part of periodical literature. But English newspapers, properly so called, date from the first year of the Long Parliament, the oldest that has been discovered being a quarto pamphlet of a few leaves, entitled "The Diurnal Occurrences, or Daily Proceedings of both houses in this great and happy Parliament, from the 3rd November, 1640, to the 3rd of November, 1641. London: printed for William Cooke, and are to be sold at his shop at Furnival's Inn Gate, in Holborn, 1641." (*Fig.* 1511.) More than 100 papers

1511.

with different titles appear to have been published from this time to the death of the king, and upwards of 80 from that date to the Restoration. These were at first published weekly; but, as the interest increased, twice or thrice a week; and even, it would seem, daily, at least for a time. Such were the "French Intelligences," the "Dutch Spy," the "Scots Dove," &c.; but "Mercuries" of all sorts were the favourite title. Thus they had "Mercurius Acheronticus," "Mercurius Democritus," "Aulicus," "Britannicus," "Laughing Mercury," and "Mercurius Mastix," which last faithfully lashed all the rest. The great newspaper editors of the day were Marchmont Needham on the Presbyterian, and Sir John Birkenhead on the royalist side. These were followed by Sir Roger l'Estrange, who has also been ranked amongst the patriarchs of the newspaper press. Pamphlets were also issued in prodigious numbers during those troubled times; the average being calculated at four or five new ones every day. (*Eccleston's Eng. Antiq.*)

In 1709, one daily paper, fifteen three times a week, and one twice a week, papers, were published in the metropolis. In 1724 there were three daily, six weekly, and ten three times a week papers, in London; and provincial newspapers had been established in various places. The reign of Queen Anne also witnessed a new and most successful species of literature—the issue of the "Guardian," "Spectator," and other such literary sheets, published at short intervals. The strong good sense of Cave, the printer, originated the "Gentleman's Magazine," which completely established the principle that the patronage of men of letters is best confided to the people, and not the great and fashionable. This publication soon had rivals to contend with in the "Monthly," "European," "London," and "Critical;" but it has survived them all; and a complete set of "The Gentleman" is highly prized at the present day, and is extremely amusing and valuable.

The first newspaper published in Scotland was the "Caledonian Mercury," in 1660, under the title of "Mercurius Caledonius;" but its publication was soon after interrupted. In 1750 a newspaper was, for the first time, attempted in Glasgow.

The increase of newspapers in America has been much more rapid than in this country; in consequence partly, no doubt, of the greater increase of population in the Union, but more probably of their freedom from taxation, and of the violence of party contests. According to a return published some few years back, the aggregate circulation of papers and other publications was about 5,000,000; and the entire number of copies printed annually in the United States amounted to about 422,600,000 annually.

The first newspaper published in the West Indies is said to have been the "Barbadoes Mercury." It was established in 1733, and died in 1852.

Practice of Printing.—The workmen principally employed in printing are of two kinds: *compositors*, who *set up* the types into lines and pages according to the MS. or *copy* furnished by the author; and *pressmen*, who apply ink to the surface of the *form* of types, and take off the impressions upon paper.

Composition.—The mode of proceeding described hereafter is that which is pursued in most of the extensive establishments in London:—The first thing to be done, when the sizes of page, type, and paper, are determined on, is to look over the MS., and see that it is correctly paged. It is then handed to a *clicker*, or foreman of a *companionship*, or certain number of compositors, each of whom has a *taking of copy*, or convenient portion of MS., given to him, to be set up in type.

Printers' types are of great variety in size, amounting to forty or fifty; the smallest is called *Brilliant*, but is seldom used; *Diamond* is a size larger, and *Pearl* larger still, which latter type is used for printing the smallest Bibles and Prayer Books. The following is a view of the comparative sizes used in printing books:—

Diamond . . .	To the art of printing it is acknowledged we owe the Reformation It has been justly remarked that
Pearl	To the art of printing it is acknowledged we owe the Reformation. It has been justly re-
Ruby	To the art of printing it is acknowledged we owe the Reformation. It has been
Nonpareil . . .	To the art of printing it is acknowledged we owe the Reformation. It has
Minion . . .	To the art of printing it is acknowledged we owe the Reformation.
Brevier . . .	To the art of printing it is acknowledged we owe the Reform-
Bourgeois . . .	To the art of printing it is acknowledged we owe the Ref
Longprimer . .	To the art of printing it is acknowledged we owe th
Smallpica . . .	To the art of printing it is acknowledged we ow
Pica	To the art of printing it is acknowledged
English . . .	To the art of printing it is acknowled
Greatprimer . .	To the art of printing it is ac

The larger sizes, used for printing bills posted in the streets, are usually called *Double Pica, Two-line Pica, Two-line English, Five-line Pica, Ten-line Pica*, and so on. A complete assortment of printing types of one size is called a *fount*, and the fount may be regulated to any weight. Type-founders have a scale, or *bill*, as it is called, of the proportional quantity of each letter required for a fount. The letter *c*, as will be seen from the following *bill*, is used more, and the letter *z* less frequently than others:—

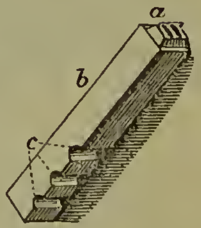
BILL OF PICA.—WEIGHT 800 POUNDS.—ITALIC $\frac{1}{10}$TH.

a	8,500	è	100	0	1,300	K	150
b	1,600	ì	100	£	—	L	250
c	3,000	ò	100	A	600	M	200
d	4,400	ù	100	B	400	N	200
e	12,000	â	200	C	500	O	200
f	2,500	ê	200	D	500	P	200
g	1,700	î	100	E	600	Q	90
h	6,400	ô	100	F	400	R	200
i	8,000	û	100	G	400	S	250
j	400	ä	100	H	400	T	326
k	800	ë	100	I	800	U	150
l	4,000	ï	100	J	300	V	150
m	3,000	ö	100	K	300	W	200
n	8,000	ü	100	L	500	X	90
o	8,000	ç	100	M	400	Y	150
p	1,700	,	4,500	N	400	Z	40
q	300	;	800	O	400	Æ	20
r	6,200	:	600	P	400	Œ	15
s	8,000	.	2,000	Q	180	Spaces.	
t	9,000	-	1,000	R	400		
u	3,400	?	200	S	500	Thick	18,000
v	1,200	!	150	T	650	Middle	12,000
w	2,000	'	700	U	300	Thin	8,000
x	400	†	100	V	300	Hair	3,000
y	2,000	‡	100	W	400	m qd.	2,500
z	200	*	100	X	180	n qd.	5,000
&	200	[	150	Y	300	Large quad.	
fi	500	‖	100	Z	80		
ff	400	§	100	Æ	40		
fl	200	(	300	Œ	30	2 em.	about 80 lb.
ffl	100	¶	60	A	300	3 em.	
ffi	150	1	1,300	B	200	4 em.	
æ	100	2	1,200	C	250	Metal rules.	
œ	60	3	1,100	D	250		
á	100	4	1,000	E	300		
é	250	5	1,000	F	200	1 em	—
í	100	6	1,000	G	200	2 em	—
ó	100	7	1,000	H	200	3 em	—
ú	100	8	1,000	I	400		
à	200	9	1,000	J	150		

In setting up indexes and similar matter, the capitals mentioned would be considerably deficient. This would also be the case with French and Italian works, where accented letters are used in great numbers.

The type itself is a thin metallic bar, an inch in length, like the following engraving (*fig.* 1512), which represents the letter *m*; *a* is the *face*, *b* the *body*, and *c* the *nicks* or notches. Whatever size of type is used, each letter must be perfectly true in its angles, otherwise the form could never be *locked up*. Besides letters, there are types for commas, periods, quotation marks, semicolons, and all other characters used in printing.

1512



The types are arranged, each sort by itself, in two *cases*,—an upper and lower,—in little cells or *boxes*. The upper case, having ninety-eight boxes, contains the capital and small capital letters, figures, accents, and other types not used so frequently as the smaller letters; and in the lower case, having fifty-four boxes, are disposed the small letters, together with the points, spaces, quadrats, &c. The boxes in the cases are arranged in the best possible manner for facilitating the work of the compositor, and enabling him to pick up the types rapidly,—the letters most frequently used being placed nearest to his hand.

Pair of Cases according to the modern Method.

Upper.

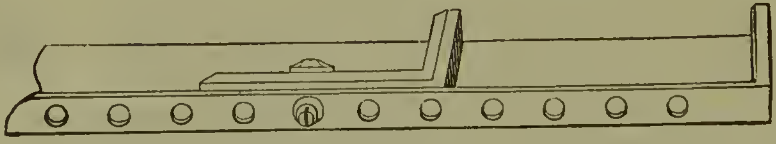
A	B	C	D	E	F	G	A	B	C	D	E	F	G
H	I	K	L	M	N	O	H	I	K	L	M	N	O
P	Q	R	S	T	V	W	P	Q	R	S	T	V	W
X	Y	Z	Æ	Œ	J	U	X	Y	Z	Æ	Œ	J	U
ä	ë	ï	ö	ü			â	ê	î	ô	û	§	‡
1	2	3	4	5	6	7	à	è	ì	ò	ù	‖	†
8	9	0	£	ç	H.S.	k	á	é	í	ó	ú	¶	*

Lower.

&	[	æ œ	' j		*Thin Sp.*	(?	!	;		fl
	b	c	d	e	i	s	f	g		ff / fi
ffi / ffl	l	m	n	h	o	y p	,	w	*en*	*em*
z / x	v	u	t	*Spaces.*	a	r	q / .	: / -	*Quadr.*	

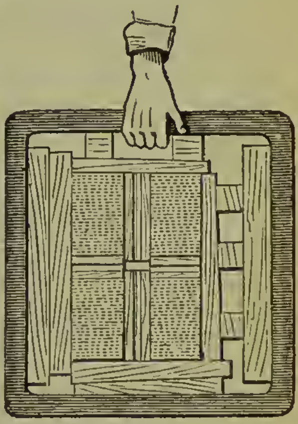
In *setting up* or *composing*, the compositor stands opposite to his cases; and, having received directions respecting the size of the type, the width of the page, the author's wishes as to punctuation, capitals, italics, &c., places his copy or MS. before him, on a spare part of the upper case, and holds in his left hand a small instrument called a *composing stick*, usually made of iron, with a movable slide, capable, by means of a screw, of being adjusted to the different widths required in miscellaneous printing, as seen in the illustration. With the right hand he picks up the types, and arranges them one by one in his composing stick. He does not look at the face, but only glances at the nick (*fig.* 1512, *e*), and takes it for granted that if it come from the

1513



right box it must be the right letter. He secures each letter with the thumb of the left hand, as the types are placed side by side in line from left to right; and, when he comes to the end of his line, and finds that he has a syllable or word which will not fill out the measure, he has to perform a task which requires considerable care and taste. This is called *justification*. The first and last letters must be at the extremities of the line; and there must not be wide spaces between some words and crowding in others, but the distances between them must be made as nearly as possible uniform by changing the *spaces* (or short blank types, not so high as the letters, and therefore giving no impression), and thus *getting in* or *driving out* part or whole of a word. The first line being thus justified, the compositor proceeds with the setting up of the next, and so on with a sufficient number of lines to fill his stick, and then lifts the *handful*, or mass of types, out of the stick, and places them upon a *galley*, or oblong tray of wood or metal, having an edge at the left side and top half an inch in height. This operation of filling and emptying the stick is repeated till the galley is sufficiently full, or the taking of copy is finished; when the *matter*, as it is then called, is taken away by the clicker, who divides it into the required lengths of pages, placing head-lines, signatures, &c., and binding them round tightly with cord. The clicker then *lays down* the pages in their proper positions on the *imposing stone*,—a flat, smooth slab of stone, or, better, of iron. The *chase*, a frame of iron, divided into compartments like the sashes of a window, is put round the pages, and the form *dressed* thus:—a set of *furniture*, consisting of slips of wood or metal, about half an inch in height, and of various thicknesses, is placed, some at the head, called *head-sticks*, some between the pages, called *gutters*, and others at the sides and feet, called *side* and *foot-sticks*. The side and foot-sticks are larger at one end than at the other, so that small wedges of wood, or *quoins*, may be driven tightly between them and the sides of the chase, locking up the types so firmly, that the *form*, as the mass is then called, may be carried from place to place with perfect safety. A form of eight pages of this Dictionary contains between 40,000 and 50,000 separate letters and spaces.

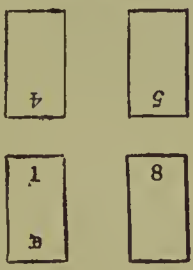
1514



The sizes of books are reckoned by the number of leaves into which a sheet of paper is folded. Thus the largest size is *broadside*, or the whole size of the sheet; *folio*, or half the sheet; *quarto*, or a sheet folded into four leaves; *octavo*, or the sheet folded into eight leaves; *duodecimo*, or the sheet folded into twelve leaves; and so on. In imposing, the pages are of course laid down in positions the reverse of those they will take when printed. The following tables show the mode of imposing some of the most common sizes:—

Sheet of Quarto.

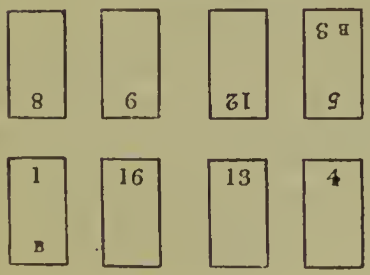
Outer Form.



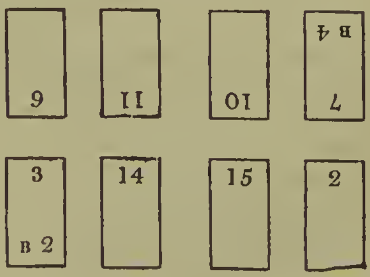
Inner Form.

Sheet of Octavo.

Outer Form.

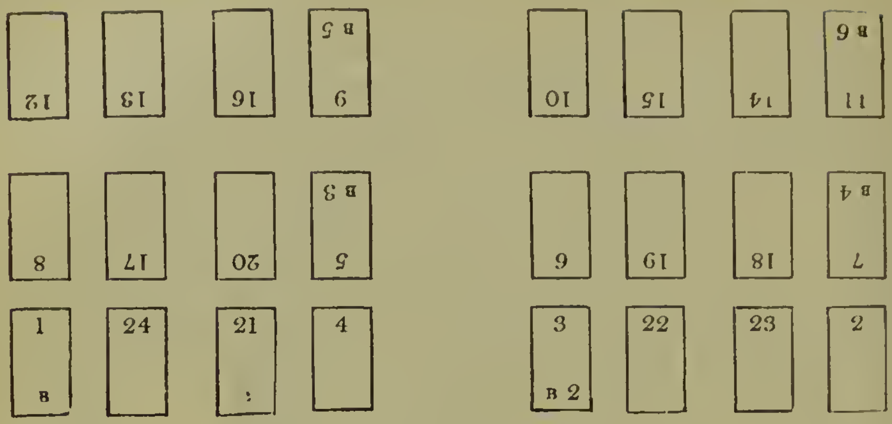


Inner Form.



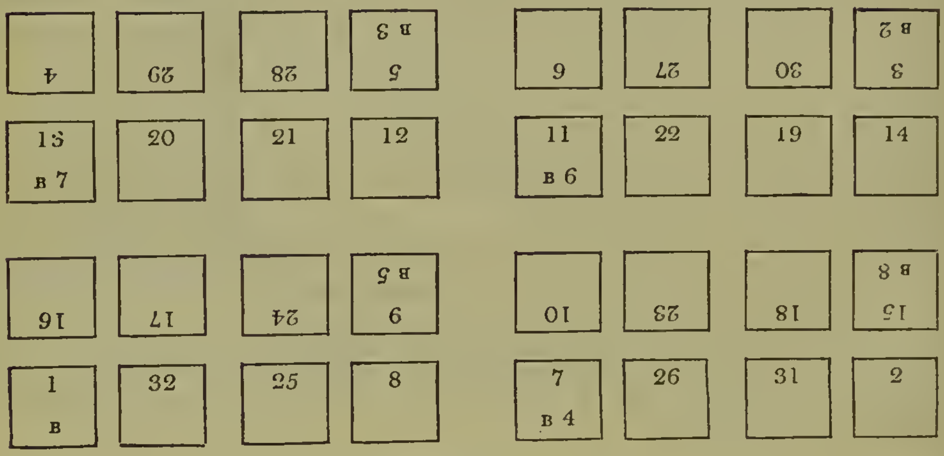
Sheet of Twelves.

Outer Form. Inner Form.



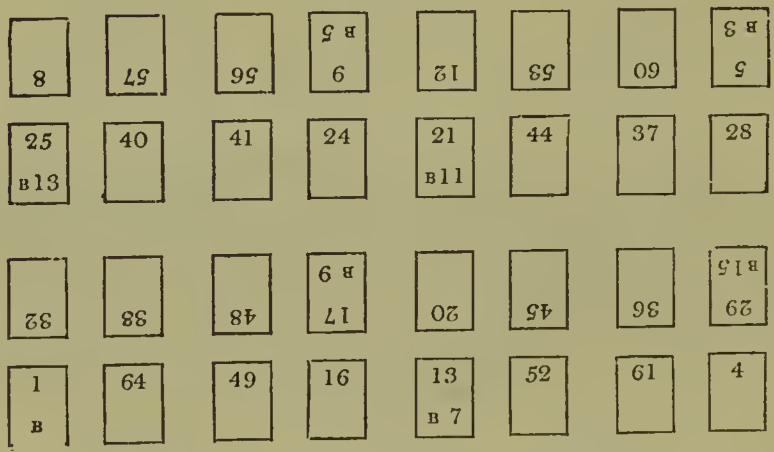
Sheet of Sixteen

Outer Form. Inner Form.



Sheet of Thirty-twos.

Outer Form.



(The inner form is the reverse of this.)

When this process of imposing is completed the form is carried to a press, and an impression is taken, called the *first proof*. This proof, with the MS., is handed to the corrector of the press, or *reader*, and a *reading boy* reads the copy to him while he examines the proof and marks the necessary corrections and errors of the compositor. In correcting a proof sheet a set of symbols are used for the purpose of calling the attention of the compositor to the several kinds of errors, and to direct him how they are to be amended. These marks are best shown by the following specimen of a corrected proof from Brande's "Dictionary," the explanation of each mark being given in the left-hand column:—

Where a word is to be changed from small let- to capitals, draw three lines under it, and write . in the margin.
Where there is a wrong letter draw the pen ugh that letter, and make the right one opposite ie margin.
A letter turned upside down.
The substitution of a comma for another point, or a letter put in by mistake.
The insertion of a hyphen.
To draw the letters of a word close together.
To take away a superfluous letter or word the is struck through it, and a round top *d* made oppo- being the contraction of *deleatur*, to expunge.
Where a word has to be changed to Italic draw ne under it, and write *Ital.* in the margin; and re a word has to be changed from Italic to Ro- ı, write *Rom.* opposite.
When words are to be transposed three ways of king them are shown; but they are not usually ibered except more than three words have their er changed.
). The transposition of letters in a word.]
. To change one word for another.
:. The substitution of a period or a colon for any er point. It is customary to encircle these two nts with a line.
3. The substitution of a capital for a small letter.
l. The insertion of a word, or a letter.
). When a paragraph commences where it is not nded. connect the matter by a line, and write in margin opposite *run on*.
. Where a space or a quadrat stands up and ap- -s, draw a line under it and make a strong per- dicular line in the margin.
When a letter of a different size to that used, or different face, appears in a word, draw a line er through it or under it, and write opposite *wf.*, wrong fount.
3. The marks for a paragraph, when its com- icement has been omitted.
). When one or more words have been struck and it is subsequently decided that they shall re- n, make dots under them, and write the word *stet* he margin.
). The mark for a space where it has been omitted veen two words.
. To change a word from small letters to small tals make two lines under the word, and write *caps.* opposite. To change a word from small tals to small letters make one line under the d, and write in the margin *lo. ca.* for lower case
:. The mark for the apostrophe; and also the ks for turned commas, which designate extracts.
3. The manner of marking an omission, or an in- ion, when it is too long to be written in the side gin. When this occurs it may be written either he top or the bottom of the page.
l. Marks when lines or words are not straight.
he subjoined specimen, when corrected, would be ollows:—

ANTIQUITY, like every other quality t attracts the notice of mankind, has un- ıbtedly votaries that *reverence* it, not from son, but from prejudice. Some seem to nire indiscriminately whatever has been g preserved, without considering that ie has sometimes co-operated with chance: perhaps are more willing to honour past n present excellence; and the mind con- ıplates genius through the shades of age, the eye surveys the sun through artificial ıcity. The great contention of criticism o find the faults of the moderns, and the ıuties of the ancients. While an author ret living, we estimate his powers by his rst performances; and when he is dead, rate them by his best.

To works, however, of which the excel- ce is not absolute and definite, but gradual l comparative; to works, not raised upon nciples demonstrative and scientifick, but ealing wholly to observation and experi- e, no other test can be applied than LENGTH luration and continuance of esteem.

Antiquity, like every other — 1 *caps*
quality that attr/cts the notice — 2 *a*
of /mankind, has undoubtedly — 3 *∂*
votaries that reverence it, not — 8 *Ital.*
from reason/ but from preju- — 4 *,/*
dice. some seem to admire — 17 *wf/*
in discriminately whatever has — 6
been long pr/served, without — 3 *∂*
considering that time has some‸ — 5 *H/*
times co-operated with chance:
all perhaps are more willing to
honour present than past ex- — 9 *trs*
cellence; and the ~~the~~ mind — 7 *∂*
contemplates gen/i/s through — 10 *iu/*
the shades of age, as the eye
~~views~~ the sun through artificial — 11 *surveys/*
opacity/ the great contention — 12 *⊙/* 12 *⊙/* 13 *T/*
of criticism is to find the faults
of the moderns,‸the beauties — 14 *and/*
of the ancients. — 15 *run on/*
While an aut/or is yet living, — 14 *h/*
we estimate his powers by his — 16
worst performances; and when
he is dead‸ To works, however, — 18 *Break, or New Par. or ¶*
of which the excellence is not
gradual but absolute and defi- — 9 *trs*
nite and comparative; to works, — 4 *,/*
raised not upon principles de- — 9 *trs*
/monstrative ~~and scientifick~~, but — 19 *stet* 24
a/pealing wholly to observa-
tio/ and experience, no other — 20 *tt*
tes/ can be applied than length — 21 *sm caps/*
of du/ation and continuance of
es/eem. — 22 *y/ y/ y/*

we rate them by his best./ 23

When the reader has read his proof it is handed to the compositor, who unlocks the form and makes the corrections in the types, by lifting out the wrong letters by means of a sharp awl, or *bodkin*, and putting in right ones in their places. The form is then locked up again, taken to the press, and another proof is *pulled.* This is termed *the revise*, and is sent to the reader, with his first proof, that he may see that all the corrections have been properly made, put queries against doubtful matters for the author's consideration, and send it, thenceforth called a *clean proof*, with the MS., to the author. When the author returns his proof and revise, and is satisfied that the sheet is correct, the form, after having been finally read with care for press, is taken to the press or machine to have the requisite number of impressions struck off. Before this is done, however, care is taken that the matter at the beginning of the sheet connects with that at the end of the preceding, that the pages are correct, and that the "signatures" are in order. The signatures are generally small capital letters placed at the foot of the first page of each sheet, commencing with B, and omitting the J, V, and W. They are said to have been first used by John Koelhof, at Cologne, in 1472; but they exist in an edition of *Terence*, printed by Antonio Zorat, at Milan, in 1470. There is a Venetian edition of "Baldi Lectura Super Codic," &c., printed by John de Colonia and Jo. Manthen de Gherretzem, in 1474, in which it is evident that these printers had only just become acquainted with the use of signatures, as these marks were not introduced till one-half of the work had been printed. The following tables show the signatures and folios of any given number of sheets, in 8vo, 12mo, and 18mo:—

Sheet of Octavo.

No. of Sheets.	Signature.	Folio.	No. of Sheets.	Signature.	Folio.	No. of Sheets.	Signature.	Folio.	No. of Sheets.	Signature.	Folio.
			23	2 A	353	46	3 A	721	69	4 A	1089
1	B	1	24	B	369	47	B	737	70	B	1105
2	C	17	25	C	385	48	C	753	71	C	1121
3	D	33	26	D	401	49	D	769	72	D	1137
4	E	49	27	E	417	50	E	785	73	E	1153
5	F	65	28	F	433	51	F	801	74	F	1169
6	G	81	29	G	449	52	G	817	75	G	1185
7	H	97	30	H	465	53	H	833	76	H	1201
8	I	113	31	I	481	54	I	849	77	I	1217
9	K	129	32	K	497	55	K	865	78	K	1233
10	L	145	33	L	513	56	L	881	79	L	1249
11	M	161	34	M	529	57	M	897	80	M	1265
12	N	177	35	N	545	58	N	913	81	N	1281
13	O	193	36	O	561	59	O	929	82	O	1297
14	P	209	37	P	577	60	P	945	83	P	1313
15	Q	225	38	Q	593	61	Q	961	84	Q	1329
16	R	241	39	R	609	62	R	977	85	R	1345
17	S	257	40	S	625	63	S	993	86	S	1361
18	T	273	41	T	641	64	T	1009	87	T	1377
19	U	289	42	U	657	65	U	1025	88	U	1393
20	X	305	43	X	673	66	X	1041	89	X	1409
21	Y	321	44	Y	689	67	Y	1057	90	Y	1425
22	Z	337	45	Z	705	68	Z	1073	91	Z	1441

Sheet of Twelves.

No. of Sheets.	Signature.	Folio.	No. of Sheets.	Signature.	Folio.	No. of Sheets.	Signature.	Folio.
			23	2 A	529	46	3 A	1081
1	B	1	24	B	553	47	B	1105
2	C	25	25	C	577	48	C	1129
3	D	49	26	D	601	49	D	1153
4	E	73	27	E	625	50	E	1177
5	F	97	28	F	649	51	F	1201
6	G	121	29	G	673	52	G	1225
7	H	145	30	H	697	53	H	1249
8	I	169	31	I	721	54	I	1273
9	K	193	32	K	745	55	K	1297
10	L	217	33	L	769	56	L	1321
11	M	241	34	M	793	57	M	1345
12	N	265	35	N	817	58	N	1369
13	O	289	36	O	841	59	O	1393
14	P	313	37	P	865	60	P	1417
15	Q	337	38	Q	889	61	Q	1441
16	R	361	39	R	913	62	R	1465
17	S	385	40	S	937	63	S	1489
18	T	409	41	T	961	64	T	1513
19	U	433	42	U	985	65	U	1537
20	X	457	43	X	1009	66	X	1561
21	Y	481	44	Y	1033	67	Y	1585
22	Z	505	45	Z	1057	68	Z	1609

Sheet of Eighteens.

No. of Sheets.	Signature.	Folio.	No. of Sheets.	Signature.	Folio.	No. of Sheets.	Signature.	Folio.
				2 A	265	16	3 A	541
1	B	1		B	277		B	553
	C	13	9	C	289		C	565
	D	25		D	301	17	D	577
2	E	37		E	313		E	589
	F	49	10	F	325		F	601
	G	61		G	337	18	G	613
3	H	73		H	349		H	625
	I	85	11	I	361		I	637
	K	97		K	373	19	K	649
4	L	109		L	385		L	661
	M	121	12	M	397		M	673
	N	133		N	409	20	N	685
5	O	145		O	421		O	697
	P	157	13	P	433		P	709
	Q	169		Q	445	21	Q	721
6	R	181		R	457		R	733
	S	193	14	S	469		S	745
	T	205		T	481	22	T	757
7	U	217		U	493		U	769
	X	229	15	X	505		X	781
	Y	241		Y	517	23	Y	793
8	Z	253		Z	529		Z	805

The paper used in printing is always damped before being sent to the press, wet paper taking the ink considerably better than dry. The warehouseman delivers the proper quantity of paper to the wetter, which is wetted thus :—The quire of paper is opened, its back broken, and divided into three, four, or five portions, or *dips*, drawn through a trough of clean water and laid on a board, dip after dip, till a convenient heap is made. This is put into a screw-press, a little pressure applied, and the next day the whole is *turned* and slightly pressed again, so that fresh surfaces of the paper coming into contact, the moisture is equally diffused throughout the heap. The paper used in printing is of three kinds: *imperfect paper*, consisting of 20 quires of 24 sheets, or 480 sheets to the ream; *perfect paper* (that most generally used) consisting of 21½ quires, or 516 sheets; and *news paper*, consisting of 20 quires of 25 sheets each to the ream, or 500 sheets. The *stamped sheets* of news paper (generally called *stamps*, and the plain paper *blanks*) are always received and delivered by the net number without allowing for spoilage in the press work; but in book work it is the practice to allow 16 sheets in each ream for "tympan sheet" and spoiled sheets. The following table shows the quantity of perfect and imperfect paper required for one sheet of 16 pages of a work like "Ure's Dictionary," from 12 to 10,000 copies:—

Quantity required of *perfect* paper.			Quantity required of *imperfect* paper.			For printing 1 sheet of 16 pages.	Total number of copies the paper will make.
Rms.	quires.	sheets.	Rms.	quires.	sheets.		
0	0	15	0	0	15	12 copies	15
0	1	4	0	1	4	25 „	28
0	2	6	0	2	6	50 „	54
0	3	7	0	3	7	75 „	79
0	4	8	0	4	8	100 „	104
0	5	9	0	5	9	125 „	129
0	6.	12	0	6	12	150 „	156
0	7	13	0	7	13	175 „	181
0	8	14	0	8	14	200 „	206
0	10	18	0	10	18	250 „	258
0	12	22	0	12	22	300 „	310
0	15	0	0	15	0	350 „	360
0	16	3	0	16	3	375 „	387
0	17	4	0	17	4	400 „	412
0	19	6	0	19	6	450 „	462
1	0	0	1	1	12	500 „	516
1	4	6	1	5	18	600 „	618
1	8	14	1	10	2	700 „	722
1	10	18	1	12	6	750 „	774
1	13	0	1	14	10	800 „	826
1	17	4	1	18	17	900 „	928
2	0	0	2	3	0	1000 „	1032
2	10	18	2	13	18	1250 „	1290
3	0	0	3	4	12	1500 „	1548
3	18	18	3	15	6	1750 „	1806
4	0	0	4	6	0	2000 „	2064
6	0	0	6	9	0	3000 „	3096
8	0	0	8	12	0	4000 „	4128
10	0	0	10	15	0	5000 „	5160
12	0	0	12	18	0	6000 „	6192
14	0	0	15	1	0	7000 „	7224
16	0	0	17	4	0	8000 „	8256
18	0	0	19	7	0	9000 „	9288
20	0	0	21	10	0	10,000 „	10,320

Presswork.—The pressman first lays the inner form on the press, and prints one copy, which is called a *press revise;* this he takes to the person appointed to revise it, and while that is being done proceeds to secure the form on the table of the press by means of quoins; to place his tympan sheet; to fix the points which make small holes in the paper that enable him to cause the pages to fall precisely on the back of each other when the second side of the paper is printed, and to produce an even and uniform impression in all the pages. He then cuts his frisket, which preserves the margin of the paper clean, and, when the revise is corrected, proceeds to ink the surface of the types by means of rollers. When the whole impression of one side of the paper is printed, he lifts the form off the press, washes the ink off the face of the type with lye, and rinses it with water. He then proceeds in a similar manner with the outer form, which completes the sheet. This process is continued sheet after sheet till the work is complete.

When the sheet is printed the compositor lays it up, distributes the type, and proceeds, sheet after sheet, till the body of the work is finished; then the title, dedication, preface, introduction, contents, and any other prefatory matter is proceeded with, these being always printed the last. This distribution of the types, or putting back the letters into the several compartments of the case where they belong, is performed with the greatest rapidity. The compositor wets the whole page or form, and takes up a number of lines on his composing rule. This wetting causes the types to adhere slightly together, and renders the manipulation easy. He then takes up a few words between his right hand finger and thumb, and by a dexterous motion he throws off the several letters into their various boxes. Distribution is performed four times faster than composition.

After the sheets have been printed on both sides, the warehouseman takes them away, and hangs them up on poles to dry, varying the number of sheets hung up together from five or six to ten or eleven, according to the heat of the room, or the pressure of business. When dry the sheets are taken down from the poles, carefully knocked up, and put away in the warehouse in piles; and when the book is nearly finished from ten to fourteen consecutive sheets are laid upon the gathering board in order, and collected sheet by sheet by boys, who deposit each *gathering* in a heap at the end of the table, so constructed that when a boy has deposited his gathering he has only to turn himself and begin again. These gatherings are then carefully *collated*, to ascertain that the different sheets are correct and in order, and folded up the middle. When the work is finished the gatherings are put together, or *in books*, one of each, which forms a copy of the work, and pressed. The work is now completed, and awaits the order of the bookseller, &c., to deliver the copies to the bookbinder.

Printing in colours. — In many of the old printed books, the initial letters, and occasionally other parts, were printed in red. This was done by two workings at press, and was an imitation of the earlier fashion of illuminating MSS. The practice is still followed in some almanacs, the saints' days and holidays being "red-letter days." Some ingenious contrivances have been devised for working in various colours; and a few years since a curious book was written and published on the subject by Mr. Savage. Still more recently, printing in gold and other metals has been practised. This is done by printing with a sort of size, and afterwards applying the metal leaf. But the specimens of printing in colours produced by Mr. Kronheim are really beautiful as works of art. The copy picture is made in colours, and the blocks for printing each colour and shade are cut in relief on "surface-metal" plates, consisting of perfectly smooth plates of type metal. These plates are then printed by the ordinary method, great care, however, being taken that each colour falls in its right place.

The following is the mode of printing two or more "rainbow tints" at the same time: — Take the cut, ink it well and rather full, with black ink, and get a perfect impression on paper not very damp; then lay the face of the printed paper carefully on the surface of the block prepared for engraving the whites on the tinted ground, and give it a good soft pull. This will transfer to the tint block a facsimile of the wood-engraving itself. This block is then handed over to the engraver, who cuts out the whites for the clouds, shadows, water, &c., according to his taste, and with a view to effect. The tint-block is printed first, and then the black block is put to press, and the pressman must be careful in distributing his different inks to make them fade away and blend at the given points. This is an easy matter after a little practice.

Laws affecting the Press. — As to the laws relating to the press, see 39 Geo. III. c. 79, amended by 51 Geo. III. c. 65, and 2 & 3 Vict. c. 12. There is no censorship over the press, which is, however, amenable to the remedy of an injured party, or to the correction of criminal justice (*Wharton's Law Lex.* 2nd ed. 1860).—R. J. C.

PRINTING BLOCKS—ELECTRO. While this book has been passing through the press, Mr. H. G. Collins has taken out two patents, which are likely to prove of essential service to the publishing world. By the one he is enabled to take on vulcanised caoutchouc, prepared with an equally elastic surface, an impression in transfer from any steel or copper plate, wood block, stereotype, lithographic stone, or, in fact, from an original drawing, if done in transfer ink on transfer paper, and increase or reduce the same to any required size. This is effected by expanding the Indian rubber in one case, after it has received the impression; and in the other, before the impression is made. In the first instance the impression is enlarged as the elastic material expands, in the other it is reduced by allowing the already expanded Indian rubber to contract in its frame; then laying the expanded or contracted copy down upon stone, and treating it after the usual manner of lithography. This presents a vast field for adapting the plates of any work of acknowledged merit which may have cost some hundreds or thousands of pounds, and years to produce, to the wants of the public in these days of cheap and well illustrated literature, by bringing out the same works in a reduced size, which, but for this plan, no publisher would think of attempting. Many plates, also, such as portraits, public buildings, or landscapes, may be enlarged and issued separately. This last application is particularly suitable for maps, as any one, from the size of a school atlas, may be taken and made to serve for large wall maps without the cost of engraving the same. The rapidity with which this alteration of size can be accomplished is not among the least of its recommendations; for an engraving that would take several months in the ordinary mode may be completed in from two to three days.

This patent offers the same facilities to a vast number of the manufactures of the country, such as the lace trade, cotton printers, damask and moreen houses, potteries, paper-hangings; in fact, to all and every one who employ *art* or *design* in their calling. It will be well to observe that the size cannot only be enlarged or diminished, as the case may be, but the pattern can be altered in form; thus a circular design can be made into an oval, if required. Mr. Collins, by his second patent, is enabled, after these impressions are once upon the stone, to make them into electro blocks, thus reducing also the cost of printing engraved plates, which is effected in the following manner:—The impression being placed on the lithographic stone or the zinc plate—either one or the other can be employed—acid is applied to abrase to a certain extent the stone or metal over the unprotected portions; when this is sufficiently deep a mould is taken in wax, the surface of which being prepared is subjected to the electrotype process, and thus a copper block is obtained.

Mr. C. has also a provisional specification for a third patent, by which he can by the assistance of photography, produce blocks for surface printing (without the aid of the engraver) in the course of a few hours. The whole of these patents are being brought into practical operation by the "Electro Printing-block Company." See Photozincography.

PRINTING INK. (*Encre d'imprimerie*, Fr.; *Buchdrückerfarbe*, 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 Enclycopædia 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 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.

3. *Soap.*—This is a most important ingredient in 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 propor-

* In his work on the Preparation of Printing Ink; 8vo, London, 1832.

tion, takes off the brown tone 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*, 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.

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 a spatula. The pot is to be now set upon the fire again, in order to complete the combination of all the constituents.

Put next of well-ground indigo and prussian blue, each $2\frac{1}{2}$ ounces, into an earthen pan, sufficiently large to hold all the ink, along with 4 pounds of the best mineral lamp black, and $3\frac{1}{2}$ 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.

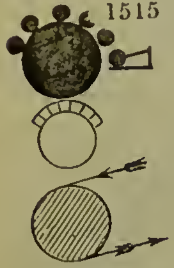
One pound of a superfine printing ink may be made by the following recipe of Mr. Savage:—Balsam of capivi, 9 oz.; lamp black, 3 oz.; indigo and prussian blue together, p. æq. $1\frac{1}{4}$ oz.; Indian red, $\frac{3}{4}$ oz.; turpentine (yellow) soap, dry, 3 oz. This mixture is to be ground upon a slab, with a muller, to an impalpable smoothness. The pigments used for colouring 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, umber, sepia, &c.

PRINTING MACHINE. (*Typographie mécanique*, Fr.; *Druckmaschine*, Germ.) No improvement had been introduced in these important machines, from the invention of the art of printing, 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.

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; nor does it much exceed the old presses in productiveness, since it can turn off only 250 impressions per hour; but it is capable of producing much finer presswork than any steam or hand machine yet invented, for this reason:—the best work requires the best ink, which is stiff, and requires a longer time in distributing over and beating into the form of types than the thin, oily, and consequently browner ink required by the rapidly moving machine. It is a remarkable fact that the *Penny Magazine* was printed at the hand press, although the editor assured his readers that the cylindrical form of machine was capable of printing the finest impressions from woodcuts. The machine, however, has the advantage of uniformity of colour in inking throughout a whole impression. The iron platen of the Stanhope press was supposed at one time to wear out types much sooner than the old wooden one, but experience does not warrant us in supporting this statement.

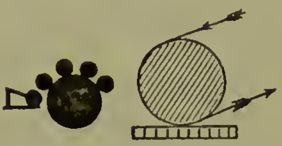
The first person who publicly projected a self-acting printing-press, was Mr. William Nicholson, the able editor of the *Philosophical Journal*, who obtained a patent in 1790, 1, for imposing types upon a cylindrical surface (see *fig.* 1515); 2, for applying the ink upon the surface of the types, &c., 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 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.* 1515, and 1516.*

1515



Nicholson's for arched type.

1516



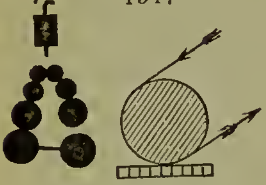
Nicholson's for common type.

The first operative printing machine was undoubtedly contrived by, and constructed under the direction of, M. König, a clock-maker 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 and Mr. G. Woodfall, well known printers, and to Mr. R. Taylor, late one of the editors of the *Philosophical Magazine*.

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 steam power, and 3000 copies of signature H of the *New Annual Register* were printed by it; 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 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 equalising rollers terminated in two which applied the ink to the types. (See *fig.* 1517.) 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.

1517

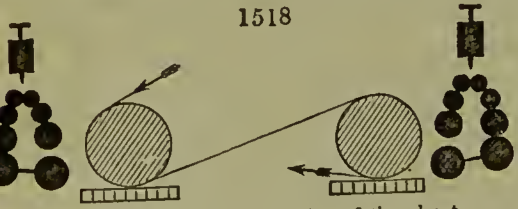


König's single, for one side of the sheet.

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 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, ∽; 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.* 1518.

1518



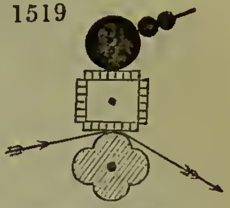
König's double, for both sides of the sheet.

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

* The black parts in these little diagrams, 1515, 1516, 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.

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.* 1519.) 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.

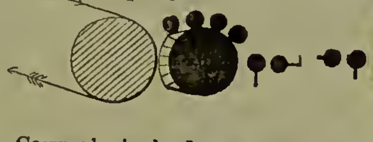
1519



Donkin and Bacon's for type.

In the year 1815, Mr. Cowper turned his mind to the subject of printing machines, and 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. See *figs.* 1520, and 1521. 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 axles 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.

1520



Cowper's single, for curved stereotype.

1521

Cowper's double, for both sides of the sheet.

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.

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.

1522

Cowper's inking table and roller.

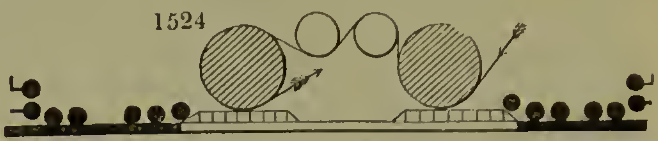
The distinctive advantages of these machines, and which have not hitherto been equalled, are the uniform distribution of the ink, the equality as well as delicacy with which it is laid upon the types, the diminution in its expenditure, amounting to one half upon a given quantity of letterpress, and the facility with which the whole mechanism is managed. The hand 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. See *fig.* 1522.

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 first, is a very difficult problem, which was practically solved by Messrs. Applegath and

1523

Applegath and Cowper's single.

1524

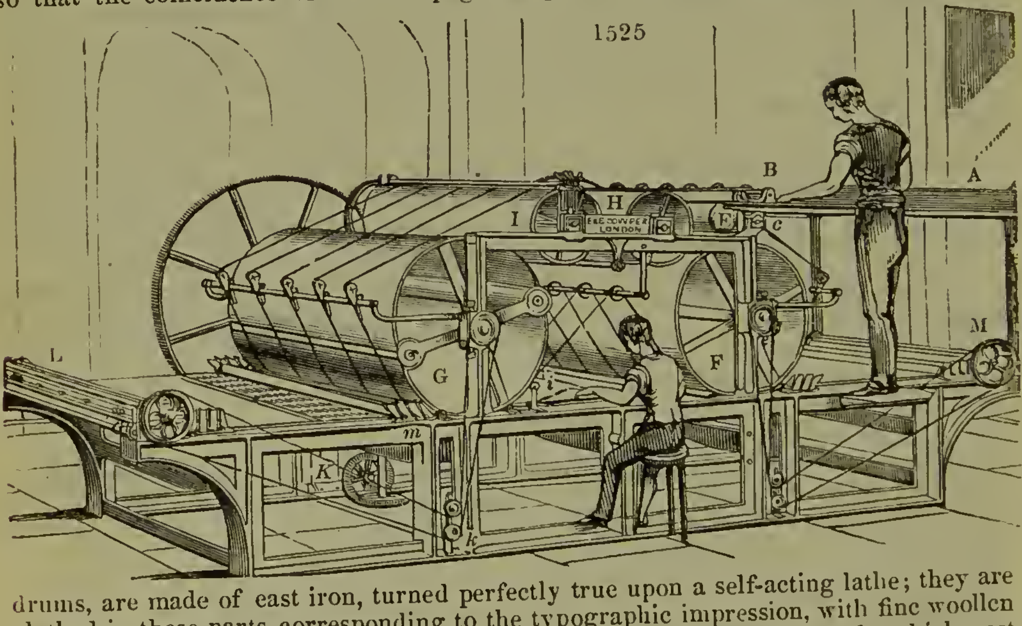


Applegath and Cowper's double.

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 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 with 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 letterpress. See *figs.* 1523, 1524.

The machines represented in *figs.* 1525, 1526, 1527, are different forms of those which have been patented by Messrs. Applegath and Cowper. That shown in *figs.* 1525, 1527, 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 E, 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

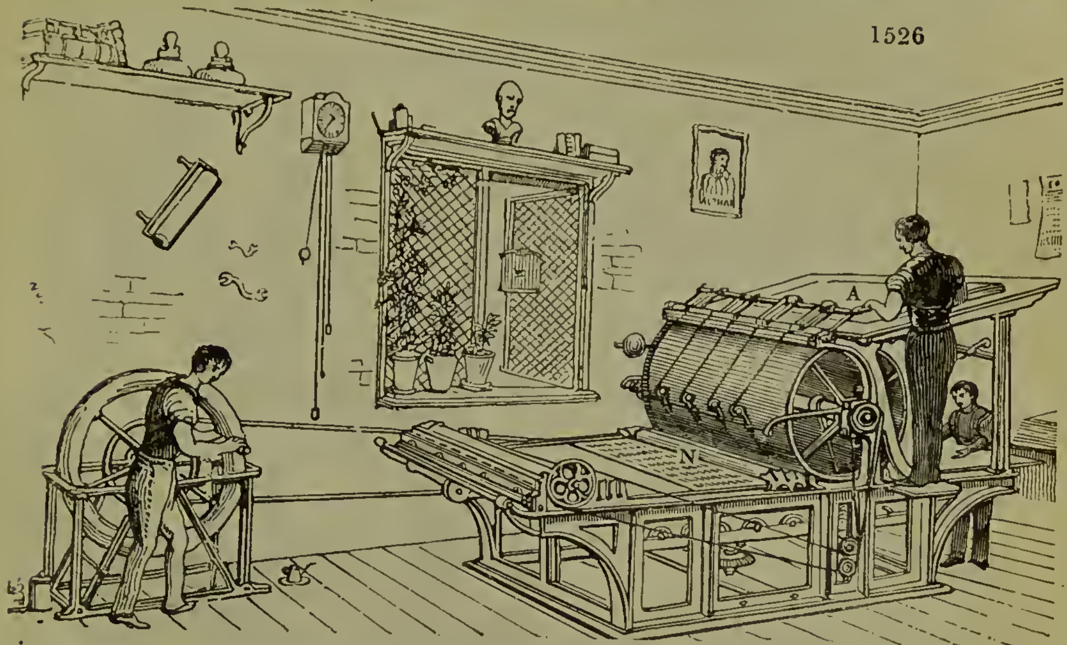
1525



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 next over the carrier-drum H, and under the carrier-drum I; then encompassing the left-hand side and under portion of the printing drum G, it passes

1526

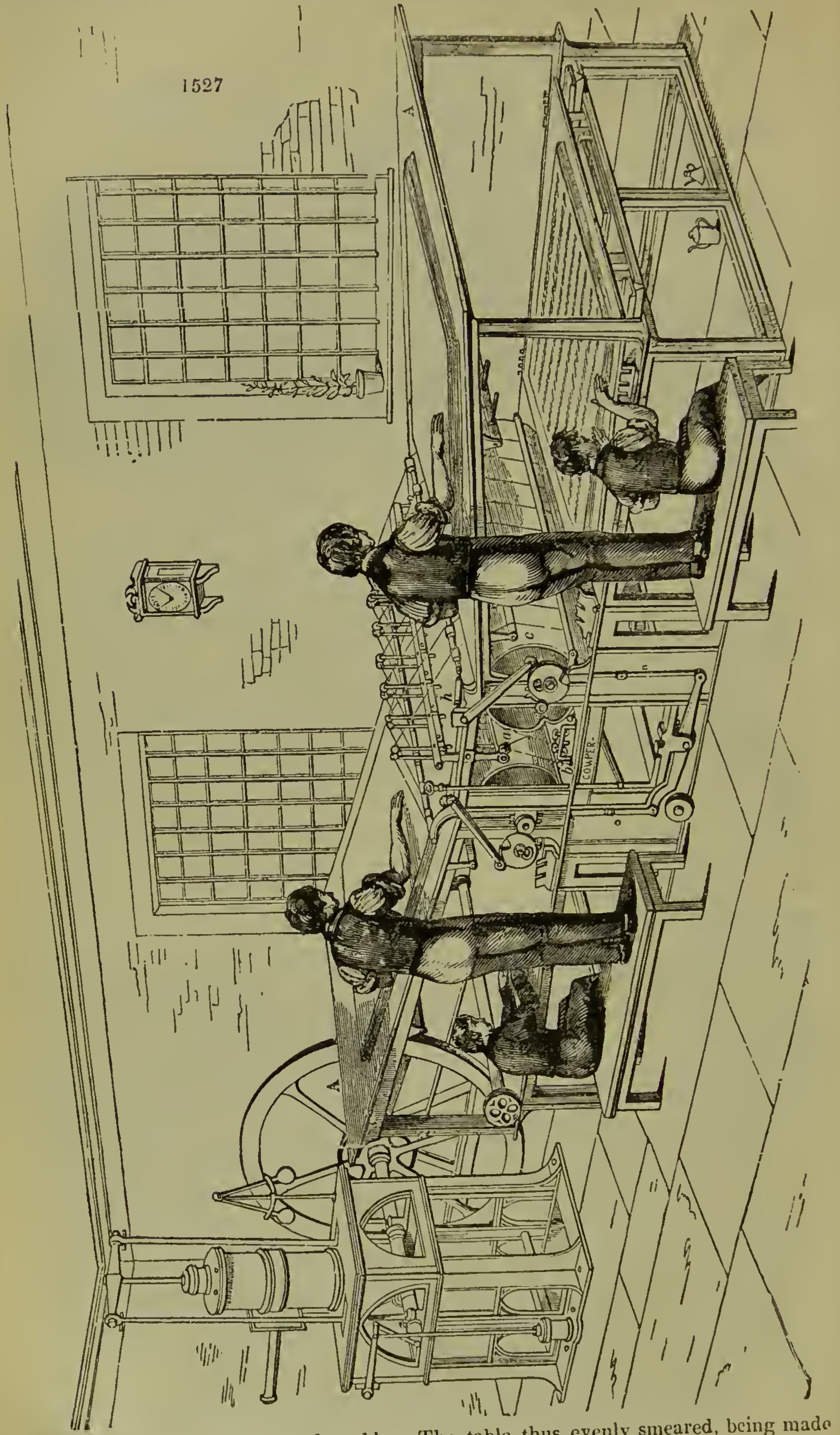


in contact with the small tension rollers *a, b, c, d, fig.* 1527, and finally arrives at the roller E, which may be called the commencement of the one series of endless tapes. The other series may be supposed to commence at the roller *h;* it has an equal number of tapes, and corresponds with the former 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.* 1527, to the entering drum E, where it meets and coincides with the first series in such a way that both sets of tapes proceed together *under* the printing cylinder F, *over* H, *under* I, and *round* G, until they arrive at the roller *i, fig.*1525, 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.

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 K.

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 L, 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 G. 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 two 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 perfect

1527



distribution of the ink along the table. The table thus evenly smeared, being made to pass under the 3 or 4 proper inking rollers N, *fig.* 1526, 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.

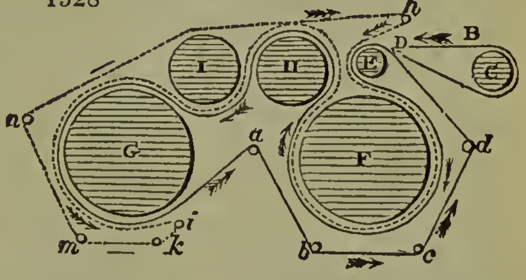
Motion is given to the whole sytem of apparatus by a strap from a steam engine going round a pulley placed at the end of the axle at the back of the frame.

The operation of printing is performed as follows :—See *fig.* 1527.

The sheets being carefully laid, one by one, upon the linen girths, at the feeder B, 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 E. 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 F, 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 H and under I, to the blanket upon the printing cylinder G, 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.

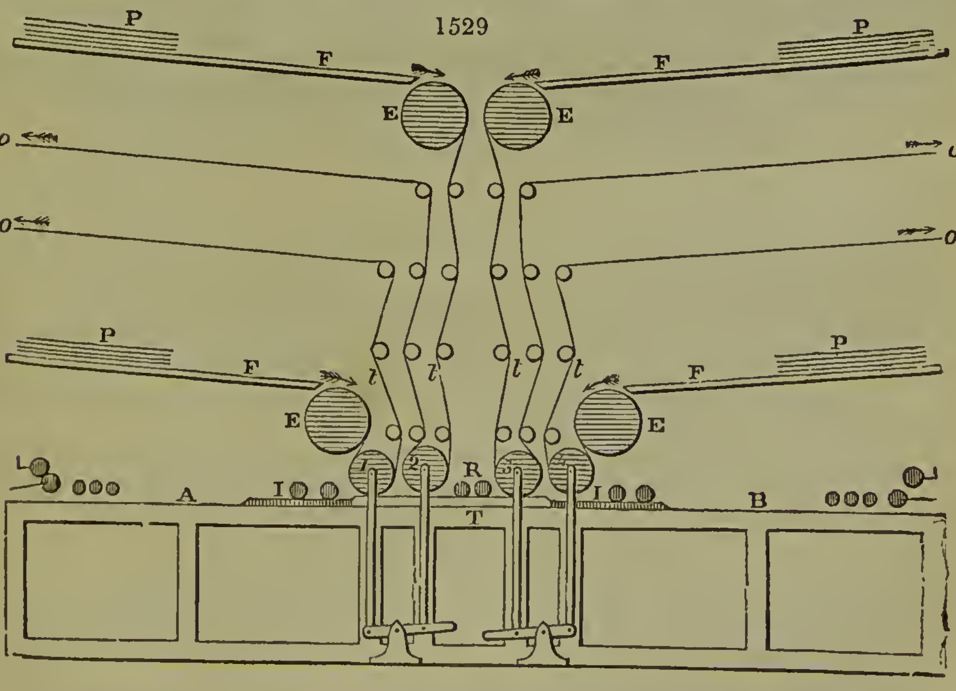
The diagram, *fig.* 1528, shows the arrangement of the tapes, agreeably to the preceding description; the feeder B, with the rollers C and D, is seen to have an independent endless girth.

1528



The diagram, *fig.* 1529, explains the structure of a machine contrived by Messrs. Applegath and Cowper for printing *The Times* newspaper; but which is now superseded by Mr. Applegath's Vertical Printing Machine. 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 piles of paper; F, F, F, F, are the four feeding-boards; E, E, E, E, are

1529



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 ; T is the form of type ; I, I, 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 R, 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 A to B, prints sheets at 1 and 3; in returning from B to A, 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 E, 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 invention fully answered the purpose of *The Times* until the immense demand upon its powers rendered it necessary to provide a machine which could *work off from* 12,000 *to* 15,000 *copies of the paper per hour.*

Mr. Applegath, to whom the world is indebted for the invention of the printing machine capable of doing this large duty, 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.* 1530, where D is the great central drum which carries the type and inking tables.

This drum is surrounded by eight cylinders, R, R, &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 reservoirs 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 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, *h*, *h*, &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 down-

1530

wards 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 spoiled, 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.

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.

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 spoiled. The waste, however, 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.

An American machine, the invention of R. Hoe and Company, of New York, has within the last two years (1860) been introduced to this country. Machines of this description have been made for *The Times*, and other newspaper offices, by Mr. Whitworth of Manchester. The following is Mr. Hoe's description of this machine.

A horizontal cylinder of about 4½ feet in diameter is mounted on a shaft, with appropriate bearings; about one-fourth of the circumference of this cylinder constitutes the bed of the press, which is adapted to receive the form of types—the remainder is used as a cylindrical distributing table. The diameter of the cylinder is less than that of the form of types, in order that the distributing portion of it may pass the impression cylinders without touching. The ink is contained in a fountain placed beneath the large cylinder, from which it is taken by a ductor roller, and transferred by a vibrating distributing roller to the cylindrical distribution table; the fountain roller receives a slow and continuous rotary motion, to carry up the ink from the fountain.

The large cylinder being put in motion, the form of types thereon is, in succession, carried to eight corresponding horizontal impression cylinders, arranged at proper distances around it, which give the impression of eight sheets, introducing one at each impression cylinder. For each impression cylinder there are two inked rollers, which vibrate on the distributing surface while taking a supply of ink, and at the proper time pass over the form, when they again fall to the distributing surface. Each page is locked up upon a detached segment of the large cylinder, called by the compositors a "turtle," and this constitutes the bed and chase. The column rules run parallel with the shafts of the cylinder, so as to bind to types near the top. These wedge-shaped column rules are held down to the bed or "turtle" by tongues, projecting at intervals along their length, and sliding in rebated grooves cut cross-wise in the face of the bed; the space in the grooves between the column rules being filled with sliding blocks of metal, accurately fitted, the outer surface level with the surface of the bed, the ends next the column rules being cut away underneath to receive a projection on the sides of the tongues and screws at the end and side of each page to lock them together, the types are as secure on this cylinder as they can be on the old flat bed.

In *The Times* office there are two of those machines, one of them being a ten-cylinder machine, which is regularly employed to print 16,000 sheets an hour, and it appears capable of printing 18,000. It is only by means of these two American machines, and two of Applegath's, all working on the different sides of the paper, that the enormous supply required every morning can be produced.

The first successful application of steam, as a motive power, to printing presses with a platen and vertical pressure, was made in the office where this book is being printed. Convinced of the superiority of the impression made by flat as compared with that of cylindrical pressure, Mr. Andrew Spottiswoode, assisted by his chief engineer, Mr. Brown, succeeded, after many experiments, in perfecting a machine which combines the excellence of the hand press with more than four times its speed, and a uniformity in colour which can never be attained by inking by hand. The main point of the invention is the endless screw or drum which takes the carriage and type under the platen, and after the impression is taken returns it to its original position.

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. 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 is removed, and great speed is attained in manufacturing the tickets, as the several operations are simultaneously performed. Pasteboard cut into strips by means of rollers 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 has been introduced 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.

M. Baranowski, of Paris, invented 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.

PRINTING, NATURE. See NATURE PRINTING.

PRINTING ROLLERS. Elastic inking rollers were introduced by Messrs. Donkin and Bacon. They are made of a mixture of glue and treacle, or of glue and honey; the American honey, it is said, being preferred. 1 pound of good glue is softened by soaking in cold water for twelve hours, and then it is united, by means of heat, with about 2 pounds of ordinary treacle. See PRINTING.

Messrs. Hoe and Co. give the following directions for making and preserving composition rollers:—For *cylinder-press rollers*, Cooper's No. 1. × glue is sufficient for ordinary purposes, and will be found to make as durable rollers as higher priced glues.

Place the glue in a bucket or pan, and cover it with water; let it stand half an hour, or until about half penetrated with water (care should be used not to let it soak too long), then pour it off, and let it remain until it is soft. Put it in the kettle and cook it until it is thoroughly melted. If too thick, add a little water until it becomes of proper consistency. The molasses may then be added, and well mixed with the glue by frequent stirring. When properly prepared, the composition does not require boiling more than an hour. Too much boiling candies the molasses, and the roller consequently will be found to lose its suction much sooner. In proportioning the material, much depends upon the weather and temperature of the place in which the rollers are to be used. 8 pounds of glue to 1 gallon of sugar-house molasses, or syrup, is a very good proportion for summer, and 4 pounds of glue to 1 gallon of molasses for winter use.

Hand-press rollers may be made of Cooper's No. $1\frac{1}{4}$ (one and a quarter) glue, using more molasses, as they are not subject to so much hard usage as *cylinder-press rollers*, and do not require to be as strong; for the more molasses that can be used the better is the roller. Before pouring a roller, the mould should be perfectly clean, and well oiled with a swab, but not to excess.

Rollers should not be washed immediately after use, but should be put away with the ink on them, as it protects the surface from the action of the air. When washed and exposed to the atmosphere for any length of time, they become dry and skinny. They should be washed about half an hour before using them. In cleaning a *new* roller, a little oil rubbed over it will loosen the ink, and it should be scraped clean with the back of a case knife. It should be cleaned in this way for about one week, when *lye* may be used. New rollers are often spoiled by washing them too soon with lye. Camphene may be substituted for oil; but owing to its combustible nature it is objectionable, as accidents may arise from its use.

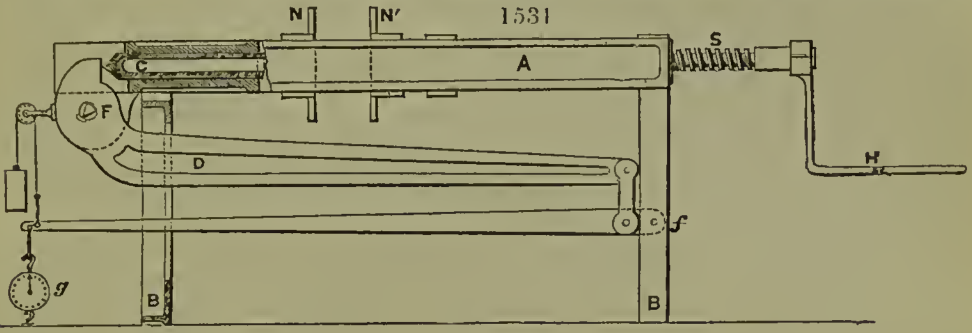
PROPYLENE. A gas obtained among the products of the decomposition of amylic alcohol. See COAL GAS.

PROTEINE. The name given to a somewhat hypothetical substance obtained by digesting albuminous matters in weak caustic potash, and precipitating by acetic acid. E. Millon (*Comptes Rendus*) proposes as a test for the so-called protein compounds, that a solution of mercury in an equal weight of concentrated nitric acid, when diluted with some water, be added to a solution of the animal matter in an alkali or sulphuric acid. When the mercurial solution is added in solutions containing only $\frac{1}{100,000}$ of nitrogenous matter, a more or less intense red colour is produced.

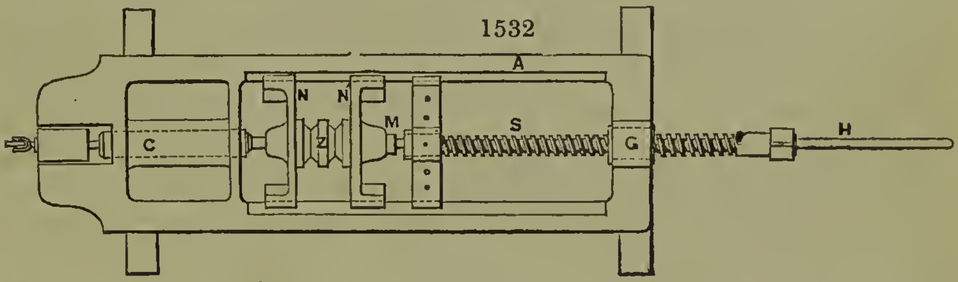
PROTOGINE (*protos*, first — *ginomai*, formed). A granite composed of felspar, quartz, and talc. This term is nearly restricted to the French geologists.

PROVING MACHINE. The drawing shows a useful machine for testing the quality and power of India-rubber springs, designed by Mr. George Spencer, of the firm of Geo. Spencer and Co., and used by them for that purpose, and referred to from CAOUTCHOUC. *Fig.* 1531 shows an elevation, partly in section, of the machine; *fig.*

1531



1532



1532 a plan of the same. A is a strong cast-iron frame, supported by two cast-iron standards, B; C is a sliding piston, working in a hole cast in the end of frame A, one end of which impinges against the short arm of a strong cast-iron lever, D, forming one of a system of compound levers as shown, having fulcrums at F and *f*, and provided with a Salter's balance, *g*, to register the power exerted by the spring.

At the other end of frame, A, a brass nut, G, is placed in a hole in the frame, through which a square-threaded screw, S, works by means of the handle, H, or by a long lever of wrought iron, according to the power of spring to be tested.

The spring to be tested is placed between the two sliding guide plates, N, N′, and a wrought-iron bolt passed through the plates, N, N′, and spring, Z, and passing into the hollow piston, C, for the purpose of keeping the spring in correct position, and receiving in its hollow head, M, the end of the screw, S. The action may be thus described:—The handle, H, being turned, the screw, S, advances and pushes on the plate, N′, by means of the bolt-head, M. The other plate, N, rests against the piston, C, and is pressed against it by the intervening spring, Z. The leverage, D, is so arranged that 1 lb. on the dial is equal to 2 cwt. on the spring, or, in other words, is 1 in 224. Springs of a force of 20 tons can be tested by this machine safely. (See CAOUTCHOUC.)

PROVISIONS, CURING OF. See MEATS, PRESERVED; PUTREFACTION.

PRUSSIAN BLUE. (*Berliner-blau*, Germ.) This is a chemical compound of iron and cyanogen. See CYANOGEN. When organic matters abounding in nitrogen, such as dried blood, horns, hair, skins, or hoofs of animals, are triturated along with potash in a strongly ignited iron pot, a dark grey mass is obtained, that affords to water the liquor originally called *lixivium sanguinis*, or blood lye. This solution yields crystals, known in commerce as the prussiate of potash. (See POTASH, PRUSSIATE.) If to this salt solutions of iron be added, prussian blue is formed. If the iron be but partially oxidised in the salt employed, it will afford a precipitate, at first pale blue, which turns dark blue in the air. If, however, the salt employed contains fully oxidised iron (peroxide of iron) the precipitate is at once a dark blue. 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 disoxidising reagents. When prussian blue is digested in warm water along with potash, soda, or lime, peroxide of iron is separated, and a ferroprussiate 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 ferrocyanodide 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-cyanodide, improperly called prussiate of mercury; consisting of 79·33 mercury, and 20·67 cyanogen; or upon the hydrogen equivalent scale, of 200 mercury, and $52 = (26 \times 2)$.

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 ferroprussiate, 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 uncrystallised 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 pearlash 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 skilfully conducted, will produce more of the cyanides of iron, and require more copperas to neutralise 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 grey, 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 liqour 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 siphon; more water is run on with agitation to wash it, which after settling is again drawn of; 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 ferroprussiate 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.

A process for prussian blue, which deserves notice, as the first in which that interesting compound has been made to any extent independently of animal matter, was introduced by Mr. Lewis Thompson, who received a medal from the Society of Arts, in 1837, for this invention. He 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 carbou and potash. He found the following to answer. Take of pearlash and coke, each 2 parts; iron turnings, 1 part; grind them together into a coarse powder; place this in an open crucible, and expose the whole for half au 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 nsual 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.

PRUSSIAN BROWN. A fine deep brown colour obtained by adding the yellow prussiate of potash (*ferroprussiate*) to a solution of sulphate of copper.

PRUSSIATE OF POTASH. See Potash, Prussiate of.

PRUSSIC ACID. See Hydrocyanic Acid.

PSILOMELANE. An ore of Manganese, which see.

PUDDLING OF IRON. The process of converting cast iron into bar or malleable iron. See Iron.

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 aud most metals. Its colour is usually greyish 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 skius and parchment. Pumice-stone is usually reckoned to be a volcanic product, resulting, probably, from the action of fire upon obsidians. The chief localities of this mineral are, the Islands of Lipari, Ponza, 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.

PUMPING MACHINERY. See Water Pressure Engines.

PUOZZOLANA is a volcanic gravelly product, used in making hydraulic mortar. See Cements and Mortars.

PURBECK MARBLE. A hard bluish-grey limestone, so called from its being found in the Isle of Purbeck, where it occurs in the upper beds of the formation of that name. Like the Sussex marble, it is susceptible of a fine polish, and is crowded with the remains of a species of freshwater snail (*Paludina carinifera*), and the beauty of the marble is the result of the pattern produced by the sections of the included shells. These latter are of a much smaller species than those which occur in the Sussex marble, and the difference in the size of the shells affords an easy means of distinguishing between the two marbles.

Many old sepulchral mouuments are partly composed of Purbeck marble, as are also the slender shafts and columns of many of the Gothic churches of this country, of which there are examples in the Temple Church in London, Westminster Abbey, Winchester and Salisbury Cathedrals, &c.

Fine blocks of this marble are still quarried in the Isle of Purbeck, but, except for ecclesiastical purposes, it is little used, in consequence probably of its inferiority to other marbles with regard to colour.—H. W. B.

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 proper pigment can be obtained only by adding to a neutral chloride of gold a mixture of the protochloride and perchloride of tin. Everything 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 crystallised protochloride of tin, with 2 parts of crystallised perchloride, produces with one part of crystallised 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 three 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 3½ 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 be edulcorated 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 36 to 10.

Gold-purple becomes brighter when it is dry, but appears still as a dirty-brown powder. Hydrochloric 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 ditto - - -	20·58	79·42
Berzelius - - - - - - -	30·725	69·275
Buisson - - - - - - - -	30·19	69·81
Gay-Lussac - - - - - - -	30·89	69·11
Fuchs - - - - - - - - -	17·87	82·13

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. A viscid fluid, secreted by the *Buccinum lappillus*, and some other shell-fish. The Tyrian dye of the Greeks, and Imperial Purple of the Romans, was in all probability obtained from the same source, — the mollusca of the Mediterranean Sea. See MUREXIDE.

PURPLE DYES. The purple dyes now obtained by more or less complex processes from coal tar, are so incomparably superior to any others, both in brilliancy and permanence, that their production has opened up a new era in dyeing and calico-printing. The process of Mr. Perkin, the discoverer of aniline purple, is simple in principle, but the operations, from the production of the coal tar to the formation of the pure purple, are so numerous, and require to be conducted on such a large scale, that the successful manufacture involves the necessity for large capital and considerable chemical skill. Mr. Perkin's process involves the following operations:—

1. Production of benzole from coal tar by fractional distillation.
2. Conversion of benzole into nitro-benzole by the action of nitric acid.

3. Conversion of nitro-benzole into aniline.
4. Production of neutral sulphate of aniline.
5. Decomposition of sulphate of aniline by bichromate of potash.
6. Washing with water of the precipitate by bichromate of potash.
7. Drying of the washed precipitate.
8. Extraction of the brown impurity contained in the precipitate.
9. Extraction of the purple colouring matter.

An outline of the process contained in Mr. Perkin's specification will be found in the article ANILINE.

Numerous patents have been taken out for the production of colours more or less resembling Perkin's purple. J. T. Beale and J. N. Kirkham employ bleaching powder as the oxidising medium. They take a saturated solution of aniline in water, and add to it acetic acid and bleaching powder until the desired tint is acquired. They then use the fluid so procured for dyeing. It is obvious that some process of concentration must be employed to enable so weak a fluid to be employed in calico-printing. Upon the latter point the patent process does not enter at sufficient length to enable us to judge of the practicability of producing colours of the great strength required for printing on with albumen. Messrs. Beale and Kirkham, by modifying the nature of the salt and the state of concentration of the fluids employed, obtain various shades of colour from blue to lilac.

Mr. R. D. Kay, in his patent of the 7th May, 1859, treats acetate, sulphate, or hydrochlorate of aniline, with peroxide of manganese, peroxide of lead, or chloride of lime.

Mr. David S. Price, in his patent of the 25th of May, 1859, claims the use of peroxide or sesquioxide of manganese, and also peroxide of lead, as his agent of oxidation. By varying the quantities of his ingredients he obtains three colours, viz., violine, purpurine, and roseine.

C. H. G. Williams patents the green manganate of potash as the oxidising agent. By this means a part of the aniline is converted into a brilliant red dye of great beauty, and another part into an equally brilliant purple. The two colours are separated by taking advantage of the fact that the purple is precipitated by a solution of the reagent, whereas the red colour remains in solution, and can be concentrated by evaporation.

In dyeing and printing with these colours it is necessary with vegetable fabrics to use mordants, but animal fabrics absorb the colours with great avidity without the use of any mordant.

For cottons, perchloride of tin, followed by sumach, or stannate of soda and sumach, are the best mordants. Mr. Perkin recommends tartaric acid to be added to the bath in dyeing; but in practice this recommendation is not generally followed.

For printing, the purple is mixed with albumen; and after printing with the mixture the colour is fixed by steaming. Sometimes a mordant is printed on, and the pattern is obtained by passing the mordanted cloth through a bath of the colour. The purple may be rendered of a bluer and very lovely tint by adding to the mixture of dye and albumen a little carmine of indigo; Prussian blue is also sometimes used for the same purpose. In selecting patterns to be printed in purple, it must not be forgotten that the beauty of the tint is greatly enhanced by the proximity of blacks properly arranged.

Very fine purples, but decidedly inferior to Mr. Perkin's colour, are now prepared from litmus; they are also tolerably permanent. They are, nevertheless, liable to the drawback of becoming red in contact with strong acids. Strange to say, however, the orchil purples when properly made resist very well the action of weak acids. The colour-producing acids are obtained by treating the lichens with an alkaline base, which forms a soluble salt. The filtered liquid on treatment with an acid gives an abundant precipitate. It is this latter which, by proper treatment, yields the "French purple." The following is an outline of the process contained in a patent granted to William Spence (being a French communication), dated 1st May, 1858.

The precipitate obtained as above is moistened with sufficient ammonia to dissolve it. On boiling, the solution becomes orange yellow; it is then exposed to the air at ordinary temperatures, until it becomes red. The fluid is then heated in very shallow vessels to a temperature between 100° and 140° Fahr., until it becomes of a violet colour, which is unalterable by weak acids, and which will dye permanent colours on silk or wool, without the aid of mordants.

This purple colour can be thrown down from the liquid by saturation with an acid. The precipitate, after being filtered off and properly dried, is in a fit condition for dyeing or printing.

Like Perkin's purple, various shades may be obtained by using the orchil purple in combination with carmine of indigo for violets, and carthamus, or cochineal, for reds.—C. G. W.

PURPURIC ACID is an acid obtained by treating uric or lithic acid with dilute nitric acid. It has a fine purple colour. See MUREXIDE.

PURPURINE is the name of a colouring principle, supposed by Robiquet and Colin to exist in madder.

PUTREFACTION, *and its Prevention.* (*Faülniss*, Germ.) Putrefaction is the spontaneous decomposition of albumenoid or protein and gelatine compounds, when exposed to a limited amount of air. It is the decomposition of bodies containing nitrogen, called by some persons azotised bodies, although they are produced only by life, are the principal means of producing life, and more fitly called *zoogens.*

These bodies decompose at any temperature between 32° and 140° Fahrenheit (0°—60° C.). Their decomposition begins by the action of the oxygen of the air, so that a partial oxidation and a gradual disruption are simultaneous. The result of this is a number of liquid and gaseous compounds; carbonic acid, hydrogen, nitrogen, ammonia, sulphuretted hydrogen, phosphuretted hydrogen, carburetted hydrogen, acetic acid and lactic, also butyric and valeric acids are formed. But these are not all, as there are compounds arising from putrefaction which have, even in small quantities, a destructive action on animal life far beyond any of the substances mentioned.

Some of these are extremely offensive, and produce nausea as the first symptom; the further symptoms are those of general prostration, or of fevers in great variety, and eruptions equally varied, with a frequently fatal termination. In the case of a diseased person or animal, all contact is most dangerous within four or five hours after death, the disease still ruling the peculiar action of the tissues and fluids. But the result of putrefaction is most shown after a few days, and after ten to fourteen days it seems less violent. If pent up, the poisons may retain their virulence for months or years; nor do we know how many diseases may be imprisoned in graves very closely fitted. If air be absolutely excluded, putrefaction ceases, and the result is a preservation of the substance in some circumstances,—perhaps in all. If air be excluded for a time and the substance dried, a return to the light, air, and moisture is not known to reproduce the same state of decomposition that would have taken place at first. The act of drying has caused chemical union to take place more according to that of unorganised substances, and the peculiar organic and complicated molecules that produce the poisons are destroyed. If the slow decomposition takes place undisturbed for many years, the entrance of oxygen being extremely difficult, as in coffins carefully closed or deeply buried, then the organic matter is removed so completely and carefully that the ashes which remain are undisturbed, and keep the position in which they remained during life. It is in this way that men have been able to see the faces of the ancient kings of France, as well as of many other personages, and may yet see some of the undisturbed and complete bodies of the Chaldees. It is most probable that in these the air has oxidised them, as oxygen must have had access to remove so much matter. Only a light dust remains, and the slightest motion either of removal or of the atmosphere would cause it to fall. As oxidation began the process of putrefaction, so when it is finished oxidation completes the destruction of the material. It is probable that the ashes are mixed with a little humus or humate of ammonia. The result differs little from complete combustion with fire.

All organised substances are decomposed in the atmosphere. When they do not contain nitrogen, they are converted, like wood, sugar, starch, &c., into humus, or a lower compound of carbon and hydrogen, or into humic or ulmic acids. Ulmic acid, obtained from sugar by action of acids, contains (according to Mulder) carbon, 40; hydrogen. 14; oxygen, 12. From turf, carbon, 40; hydrogen, 14; oxygen, 12 + 4 aq. Humin contains, *carbon*, 40; *hydrogen*, 14; oxygen, 12. Humic acid, carbon, 40; hydrogen, 14; oxygen, 12 + 3 aq. Here the decomposition is signalised by a great diminution of hydrogen and oxygen,—a nearer approach to mere carbon. When nitrogenous bodies decompose, part of their nitrogen remains as ammonia, and a humate of ammonia is formed. Mulder traces it in the following manner. It is to be remarked that there is no proof of the existence of protein as a substance, but allowing it to represent the part of the albumenoids containing carbon, hydrogen, nitrogen, and oxygen, we have,

	C.	H.	N.	O.
1 equiv. protein + O_4 =	40	31	5	16
= 1 equiv. humic acid =	40	16	0	15
1 „ water =	0	1		1
5 „ ammonia =	0	15	5	0
	40	32	5	16

Before arriving at this stage of decomposition, the various forms of volatile substances already mentioned are given off. It has been frequently asked why such decompositions go forward; why does not the substance remain undecomposed? The very complex molecules of highly organised bodies readily lose their vital condition, and become simply chemical compounds, such as we may be able to form according to laws comparatively well understood. But compounds such as albumen seem to contain many compounds united together; or, in other words, there are many axes through which the affinity acts. These may bear an analogy to the several axes of crystals. When the force of one predominates, and the elements combine in a simple form, say of two molecules or atoms, then the breaking up of the compound as a whole must begin. In order to begin this motion, the substances must be in a condition in which the particles and atoms can move readily. This condition appears to be found when there is water present of a moderate warmth. If the temperature be below 60° Fahr. the decomposition is hindered by the cold, but it is not quite prevented at any temperature above freezing. If the temperature be above 100° Fahr. it is not certain that true putrefaction goes forward, and a much higher temperature entirely prevents it. If substances of the class which putrefy are much heated, they lose their peculiar constitution and readily yield to the ordinary chemical affinities, the action of heat rapidly destroying the balance of their forces. Cold, on the other hand, does not destroy, but preserves the relation of the substances unaltered. If left to themselves, organised substances in moderate temperature with moisture would even without air lose their peculiar condition. Some change of temperature or in the electric state of the atmosphere would in time cause a want of perfect balance of power; nay, it is even possible that some force existing in the substances themselves is capable of gaining the upper hand by the aid of time. In ordinary cases, however, the balance is disturbed by oxygen, as we know from very early times, by the action of air on organic substances. But Gay-Lussac made this remarkably clear by a beautiful and unexpected experiment, wherein he showed that the juice of grapes remained without fermentation until he allowed a single bubble of air to enter, when the fermentation, once begun, continued. Liebig explained this by saying, with La Place and Berthollet, that "a molecule set in motion by any power can impart its own motion to another molecule with which it may be in contact." This is an analogy drawn from mechanics, but only an analogy. The molecule will not, in the conditions found in Gay-Lussac's experiment, set in motion the molecules of silica or lime. Chemical action is not the same as mechanical, although, somewhere, the borders of the two touch. The use of a chemical form of explanation makes the matter much clearer. Suppose a particle of oxygen to touch the matter ready to ferment or putrefy, an oxide is formed. The oxygen has taken the place of another atom, which is now left to follow its affinities, and the whole relations of the mass are gradually changed. If the mass were neutral, having no sign of + or — before it, oxygen at once by its action changes one sign to +. The sign changed to plus, or the atom containing it, converts the one next it to minus, and so the chemical action is continued through the mass. Berzelius used the word *catalysis* for the breaking up of a substance without any strong chemical affinities. The word means simply *loosening out*, or *breaking up*, and is well adapted for the purpose, although much misapplied. Putrefaction may be said then to be an albumenoid in a state of catalysis. This catalys is is begun by the air disturbing the equilibrium of the compound. A change of electric condition will disturb the equilibrium in the air, and it will assist the first attacks of the oxygen. This action of electricity is popularly known by the changes so common in milk and beer during thunderstorms. As oxygen begins the action, so does it bring it to a conclusion, and completely destroy all decomposing matter. The same thing must no doubt be said of Ozone in a still higher degree. Now, many things may destroy this equilibrium. We see then the reason why so many substances and so many conditions act so as to alter the putrefiable substance. This equilibrium may be destroyed by the use of a strong acid, causing strong chemical affinities to upset all the delicately balanced forces in the organic substance; the same thing may be done by alkalies and by many salts that act in an antiseptic manner. But if a condition or a substance be found merely to keep the putrefactive mass in a state in which it will not putrefy, the agent is exactly opposed to catalysis. It is a *colytic* or restraining agent. See DISINFECTANT.

When resin and fat are present, they are not readily oxidised. The first may be retained for an unknown time; the second remains long in bodies when all the rest has been removed. It has been found in catacombs in Paris in large quantities, and been called *adipocere*, meaning *wax of fat* (*adeps*, fat; and *cera*, wax).

If the explanation given be correct, it is at once seen why a body in a state of putrefaction communicates its own condition to another. The loss of equilibrium has already taken place, and cannot stop till the material is consumed, unless more powerful forces arrive. Liebig says that "no other explanation can be given than that a body in the act of combination or decomposition enables another body with which it is in contact to enter the same state." It is not intended here to oppose, but rather to take another step in this theory. On the same principles both the disorganised and the organised matters carried about by the air will promote decomposition: both will break up the structure, but by different methods. The disorganised will act as shown; the organised will act by growing and by eliminating compounds, such as funguses, which will break down the equilibrium of the mass. If air be passed into the juice of grapes through red-hot tubes, it does not ferment for a long time, nor does it produce mould or infusoria. The animal and vegetable assistance to decomposition is removed. Flesh under these conditions keeps some weeks. Ozone is also destroyed by heat, and would leave only ordinary oxygen to act. Schrœder and V. Dusch even found that flesh would keep in air filtered through cotton, and in similar air no infusoria or mould occurred. Milk recently boiled and flesh warmed on a sand-bath without being steeped in water decayed equally in filtered and unfiltered air, still without vegetable or animal life.

In the case of the grape juice, one bubble of air begins fermentation which continues, but we are not sure that putrefaction can be so continued; it seems to require a more frequent stimulus. Certain products of putrefaction have been mentioned, but in reality the word putrefaction includes many modes of decomposition. There are compounds formed that destroy life more rapidly than any substance whose constitution is known, and these seem to be the more destructive according as the matter from which they are derived is from animals in a higher scale of being,—from man, for example. This idea is in accordance with all we know of the compounds of organised life. For effects, see Sanitary Economy. Sometimes a peculiar ferment is formed, which produces a similar condition in living bodies, constituting a great variety of diseases, according to its special nature and the condition of the body attacked. As we have seen, some fermentations and putrefactions begin entirely by the action of air, and some by the assistance of liquids or solids, such as yeast; so we find some diseases propagated by infection conveyed through the air, and some only by contact. In cases where air acts, it is to be understood that the organic substances are conveyed in it. We find by this means that both the contagionists and noncontagionists are correct; but it is to decide, as men are now endeavouring to do, in what diseases one or the other prevails.

As in the decomposition of flesh into humate of ammonia and ashes many deadly exhalations are given off, so in the decomposition of analogous substances in the earth putrefaction causes the rise of miasma. When there is an abundant supply of air, the ammonia is converted into nitric acid; when there is an abundant supply of vegetation, the nitric acid is reconverted into ammonia, as Kuhlman has shown, and as agriculture, by its love of nitrates, has long demonstrated. The humus and humate of ammonia spoken of form the chief portion of what we call vegetable mould. Acetic acid and other acids are also found in one if not in every layer of the soil; and the acids and ammonia are in a constant struggle for the mastery. The soil is slightly acid. A *sour* soil is not uncommon.

1. Conditions of the Prevention of Putrefaction.

The circumstances by which putrefaction is counteracted, are 1, the chemical change of the azotised juices; 2, the abstraction of water; 3, the lowering of the temperature; and 4, the exclusion of oxygen. The methods actually in use may be called salting, smoking, drying, exclusion of air, and parboiling.

1. *The chemical change of the azotised 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 probably 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. 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, and the residuary solid matter may be readily dried in the air, so as to be rendered unsusceptible of decomposition.

Some acids combine with the albumen, 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, chiefly in consequence of the *kreasote* contained in it, according to the discovery of Reichenbach. This peculiar substance has so decided a power of coagulating albumen, that even the minute portion of it present in pyroligneous vinegar assists in preserving animal parts from putrefaction, when they are simply soaked in it. Thus, also, flesh is cured by wood smoke. Distilled wood tar likewise protects animal matter from change, by the kreasote it contains. The ordinary pyroligneous acid sometimes contains 5 per cent. of kreasote.

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 $\frac{1}{500}$ 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, as the albumen itself runs much more slowly into putrefaction, when less water is contained in it; 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, and flesh may be preserved from corruption. If the air be not cold and dry enough to cause the evaporation of the fluids before putrescence begins, the organic substance must be dried by artificial means, such as by being exposed in thin slices in properly constructed air-stoves. At a temperature under 140° F., the albumen dries up without coagulation, and may then be redissolved in cold water, with its valuable properties unaltered. 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, and probably by chemical combinations, 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 solids. 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 a long 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 found in the polar ices are proofs of the preservative 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 solids, as this portion suffices in general to excite putrefaction, if other circumstances be favourable. The expulsion is most readily accomplished by a boiling or lower heat, which, by expanding the air, evolves it in a great measure. 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, and causing it to combine with putrefying substances. 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.

2. 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.

Preservation of specimens of animals. — Many methods have been planned to preserve animals: all of them dependent on substances mentioned under Disinfectants. Charles Waterton uses corrosive sublimate dissolved in alcohol. The skin of the animal being separated, is dipped into the solution and dried. The inside of the animal is always removed, the bones scraped clean and dipped, the feathers or hairs touched by the solution or the whole immersed in it. Sometimes alcohol of 60 to 70 per cent. is used, or alcohol of 30 per cent. with kreasote dissolved in it. Sulphurous acid will not suit when there are colours, but sulphites of the alkalies have been injected into the veins and arteries with good result; as also sulphurous acid and kreasote. Peron preserved fishes for specimens on shipboard by floating them in an alcoholic liquor by corks, thus preventing them from being pressed. He first washed them in sea-water, vinegar, and camphor spirits: he corked the vessels with tallowed corks. Dufresne wrapped each in a cloth with tow between the specimens, and all in alcoholic liquids. Louis Vernet used arsenic, 1 lb. in 40 gallons of water. Sulphate of zinc was proposed for embalming by Comte de Fontainemoreau, sometimes adding alcohol. Wood is preserved by Kyan's process, corrosive sublimate being used; also by Bethel's process, the use of heavy oil of tar; and manures are preserved by carbonites by McDougall. Injection of the arteries and veins by chloride of zinc, chloride of arsenic, and chloride of aluminum, sulphate of zinc, and sulphates, corrosive sublimate, &c., have all been tried, and are more or less satisfactory. Peppers and spices of all kinds have been used in stuffing and embalming, and may all be made to act when care is employed and abundance used. Girolamo Segato dried bodies so hard that he made a table of 214 pieces of human flesh from different parts of the body. He is said also to have made members preserve their elasticity for an indefinite time. Some remarkable specimens of this kind are said to exist, and have received the honour of sanctity. Waterton made skins preserve their flexibility for some days by the use of corrosive sublimate and slow drying. Dr. Ure says, "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 kreasote, 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."

Curing of Provisions.

Flesh, &c.—The ordinary means employed for preserving butcher meat are, drying, smoking, salting, and pickling or souring.

Drying.—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.

Baron Cha. Wetterstedt encloses meat in corn or potato flour, then dries it on shelves at 120° F. Graefer, in 1780, parboiled and then dried. Some have proposed to hang the substances up and to allow no air to approach without passing it first through chloride of calcium to dry it. Milk is often preserved by drying to a powder.

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 kreasote volatilised 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 pyroligneous acid, then hanging it out 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 pyroligneous acid or kreasote alone 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-secondth 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.

M. Fitch patented the use of a liquid containing 2 cwt. of common salt to the product of distillation of 2 cwt. of wood, adding sugar, treacle, and saltpetre. Some people drive the salt in by force of pressure, some by centrifugal motion.

Milk has been preserved by the use of carbonate of soda, preventing acidity. Alum has been patented, for shellfish especially.

E. Masson injects the veins and arteries of carcases with a solution containing $10\frac{1}{2}$ oz. of common salt and $3\frac{1}{2}$ of nitre in $2\frac{1}{2}$ pints of water. D. R. Long injects anti-putrescent and flavouring substances, such as salt, saltpetre, spices, and vinegar. J. Murdoch injected cloride of aluminum, a very powerful agent, common salt, and nitre. Brooman communicates a proposal to use, first, sulphurous gas, and then coat thick with a substance keeping out the air. Chloride of lime has also been used in chambers holding meat, and sulphur has been burnt and nitrous gas has been evolved in similar places.

Preserving with vinegar, sugar, &c.—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. Faülniss Abhaltung.*

Meat may also be preserved by boiling in its own gravy, or embedding in fat (Plowden's patent, 1807), or in animal jelly.

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 Dr. Ure 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. S. Carson's patent says, that after this 1 minute in hot water cooks the egg. 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 $\frac{3}{4}$ of a grain of their weight daily, and become concentrated in their albuminous part, so as to be little liable to putrefy. This is an extremely simple and clean method, but requires a good deal of space. Each egg requires a hole in the shelf for itself. 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.

Mixed modes, &c.—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 hither 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 to 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.

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.

Gunter effects the plan more rapidly by sealing the tin case whilst steam is blowing off, letting the solder fall upon the open hole, and at once closing it.

Alexander Cockburn, in 1763, cured salmon with spices — vinegar, salt, cloves, mace, and pepper. The use of a vacuum in preserving meat is old — before 1810, when two patents were taken for a mode of doing it.

A layer of oil is also used for preserving milk from the air.

Mr. R. Warrington uses oils not subject to oxidation and glycerine or treacle, also gypsum; he stops the vessels with gutta percha or caoutchouc.

Fat is preserved by melting gently and putting in bladders (*Palmer*). Charcoal powder has also been used to preserve it. A coating of collodion to keep out the air has been patented.

Grain, fruit, &c.—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. Granaries are sometimes heated with warm air.

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, spead 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 the stalks, with melted wax; others lay the apples, &c., upon wicker-work shelves in a vaulted chamber, and smoke them daily during four or five 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 five to six measures of fresh apples, and from six to seven of pears, afford in general one measure of dry fruit (biffins). Dried plums, grapes, and currants are a common article of commerce, coming from Greece, Spain, and the Mediterranean.

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. Tuberous 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 and squeezed in bags to expel the juices, which must then be inspissated either over the naked fire, or on a water or steam bath, in the air or in vacuo. Sometimes a small proportion of spice is added, which tends to prevent mouldiness. Such extracts may be conveniently mixed with sugar into what are called conserves, preserves, and jelly.

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 *saur kraut*, sour herb or cabbage, of the northern nations of Europe, which is prepared simply by salting; a little vinegar being formed spontaneously by fermentation. The cabbage must be cut into small pieees, stratified in a cask along with salt, to which juniper berries and caraway seeds may be 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, while a quantity of juice exudes and floats on the surface, which causes the cabbage to become more compact, 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 use during the year; and indeed, where, if well made and packed, it may be kept for several years.

Potatoes and other vegetables, as carrots and turnips, are preserved by cutting out the eyes or germinating parts (Roberts's patent, 1825). Grain and vegetables are also preserved in air-tight vessels. Potatoes have been much used dried; they are driven through small holes and thus broken, and then dried. They do not seem to retain a good flavour. The seeds of plants have been preserved by covering them with a solution of sulphate of zinc, copper, &c. E. Acres cools the air passing into air-tight reservoirs containing grain, and into the space between the mill-stones when in action.

This article may be concluded with some observations upon the means of preserving water fresh on sea voyages. Some waters kept in wooden casks, undergo a kind of putrefaction, contract a disagreeable sulphurous smell, and become undrinkable. 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 waters containing sulphate of lime, 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 admixture 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 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. An occasionally useful 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 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. 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, but chlorine and chlorides should be avoided in water, the chlorides of the earths formed, being unpleasant to the taste and hurtful to metals.

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. Iron itself has been proposed as a purifier of water. Sea water can be purified only by distillation first and animal charcoal afterwards. The addition of chemical agents should be resorted to only when unavoidable.—R. A. S.

PUTTY POWDER. Oxide of tin, or more frequently oxide of tin and lead, in various proportions. The usual process is to oxidise the metal in a rectangular box. This is surrounded by the fire and kept at a red heat; the contents are constantly stirred, so that fresh portions of the metal are exposed to the heated air. The process is complete when all the metal has disappeared, and the oxide glows with incandescence. It is then removed with ladles and spread over the bottom of large iron pans to cool. The hard lumps of oxide are selected from the mass, ground dry, and carefully sifted through fine lawn sieves.

For the use of the optician the tin is precipitated from its solution in nitro-muriatic acid, by liquid ammonia, both the solutions being very largely diluted. The oxide of tin is then well washed, and dried by pressure in a screw-press; when dry the mass is finely powdered, and afterwards exposed in a crucible to a tolerably high temperature, 1600 Fahr. See Tin.

PYRITES. A term formerly applied to the yellow sulphide of iron, because it struck fire with steel. It is in strictness still confined to this mineral; but where sulphur is in combination with copper, cobalt, nickel, and some other metals, they, provided they assume an especial colour, are called pyrites.

Pyrites, *Iron pyrites*, *mundic*, is found in almost every formation. Its composition is, iron, 45·75; sulphur, 54·25.

Pyrrhotine, *Magnetic iron pyrites*, is found in many of the Cornish mines. Its composition is, iron, 59·72; sulphur, 40·22.

Marcasite, *White iron pyrites*. This is but a variety in form of the first named; they are identical in composition.

Copper Pyrites (*Chalcopyrite* of Dana), *Yellow copper pyrites*. The common copper ore of Cornwall. It appears to be a double sulphide of copper and iron. Its composition being, sulphur, 34·9; copper, 34·6; iron, 30·5.

Tin Pyrites, *Sulphide of tin; Bell-metal ore.* This mineral is found in many of the Cornish mines. Its composition is usually, sulphur, 30·0; tin, 27·2; copper, 29·7; iron, 13·1.

The term is occasionally applied to the other minerals named above. Combinations with arsenic are sometimes termed *Arsenical Pyrites*—as the

Leucopyrite (Dana), which is an arsenical iron composed of arsenic, 78·2; iron, 27·2.

Mispickel is a compound of arsenic, 46·0; sulphur, 19·6; iron, 34.

These ores are used largely in the manufacture of oil of vitriol. See SULPHURIC ACID.

The production of iron pyrites in the United Kingdon in 1858 was as follows:—

	Tons.	Cwts.	Qrs.	Value. £	s.	d.
Cornwall - - - - -	10,549	1	0	9,923	14	9
Devonshire - - - - -	274	10	0	97	11	9
Cumberland - - - -	1,319	0	0	762	12	7
Northumberland and Durham -	3,570	0	0	1,500	0	0
Yorkshire - - - - -	4,110	0	0	1,837	0	0
Lancashire - - - - -	4,000	0	0	1,800	0	0
North Wales - - - -	620	0	0	407	0	0
South Wales - - - -	9,790	18	0	2,100	0	0
Ireland - - - - -	73,030	0	0	58,696	0	0
	100,263	9	0	£77,123	19	1

Enormous quantities of iron pyrites exist in Spain, and are now being brought to this country. These sulphur ores contain a small quantity of copper, which increases their value.

Iron pyrites, mundic, is a mineral which is largely employed in the manufacture of copperas and of sulphuric acid. The pyrites ("brasses") of the coal measures are used in the preparation of copperas. Mr. Kirwan iu his "Antiquated Mineralogy," which is, however, very full of information, gives us the following passage, which shows that the changes which take place in the sulphur ores (*Martial pyrites*), had been well studied by him.

"Vitriol is formed in these stones by exposing them a long time to the action of the air and moisture, or by torrefaction in open air, and subsequent exposure to its action, which operation in some cases must be often repeated, according to the proportion of sulphur, and the nature of the earth; the calcareous pyrites are those in which it is most easily formed, and they effloresce the soonest. Good pyrites, properly treated, yield about two-thirds of their weight of vitriol." See SULPHURIC ACID.

In the chemical works of Yorkshire the "*coal brasses*" are exposed in thin beds, which are often turned over to the action of the air. The sulphur is converted by the oxygen of the air into sulphuric acid, which combines with the iron, forming sulphate of iron, *copperas*, which is dissolved out and crystallised. The same result may be obtained more quickly by roasting the sulphur ores.

PYRIDINE, $C^{10}H^5N$. A volatile base homologous with picoline, latidine, collidine, and parvoline. It was discovered by Anderson in bone oil. It is also contained in Dorset shale, naphtha, coal naphtha, and in crude chinoline.—C. G. W.

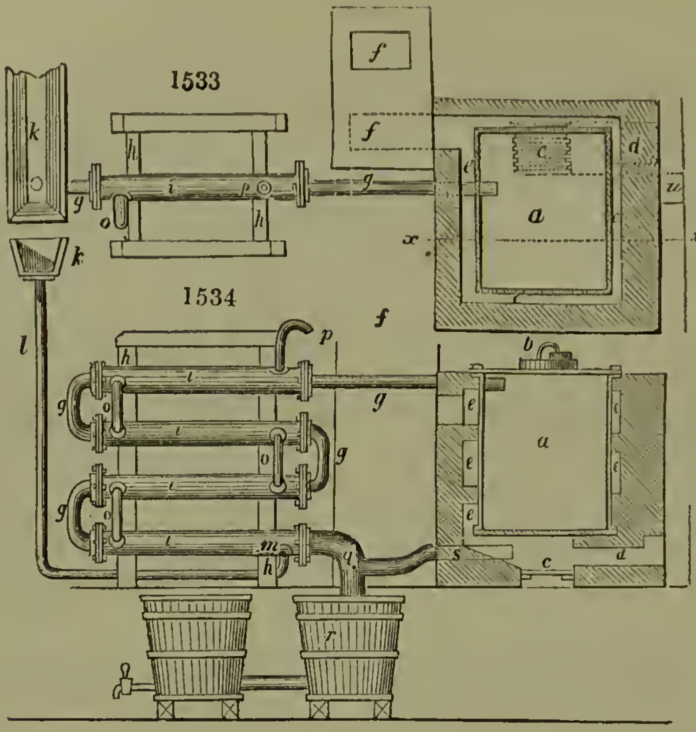
PYROACETIC SPIRIT. See ACETIC ACID.

PYROGALLIC ACID. If gallic acid is carefully heated to about 400°, it is totally decomposed into carbonic acid and pyrogallic acid ($C^7H^3O^5 = C^6H^3O^3 + C^2O$), which sublimes in brilliant white plates; it is easily soluble in ether, alcohol, and water; it reacts feebly acid; it fuses at 240°, and sublimes at 400°. If a solution containing peroxide of iron be added to a solution of pyrogallic acid, a black colour is struck, but the iron is rapidly reduced to a state of protoxide, and the liquor assumes a rich red tint.—*Kane.*

Dr. Stenhouse has fully investigated the formation of gallic and of pyrogallic acid; to his papers on this subject those interested are referred. Pyrogallic acid has of late years been largely employed in PHOTOGRAPHY, which see. See GALL NUTS.

PYROLIGNEOUS ACID. See ACETIC ACID.

The apparatus represented in *figs.* 1533 and 1534 is a convenient modification of that exhibited under acetic acid, for producing pyroligneous acid. *Fig.* 1533 shows the furnace in a horizontal section drawn through the middle of the flue which leads to the chimney. *Fig.* 1534 is a vertical section taken in the dotted line *x*, *x*, of *fig.* 1533. 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 rests 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*, *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.* 1533, in the brickwork of the furnace. About 60 per cent. of charcoal may be obtained from 1000 feet of fir-wood, with a consumption of as much brush-wood for fuel.

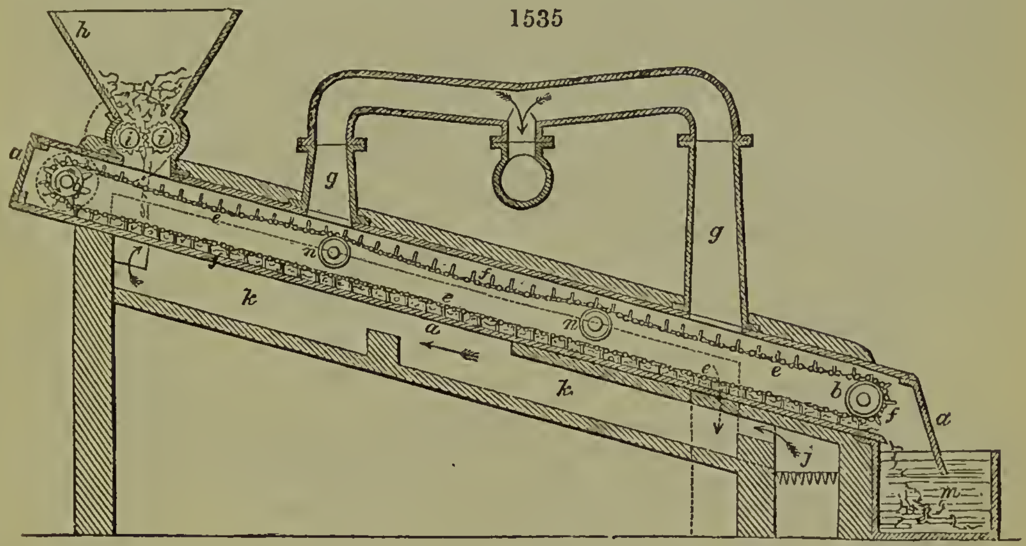
A new mode of distilling wood and producing this acid has been introduced by Mr. W. H. Bowers, of Manchester. In the rectangular retort which is used there are two revolving drums, one at each end. On these drums are endless chains; on these chains there is formed a flat surface by means of bars laid across. A hopper supplies this surface with the sawdust or other material to be heated. The surface is somewhat inclined. A very small engine is used to set the endless chain in motion. The sawdust is carried from the upper end of the retort to the lower, during which time it is exposed to heat and becomes distilled. At the lower end, as it is turning over the drum, it falls in a carbonised state into water. The vapours are carried away by pipes, as in the usual method, and the water joint at the lower part of the retort prevents any escape in that direction, whilst the thickness of the mass of sawdust passing into the retort readily prevents any from passing out there. It is said that one retort can do the work of five of those made on Halliday's plan with the screw. Two of them produce with slow motion 2500 gallons of acid in six days. The motion may be increased at will, and heat regulated accordingly. There are scrapers to prevent charcoal clogging the bars forming the inclined plane, and the apparatus does not require to be stopped for any purpose of cleansing. It feeds and discharges continuously, from month to month.

Sawdust, wood turnings, small chips, spent dye wood, and tanners' bark, peat, and such like ligneous, and carbonaceous substances, are distilled, and the carbon discharged as shown.

It is believed also that the distillation is effected more rapidly, and the gases more directly removed by this method, than by any other.

Fig. 1535 is a longitudinal section taken through the middle of the retort or

1535



rectangular vessel a, a, a; b, b are the revolving drums on which the endless chain e, e, e, revolves; f, f are cross-bars or scrapers; g, g, are tubes to convey the gases, one from the lower and one from the higher point of the moving plane; h is a hopper filled with sawdust and other material to be distilled; the supply is regulated by two small cog-wheels i, i; j, the fire-place; k, k, the flues; m is a cistern showing the level of the water and the carbon falling into it, the lower part of the retort dipping into it.

PYROTECHNY. (*Feux d'artifice*, Fr.; *Feurwerke*, Germ.) The composition of luminous devices with explosive combustibles is a modern art resulting from the discovery of gunpowder. The finest inventions of this kind are due to the celebrated Ruggieri, father and son, who executed in Rome and Paris, and the principal capitals of Europe, the most beautiful and brilliant fire-works that were ever seen. The following description of some of their processes will probably prove interesting:—

The three prime materials of this art are, nitre, sulphur, and charcoal, with filings of iron, steel, copper, zinc, and resin, camphor, lycopodium, &c. Gunpowder is used either in grain, half crushed, or finely ground, for different purposes. The longer the iron filings, the brighter red and white sparks they give; those being preferred which are made with a very coarse file, and quite free from rust. Steel filings and cast-iron borings contain carbon, and afford a more brilliant fire, with wavy radiations. Copper filings give a greenish tint to flame; those of zinc a fine blue colour; the sulphuret of antimony gives a less greenish blue than zinc, but with much smoke; amber affords a yellow fire, as well as colophony, and common salt; but the last must be very dry. Lampblack produces a very red colour with gunpowder, and a pink with nitre in excess.

Golden showers are formed with lampblack and nitre; yellow micaceous sand is also employed for the same purpose. All the copper salts tinge the flame green; those of strontian a red colour; and barytes and its salts also impart a peculiar green. Lycopodium burns with a rose colour and a magnificent flame; but it is principally employed in theatres to represent lightning, or to charge the torch of a fury.

Fire-works are divided into three classes: 1, those to be set off upon the ground; 2, those which are shot up into the air; and 3, those which act upon or under water.

Composition for *jets of fire*; gunpowder, 16 parts; charcoal, 3 parts.

Brilliant revolving-wheel; for a tube less than $\frac{3}{4}$ of an inch: gunpowder, 16; steel filings, 3. When more than $\frac{3}{4}$: gunpowder, 16; filings, 4.

Chinese or jasmine fire; when less than $\frac{3}{4}$ of an inch: gunpowder, 16; nitre, 8;

charcoal (fine), 3; sulphur, 3; pounded cast-iron borings (small), 10. When wider than $\frac{3}{4}$: gunpowder, 16; nitre, 12; charcoal, 3; sulphur, 3; coarse borings, 12.

A fixed brilliant; less than $\frac{3}{4}$ in diameter: gunpowder, 16; steel filings, 4; or gunpowder, 16, and finely-pounded borings, 6.

Fixed suns are composed of a certain number of jets of fire distributed circularly, like the spokes of a wheel. All the fusees take fire at once through channels charged with quick matches. *Glories* are large suns with several rows of fusees. *Fans* are portions of a sun, being sectors of a circle. *Patte d'oie* is a fan with only three jets.

The *mosaic* represents a surface covered with diamond-shaped compartments, formed by two series of parallel lines crossing each other. This effect is produced by placing at each point of intersection, four jets of fire, which run into the adjoining ones. The intervals between the jets must be associated with the discharge of others, so as to keep up a succession of fire in the spaces.

Cascades imitate sheets or jets of water. The Chinese fire is best adapted to such decorations.

Fixed stars. The bottom of a rocket is to be stuffed with clay, the vacant space is to be filled with the following composition, and the mouth covered with pasteboard, which must be pierced into the preparation, with five holes, for the escape of the luminous rays, which represent a star.

	Ordinary.	Brighter.	Coloured.
Nitre - - - - -	16	12	0
Sulphur - - - -	4	6	6
Gunpowder meal - -	4	12	16
Antimony - - -	2	1	2

Lances are long rockets of small diameter, made with cartridge paper. Those which burn quickest should be the longest. They are composed as follows:—

White lances: nitre, 16; sulphur, 8; gunpowder, 4 parts.

Bluest white lances: nitre, 16; sulphur, 8; antimony, 4 parts.

Blue lances: nitre, 16; antimony, 8 parts.

Yellow lances: nitre, 16; sulphur, 8; gunpowder, 16; amber, 8 parts.

Yellower lances: nitre, 16; sulphur, 4; gunpowder, 16; colophony, 3; amber, 4 parts.

Greenish lances: nitre, 16; sulphur, 6; antimony, 6; verdigris, 6 parts.

Pink lances: nitre, 16; gunpowder, 3; lampblack, 1.

Cordage is represented by imbuing soft ropes with a mixture of nitre, 2; sulphur, 16; antimony, 1; resin of juniper, 1 part.

The Bengal flames consist of nitre, 7; sulphur, 2; antimony, 1. This mixture is pressed strongly into earthen porringers, with some bits of quick match strewed over the surface.

Revolving suns are wheels upon whose circumference rockets of different styles are fixed, and which communicate by *conduits*, so that one is lighted up in succession after another. The composition of their common fire is, for sizes below $\frac{3}{4}$ of an inch: gunpowder meal, 16: charcoal, not too fine, 3. For larger sizes: gunpowder, 20; charcoal, not too fine, 4. For *fiery radiations:* gunpowder, 16; yellow micaceous sand, 2 or 3. For *mixed radiations:* gunpowder, 16; pitcoal, 1; yellow sand, 1 or 2.

The *waving or double Catherine wheels*, are two suns turning upon the same axis in opposite directions. The fusees are fixed obliquely and not tangentially to their peripheries. The wheel spokes are charged with a great number of fusees; two of the four wings revolve in one direction, and the other two in the opposite; but always in a vertical plane.

The *girandoles, caprices, spirals*, and some others have on the contrary a horizontal rotation. The fire-worker may diversify their effects greatly by the arrangement and colour of the jets of flame. Let us take for an example the *globe of light.* Imagine a large sphere turning freely upon its axis, along with a hollow hemisphere, which revolves also upon a vertical axis passing through its under pole. If the two pieces be covered with coloured lances or cordage, a fixed luminous globe will be formed, but if horizontal fusees be added upon the hemisphere, and vertical fusees upon the sphere, the first will have a relative horizontal movement, the second a vertical movement, which, being combined with the first, will cause it to describe a species of curve, whose effect will be an agreeable contrast with the regular movement of the hemisphere. Upon the surface of a revolving sun, smaller suns might be placed, to revolve like satellites round their primaries.

Ruggieri exhibited a luminous serpent pursuing with a rapid winding pace a butterfly which flew continually before it. This extraordinary effect was produced in the following way. Upon the summits of an octagon he fixed eight equal wheels turning freely upon their axles, in the vertical plane of the octagon. An endless chain passed round their circumference, going from the interior to the exterior, covering the outside semi-circumference of the first, the inside of the second, and so in succession; whence arose the appearance of a great festooned circular line. The chain, like that of a watch, carried upon a portion of its length, a sort of scales pierced with holes for receiving coloured lances, in order to represent a fiery serpent. At a little distance there was a butterfly constructed with white lances. The piece was kindled commonly by other fire-works, which seemed to end their play, by projecting the serpent from the bosom of the flames. The motion was communicated to the chain by one of the wheels, which received it like a clock from the action of a weight. This remarkable curious mechanism was called by the artists a *salamander*.

The rockets which rise into the air with a prodigious velocity, are among the most common, but not least interesting fire-works. When employed profusely they form those rich volleys of fire which are the crowning ornaments of a public fête. The cartridge is similar to that of the other jets, except in regard to its length, and the necessity of pasting it strongly, and planing it well; but it is charged in a different manner. As the sky-rockets must fly off with rapidity, their composition should be such as to kindle instantly throughout their length, and extricate a vast volume of elastic fluids. To effect this purpose, a small cylindric space is left vacant round the axis; that is, the central line is tubular. The fire-workers call this space the soul of the rocket (*âme de la fusée*). On account of its somewhat conical form, hollow rods, adjustable to different sizes of broaches or skewers, are required in packing the charge; which must be done while the cartridge is sustained by its outside mould, or copper cylinder. The composition of sky-rockets is as follows:—

When the bore is - -	$\frac{3}{4}$ of an inch;	$\frac{3}{4}$ to 1;	$1\frac{2}{3}$.
Nitre - - - -	16	16	16
Charcoal - - -	7	8	2
Sulphur - - -	4	4	4
Brilliant Fire.			
Nitre - - - -	16	16	16
Charcoal - - -	6	7	8
Sulphur - - -	4	4	4
Fine steel filings - -	3	4	5
Chinese Fire.			
Nitre - - - -	16	16	16
Charcoal - - -	4	5	6
Sulphur - - -	3	3	4
Fine borings of cast iron	3 coarser	4 mixed	5

The cartridge being charged as above described, the *pot* must be adjusted to it, with the *garniture;* that is, the serpents, the crackers, the stars, the showers of fire, &c. The pot is a tube of pasteboard wider than the body of the rocket, and about one-third of its length. After being strangled at the bottom like the mouth of a phial, it is attached to the end of the fusee by means of twine and paste. These are afterwards covered with paper. The garniture is introduced by the neck, and a paper plug is laid over it. The whole is enclosed within a tube of pasteboard terminating in a cone, which is firmly pasted to the pot. The quick-match is now finally inserted into the *soul* of the rocket. The rod attached to the end of the sky-rockets to direct their flight, is made of willow or any other light wood. M. Ruggieri replaced the rod by conical wings containing explosive materials, and thereby made them fly further and straighter.

The *garnitures* of the sky-rocket pots are the following:—

1. *Stars* are small, round, or cubic solids, made with one of the following compositions, and soaked in spirits. *White stars:* nitre, 16; sulphur, 8; gunpowder, 3. Others more vivid consist of nitre, 16; sulphur, 7; gunpowder, 4.

Stars for golden showers: nitre, 16; sulphur, 10; charcoal, 4; gunpowder, 16; lampblack, 2. Others yellower are made with nitre, 16; sulphur, 8; charcoal, 2; lampblack, 2; gunpowder, 8.

The serpents are small fusees made with one or two cards; their bore being less than half an inch. The *lardons* are a little larger, and have three cards; the *vetilles* are smaller. Their composition is, nitre, 16; charcoal, not too fine, 2; gunpowder, 4; sulphur, 4; fine steel filings, 6.

The *petards* are cartridges filled with gunpowder and strangled.

The *saxons* are cartridges clayed at each end, charged with the brilliant turning fire, and perforated with one or two holes at the extremity of the same diameter.

The *cracker* is a round or square box of pasteboard, filled with granulated gunpowder, and hooped all round with twine.

Roman candles are fusees which throw out very bright stars in succession. With the composition (as under) imbued with spirits and gum-water, small cylindric masses are made, pierced with a hole in their centre. These bodies, when kindled and projected into the air, form the stars. There is first put into the cartridge a charge of fine gunpowder of the size of the star; above this charge a star is placed; then a charge of composition for the Roman candles.

The *stars*, when less than $\frac{3}{4}$ of an inch, consist of nitre, 16; sulphur, 7; gunpowder, 5. When larger, of nitre, 16; sulphur, 8; gunpowder, 8.

Roman candles, nitre, 16; charcoal 6; sulphur, 3. When above $\frac{3}{4}$ of an inch, nitre, 16; charcoal, 8; sulphur, 6.

The *girandes*, or bouquets, are those beautiful pieces which usually conclude a firework exhibition; when a multitude of jets seem to emblazon the sky in every direction, and then fall in golden showers. This effect is produced by distributing a number of cases open at top, each containing 140 sky-rockets, communicating with one another by quick-match strings planted among them. The several cases communicate with each other by *conduits*, whereby they take fire simultaneously, and produce a volcanic display.

The *water fire-works* are prepared like the rest; but they must be floated either by wooden bowls, or by discs and hollow cartridges fitted to them.

Blue fire for lances may be made with nitre, 16; antimony, 8; very fine zinc filings, 4; Chinese paste for the stars of Roman candles, bombs, &c.:—Sulphur, 16; nitre, 4; gunpowder meal, 12; camphor, 1; linseed oil, 1; the mixture being moistened with spirits.

The *feu grégois* of Ruggieri, the son:—Nitre, 4, sulphur, 2; naphtha, 1.

The red fire composition is made by fixing 40 parts of nitrate of strontia, 13 of flowers of sulphur, 5 of chlorate of potash, and 4 of sulphuret of antimony.

White fire is produced by igniting a mixture of 48 parts of nitre; $13\frac{1}{4}$ sulphur; $7\frac{1}{4}$ sulphuret of antimony; or, 24 nitre, 7 sulphur, 2 realgar; or, 75 nitre, 24 sulphur, 1 charcoal; or, finally, 100 of gunpowder meal; and 25 of cast-iron fine borings.

The blue fire composition is, 4 parts of gunpowder meal; 2 of nitre; sulphur and zinc, each 3 parts.

Mr. A. H. Church has published the following very interesting process for the production of coloured flames:—Bibulous paper soaked for ten minutes in a mixture of 4 parts by measure of oil of vitriol with 5 parts of strong fuming nitric acid, and then wash out thoroughly with warm distilled water, is to be dried at a gentle heat. The gun-paper thus prepared is then saturated with chlorate of strontium, with chlorate of barium, or with nitrate of potassium, by immersion in a warm solution of these salts; a solution of chlorate of copper also may be used. If, after complete drying, a small pellet of any of these papers be made, lighted at one point at a flame, and then thrown into the air, a flash of intensely-coloured light is produced, while the combustion is so perfect that there is no perceptible ash. The barium salt gives a beautiful green light, the strontium salt a crimson, the potassium salt a violet, and the copper salt a fine blue. The chlorate may be prepared sufficiently pure for these experiments by mixing warm solutions of the chlorides of barium, strontium, or copper, with an equivalent quantity of a warm solution of chlorate of potassium. The clear liquid is to be poured off the precipitated chloride of potassium, and employed for the saturation of different portions of the gun-paper. The foregoing makes an admirable lecture-experiment, for illustrating the colours imparted to flame by barium, strontium, and other salts.

PYROMETER. An instrument employed to measure temperatures which are too high to be determined by any thermometer. Some pyrometers have been constructed of bars of metal; the rates of expansion of which are known, and by which, therefore, any high degree of heat could be, with some precision, determined. The pyrometer of Wedgwood has been much employed; but it is still a defective instrument. It consists of two slightly convergent pieces of copper, between which a small cylinder of clay is set; the latter contracts by the heat, and the convergence is therefore increased. Its amount being measured, the heat to which the cylinder has been exposed can be calculated.

A good pyrometer is an instrument much wanted.

PYROPE, *Bohemian Garnet.* From the mountain on the south side of Bohemia, imbedded in trap tufa. It occurs also at Toblitz, in Saxony, in serpentine.

PYROPHORUS. The generic name of any chemical preparation which inflames spontaneously on exposure to the air. The sulphide of potassium is a good example of this when it is prepared with lampblack, in the place of charcoal.

PYROXANTHINE. A substance detected in pyroxylic spirit by Mr. Scanlan. He thus describes this compound:—

If potash water be added to raw wood-spirit (*pyroligneous*), as long as it throws down anything, a precipitate is produced, which is *pyroxanthine*, mixed with tarry matter. The precipitate is to be collected on a filter cloth, and submitted to a 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 pyroxyline is left nearly pure. If it be dissolved in boiling alcohol, or hot oil of turpentine, it crystallises 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 ferroprussiate 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 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.

Pyroxanthine consists, according to the analysis of Drs. Apjohn and Gregory, of carbon, 75·275; hydrogen, 5·609; oxygen, 19·116, in 100 parts.

PYROXILIC SPIRIT. *Syn. Pyroligneous spirit, Pyroligneous ether, Wood-spirit, Wood-naphtha, Methylic alcohol, Hydrate of methyle, Hydrated oxide of methyle.* $C^2H^4O^2 = C^2H^3O,HO$. Density of strongest wood-spirit at 32°, 0·8179. Density at 68°, 0·798. Density of vapour, 1·12 = 4 volumes. Boiling-point, 150° F.

Wood-spirit was first recognised as a distinct substance by Taylor, in 1812. Its true nature, however, was unknown until the appearance of the important research of MM. Dumas and Peligot, in 1835.

Pyroxilic spirit is obtained from the liquid products of the distillation of wood by taking advantage of its superior volatility. The crude wood-vinegar, if distilled *per se*, yields up to a certain point highly impure and weak spirit. It is, however, free from ammonia and alkaloids. If, on the other hand, the vinegar is first neutralised by lime or soda previous to the distillation of the spirit, it is rendered more free from acetate of methyle and some other impurities, but it then contains alkaloids and ammonia. At times the quantity of the latter substance present is so large that the spirit smokes strongly on the approach of a rod dipped in hydrochloric or acetic acid. In order to apply this test it is obvious that the hydrochloric acid must be diluted until it does not fume by itself. By repeated rectifications over lime or chalk, rejecting the latter portions, the wood-spirit may be obtained colourless, and of a strength varying from 80 to 90 per cent. of pure spirit, the specific gravity being from 0·870 to 0·830.

Inasmuch as wood-spirit boils at a temperature far less than the point of ebullition of the impurities ordinarily found in it, it may always be greatly improved in solvent power, appearance, and odour, by mere rectification on the water bath or in a rectifying still. But, nevertheless, a certain quantity of the more volatile impurities always accompany the methylic alcohol, being carried over with its vapour. Among the foreign bodies may be mentioned the hydrocarbons of the benzole series. These may be entirely removed by mixing the crude spirit with three or four times its volume of water; the hydrocarbons are thus rendered insoluble and rise to the surface of the fluid. By means of a separator the lower layer may be removed, and after two or three rectifications, at as low a temperature as possible, the spirit may be procured quite clean.

To obtain wood-spirit quite pure it is generally recommended to mix it with chloride of calcium, and again rectify on a steam or water bath. By operating in this manner, the methylic alcohol combines with the chloride of calcium, forming a compound not decomposable at the temperature of the water bath. The impurities present therefore distil away, leaving in the still a compound of pure methylic alcohol with chloride of calcium. But this latter compound possesses little stability, and may be decomposed by the mere addition of water, which liberates the spirit. It is then to be distilled away from the salt, and after one or two rectifications over quicklime will be quite pure.

It is highly important that wood-spirit should be of considerable purity if required for the purpose of dissolving the gums. It is true, that as far as its use for dissolving shellac is concerned, there is no need for extreme purity, as shellac will dissolve in most specimens of wood-spirit. But it is not in this case the mere solvent power that is required; for if a solution of shellac in impure wood-spirit be employed by hatters, the vapour evolved is so irritating to the eyes that the workmen are unable to proceed. If the spirit has the property of fuming on the approach of a rod dipped in acetic or hydrochloric acids, it may be taken for granted that it will be incapable of dissolving gum sandarach. This arises from the fact that such spirit has been distilled from an alkaline base, such as lime or soda, and contains alkaloids, ammonia, and various other impurities which destroy its solvent power. The alkaline reaction may be destroyed and the spirit rendered fit for use by adding 2 or 3 per cent. of sulphuric acid and tnen distilling. The alkaloids and many other impurities will then be retained, and the spirit may either be used at once or still further purified by dilution with water and subsequent rectification. It is possible to combine the two processes at one operation, by diluting the spirit with four times its bulk of water, and adding just enough oil of vitriol to the diluted liquid to give it a faint acid reaction to litmus paper. It is absolutely essential to the success of this process that the mixture of spirit water and acid be perfectly well mixed.

A wood-spirit which refuses to dissolve sandarach may often be rendered a good solvent by adding from 5 to 7 per cent. of acetone. See ACETONE.

When wood-spirit is required in a state of extreme purity for the purpose of research, it may be obtained by distilling oxalate of methyle with water. Oxalate of methyle, or methyle oxalic ether may be obtained by distilling equal parts of sulphuric acid, oxalic acid, and wood-spirit. The distillate when evaporated very gently yields crystals of the compound in question. As it does not volatilise below 322° F., the retort containing the materials for its preparation requires to be pretty strongly heated to bring the ether over. It may be purified by sublimation from oxide of lead.

Pure methylic alcohol is a colourless transparent liquid, neutral, very inflammable, burning with a blue flame like common alcohol. It has a very nauseous flavour, and is fiery in the mouth. It dissolves in any proportion in water, alcohol, or ether, and is a good solvent for fatty bodies and certain resins. It is miscible with essential oils.

Wood-spirit may be detected, according to Dr. Ure, even when greatly diluted with alcohol, by the brown colour which it assumes in presence of solid caustic potash. Even when alcohol contains only 2 per cent. of wood-spirit, it acquires a yellow tint in 10 minutes on addition of powdered caustic potash. In half an hour the colour becomes brown.

According to Mr. Maurice Scanlan, wood-spirit may be distinguished from acetone (with which it appears to have sometimes been confounded in medicine), by the action of a saturated solution of chloride of calcium, which readily mixes with the former, but separates immediately from the latter.

Wood-spirit is but seldom employed now in the arts, as it is generally cheaper and more convenient to use the mixture of 90 parts of spirit of wine with 10 parts of purified wood-spirit, which is now permitted by Government to be employed free of duty under the title of "methylated spirit." See METHYLATED SPIRIT.

The theoretical constitution of methylic alcohol is of course represented differently by various chemists. The radical theory regards it as the hydrated oxide of methyle. The formula being C^2H^3O,HO. Another theory assumes it to be methylene (or the olefiant gas of the methyle series), plus two equivalents of water: thus, $C^2H^2,2HO$. But the most convenient method of viewing it is, perhaps, by using the water type, and considering it as two equivalents of water in which one atom of hydrogen is replaced by methyle, thus:—

$$\left.\begin{matrix} C^2H^3 \\ H \end{matrix}\right\} O^2$$

This method of regarding it has the advantage of enabling us to give a direct and simple definition of alcohols and ethers. Thus, an alcohol may in this manner be defined as two atoms of water in which one atom of hydrogen is replaced by an electro-positive radical, while an ether is to be looked upon as two atoms of water in which both atoms of hydrogen are replaced by the electro-positive radical.

Methylic alcohol, treated with solution of bleaching powder, yields chloroform, but the resulting product is not so fine as that prepared from the vinic alcohol. In fact, methylic alcohol is seldom or never found in commerce of such purity as to enable good chloroform to be prepared by the action of chloride of lime. Moreover it should be mentioned that so acrid and pungent are the products of the action of chlorine on the bodies accompanying crude wood-spirit, that great danger would be incurred in using a chloroform containing even minute traces of them. The following equation represents the action of the chlorine of the bleaching powder on wood-spirit:—

$$\underbrace{C^2H^4O^2}_{\text{Wood spirit.}} + 4Cl = \underbrace{C^2HCl^3}_{\text{Chloroform.}} + 2HO + HCl.$$

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			Under proof.
·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	28·80
·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			

The above table contains the percentages of pure wood-spirit of the specific gravity 0·8136 in various mixtures. The temperature at which the experiments must be made to correspond with the above table being 60° F.

According to M. Deville, the above table is not absolutely correct, the spirit used by Dr. Ure not being entirely free from water. M. Deville's numbers are as follows:

Specific gravity.	Percentage of wood-spirit.
0·8070	100
0·8371	90
0·8619	80
0·8873	70
0·9072	60
0·9232	50
0·9429	40
0·9576	30
0·9709	20
0·9751	10
0·9857	5

Wood-spirit unites with chloride of calcium with such energy that the liquid enters into ebullition. The product of the union is sufficiently stable to endure a heat considerably above the boiling-point of water, without giving off the alcohol. Water, however, destroys the compound, and enables the spirit to be distilled away on the water bath. — C. G. W.

PYROXYLINE is one of the names given to gun-cotton.

PYRROL. C^8H^5N. A volatile organic base, discovered in coal naphtha by Rungé. It has been chiefly studied by Dr. Anderson. Its vapour possesses the singular property of dyeing fir-wood moistened with hydrochloric acid, a deep red. It appears to be formed whenever animal or vegetable matters containing nitrogen are distilled.—C. G. W.

Q.

QUANNET, THE. A kind of file. It is especially used for scraping zinc plates for the process denominated anastatic printing.

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. Flint, Silex. Pure silica in the insoluble state. Quartz includes as sub-species, *Amethyst*, *Rock-crystal*, *Rose-quartz*, *Prase* or *Chrysoprase*, and several varieties of chalcedony, 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.

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. Turbith's mineral; the 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 developes from it, by degrees, a beautiful yellow dye. See CALICO-PRINTING and YELLOW DYE.

QUICKLIME. See LIME.

QUICKSILVER. See MERCURY.

QUILL. See FEATHERS.

QUINIDINE is one of the alkaloids obtained from the cinchona barks, and is found in most of them. The quantity, however, varies with the quality of the bark; *Cinchona calisaya*, or *yellow bark*, which is the most prized, containing *quinine*, with but little, if any, *quinidine*, while some of the Loxa barks contain *quinidine*, and some *cinchonine*, and little or no *quinine;* such are the H.O. Crown barks.

Quinidine was discovered in 1833 by MM.Henry and Delandre. It has the same composition as quinine, $C^{40}H^{24}N^{2}O^{4}$, but is nevertheless a distinct alkaloid.

It is obtained from the barks containing it in the same manner as quinine from the quinine-yielding barks; and owing to the employment of the inferior barks in the manufacture of this latter alkaloid or its sulphate, some quinidine is always present in it, but from the greater solubility of the salts of quinidine, they principally remain in the mother liquors, from which the sulphate of quinine has crystallised.

Van Heijningen (*Gerhardt's Chemie Organique*), gives the following description of quinidine:—" When crystallised from its ethereal solution, it yields crystals, which are oblique rhombic prisms, perfectly transparent, but which effloresce in the air, becoming opaque. They contain 4 atoms = 10·8 per cent. of water of crystallisation. It fuses at 320° F., and, on cooling, becomes a resinoid mass. It requires for solution 1,500 parts of cold water, 750 parts of boiling-water, 45 parts of cold absolute alcohol, 3·7 parts of hot ordinary alcohol, and 90 parts of cold ether." Gerhardt states also that its solution yields with chlorine and ammonia the same green colour as quinine. The alcoholic solution of quinidine turns the plane of polarisation strongly to the right, while quinine turns it powerfully to the left.

Finding that Pereira did not agree in any point with Van Heijningen, I determined to make some experiments on quinidine myself, in which I was greatly assisted by the kindness of Messrs. Howard and Sons, who placed at my disposal some of the purest quinidine they had ever prepared. The results are as follows, and will be found to agree closely with those of Van Heijningen.

I found that the sample I experimented on required for solution 3,500 parts of water at 60° F., 750 parts of boiling-water, 30 parts of ordinary alcohol at 60° F., and 60 parts of cold ether. By the spontaneous evaporation of its alcoholic solution it yielded clear crystals, possessing a brilliant lustre, but became opaque by exposure to the air. They contained 4 atoms of water of crystallisation. When treated with chlorine and then ammonia, it yielded the same green colour as quinine does under the same circumstances. It crystallises readily from water, alcohol, or ether, when the hot saturated solutions are allowed to cool. By the application of heat it first fuses, and, by raising the heat, decomposes, yielding an odour of bitter almonds.

Quinidine, like quinine and cinchonine, forms two kinds of salts; the one neutral, the other acid.

The neutral sulphate, $C^{40}H^{24}N^2O^4HSO^4 + 10$ aq., very much resembles sulphate of quinine. It crystallises in long, silky, shining, acicular crystals, but which are somewhat more downy than the sulphate of quinine. It requires for solution 350 parts of water at 50° F., and 32 parts of absolute alcohol. At 266° F. it loses 15·6 per cent. of water of crystallisation = 6 atoms. Its solution is fluorescent, like that of quinine.

The acid or bisulphate, $C^{40}H^{24}N^2O^4,2HSO^4 + 12$ aq. This salt is obtained by adding sulphuric acid to the neutral sulphate, and crystallising. It consists of an asbestos-like mass of fine acicular crystals, which are very soluble in water.

Quinidine may in some degree be distinguished from quinine by the difference of solubility of the neutral oxalates; that of quinine being but little soluble in water, while that of quinidine is very soluble.—H. K. B.

QUININE. This alkaloid is found, together with four other alkaloids, in the cinchona barks, of which there are numerous varieties, some containing principally *quinine*, as the *Calisaya* or yellow bark, which is the most valuable of all the barks on that account; others containing principally *quinidine* and *cinchonine*, with but little *quinine*.

Quinine is the principal of these alkaloids, and is now manufactured on a very large scale for medicinal purposes, it being a valuable tonic and febrifuge.

It was usually prepared from the *C. calisaya*, but, owing to the scarcity and high price of this bark, several of the inferior barks have been employed in its manufacture, and on that account the quinine of commerce frequently contains some of the other alkaloids. The sulphate is the only salt of quinine which is manufactured for commercial purposes, and is generally known, though improperly, as "Disulphate of quinine."

The following is the process most generally followed in the manufacture of this salt. The coarsely-powdered bark is digested with hot dilute sulphuric or hydrochloric acid for one or two hours; the liquor is strained off, and the bark treated with a fresh portion of still more dilute acid for the same time. This process may be repeated a third time, but the liquor then obtained, containing so little quinine, is used for a fresh portion of bark. The liquors from the first and second digestion are strained and mixed, and are then mixed with lime, magnesia, or carbonate of soda, until the liquid acquires a slight alkaline reaction, which may be known by its turning red litmus paper blue. Owing to the solubility of quinine, to a certain extent, in milk of lime and chloride of calcium, carbonate of soda is the best to be used for this purpose. A precipitate is formed, which is separated from the supernatant liquid by straining through a cloth. This dark-coloured mass, which contains the alkaloids, colouring matter, some lime, and some sulphate of lime,—these latter, of course, only when both lime and sulphuric acid have been used in the process,—is treated with boiling ordinary alcohol, which dissolves the alkaloids and colouring matter. This solution is filtered, and the greater part of the alcohol removed by distillation, when a brown viscid mass remains; this is treated with dilute sulphuric acid, till the solution remains slightly acid; this solution is then digested with animal charcoal, filtered, evaporated, and allowed to cool, when the sulphate of quinine crystallises out, together with some sulphate of quinidine or cinchonine, according to the barks which have been employed; but, owing to the greater solubility of these latter salts than the sulphate of quinine, they principally remain in the mother liquors. When *pure* animal charcoal has not been used, the sulphate of quinine is likely to be contaminated with some sulphate of lime, formed by the action of the sulphuric acid on the lime in the animal charcoal; and in this process also some quinine is likely to be precipitated by the lime and lost in the animal charcoal.

In order to separate the sulphate of quinine thus obtained from the sulphates of quinidine and cinchonine, advantage is taken of the greater solubility of the two latter salts, as above mentioned, and by several crystallisations the sulphate of quinine may be obtained nearly free from these salts. The quantity of sulphate of quinine obtained from each pound of bark of course varies with the bark used. Some of the best calisaya bark will yield half an ounce of the sulphate from every pound of bark, while many other barks which are used in the manufacture of sulphate of quinine do not yield a quarter of an ounce.

A process has been patented by Mr. Edward Herring for the manufacture of sulphate of quinine without the use of alcohol, and it yields the article known as hospital sulphate of quinine at the first crystallisation and without the use of animal charcoal. The following is the outline of the process:—

The powdered bark is boiled in solution of caustic alkali (soda preferred), which removes the useless extractive gummy matters and colouring matter. After being well boiled, the bark is washed and pressed. This process of boiling with alkali, &c., may be repeated, if necessary, and the bark, after being well washed and pressed, having become decolourised, is boiled with dilute sulphuric acid, being kept constantly stirred whilst boiling. After the separation of the liquid, the bark is boiled with a second portion of dilute acid, and sometimes with a third; but the liquid from the last boiling is kept to be used for a fresh portion of bark. The first and second portions are mixed, strained, and treated with soda, which precipitates the alkaloids; the precipitate is washed and pressed, and then digested with dilute sulphuric acid, which dissolves the alkaloids; this solution is evaporated and allowed to cool, when the sulphate of quinine crystallises out, accompanied with some sulphates of quinidine and cinchonine, if the bark employed contained these latter alkaloids in any quantity. The sulphate of quinine thus obtained is dried, and forms the unbleached or hospital quinine. When the sulphate of quinine is required quite pure, this is treated with *pure* animal charcoal, and subjected to two or three further crystallisations.

It will be seen that the principal points in this process are the extraction of the colouring matter by the caustic alkali and the use of *pure* animal charcoal in producing the perfectly white sulphate, which prevents completely the admixture of sulphate of lime with the sulphate of quinine.

This process yields from 80 to 90 per cent. of the quinine contained in the bark employed; and to obtain the remaining 10 or 20 per cent. the blood-red solutions formed by boiling the bark with the caustic alkali are treated with dilute hydrochloric acid in excess, which retains in solution any alkaloids that are present. This solution is strained and mixed with lime. The precipitate thus formed is collected, pressed, dried, and powdered.

It is then digested with *benzol*, or any solvent which is not a solvent of lime. These various tinctures or preparations are well agitated with dilute sulphuric acid, which extracts the quinine, &c.; when allowed to settle, the *benzol*, *oil of turpentine*, or *lard*, whichever has been used, rises to the surface. The acid liquid is then siphoned off and evaporated, and the sulphate of quinine obtained from it is purified by two or three crystallisations, when it yields a salt equal to that obtained by the first process, viz. the unbleached or hospital sulphate of quinine.

The sulphate of quinine of commerce is the neutral sulphate, and has the following composition:

$$2C^{40}H^{24}N^{2}O^{4},2HSO^{4} + 14\ aq.$$

When pure it occurs as white spangles, or slender needles, which are slightly flexible, and possess a pearly lustre and an intensely bitter taste. It effloresces in the air, and loses about 12 atoms of water (*Baup*). It requires for solution, 740 parts of cold water and 30 parts of boiling water, 60 parts of alcohol at ordinary temperatures, and much less of boiling alcohol.

Its solution in acidulated water turns the plane of polarisation strongly to the left, and presents a blue tint, which is due to a peculiar refraction of the rays of light on the first surface of the solution, and is termed *fluorescence* by Professor Stokes, who, as well as Sir John Herschel, has examined the cause of it, the latter referring it to epipolic dispersion.

Heated to 212° F., sulphate of quinine becomes luminous, which is augmented by friction, and the rubbed body is found to be charged with vitreous electricity, sensible to the electroscope. It fuses easily, and in that state resembles fused wax; at a higher temperature it assumes a red colour, and at length becomes charred. When a solution of quinine is treated with chlorine and ammonia, it yields a bright green solution, very characteristic of quinine.

Besides the neutral sulphate, there exists an acid sulphate, or *bisulphate*, of the following composition:

$$C^{40}H^{24}N^{2}O^{4},2HSO^{4} + 16HO.$$

It is formed by dissolving the neutral sulphate in dilute sulphuric acid, evaporating and crystallising. It crystallises in rectangular prisms, or silky needles. It is much more soluble in water than the neutral sulphate, requiring only 11 parts of water at ordinary temperatures to dissolve it. The solution reddens blue litmus paper.

It fuses in its water of crystallisation, and at 212° F. loses 24·6 per cent. of water (*Liebig* and *Baup*). With sulphate of sesquioxide of iron, it forms a double salt, which crystallises in octahedra resembling those of alum.

An interesting compound of iodine and bisulphate of quinine has been discovered by Dr. Herapath, which crystallises in large plates, and by reflected light presents an emerald green colour and a metallic lustre, but by transmitted light appears almost colourless. The point of interest in this compound is, that its crystals have the same effect upon a ray of light as plates of *tourmaline*, and have even been used instead of this latter substance.

Its composition is: $C^{40}H^{24}N^2O^4,I^2,2HSO^4 + 10$ aq.

It may be obtained by dissolving the bisulphate of quinine in concentrated acetic acid, and adding to the heated liquid an alcoholic solution of iodine, drop by drop. After standing a few hours, the salt is deposited in large flat rectangular plates.

Adulteration of sulphate of quinine.—Owing to the high price of sulphate of quinine, it is often adulterated with various substances, as alkaline and earthy salts, boracic acid, sugar, starch, mannite margaric acid, salicine, sulphates of cinchonine and quinidine; the two latter substances will be found in most of the commercial sulphate of quinine, and are not looked upon as fraudulent mixtures when present only in small quantities, arising then from the imperfect purification of the sulphate of quinine. Sometimes, however, sulphate of cinchonine is present in large quantities, and this is effected by briskly stirring the solution from which the sulphate of quinine is crystallising, when, although under other circumstances the sulphate of cinchonine would remain in solution, it will by this agitation be deposited in a pulverulent form, together with the sulphate of quinine. No doubt this fraud has been practised to a considerable extent.

The inorganic substances may be easily detected by incinerating some of the suspected salt, when they will be left as ash. When some of the suspected sample is dissolved in dilute sulphuric acid, the margaric acid would remain undissolved; if we then add to the solution a slight excess of baryta water, the sulphuric acid and quinine will be precipitated; the excess of baryta is preciptated by carbonic acid, the solution is then boiled and filtered, when the sugar, mannite, and salicine remain in solution, and may be detected afterwards. The presence of salicine may be detected directly in sulphate of quinine by the addition of sulphuric acid, when it becomes red if salicine be present. Starch is detected by solution of iodine, with which it forms a deep blue compound. Boracic acid is dissolved by alcohol, and is recognised by the green tinge given to the flame of the ignited alcohol. For the discovery of cinchonine, several processes have been proposed. The one most generally adopted, and perhaps the best, is that known as Liebig's process, which depends on the difference of solubility, in ether, of quinine and cinchonine. It consists in putting into a test tube 10 grains of the sulphate of quinine with 120 grains of ether, then adding 10 or 20 drops of caustic ammonia; it is then briskly shaken. If the sulphate of quinine under examination contains no cinchonine, we obtain two layers of liquids, the one of water containing sulphate of ammonia, and the other ether holding the quinine in solution; if the salt contained cinchonine, this would remain suspended at the surface of the watery layer. The same process will detect quinidine also when present in quantities exceeding 10 per cent. of the sulphate of quinine; but the great distinction between quinine and quinidine is their deportment with oxalate of ammonia, this re-agent causing in a solution of sulphate of quinine, a precipitate of oxalate of quinine, whereas the oxalate of quinidine, being very soluble in water, no precipitate is formed by the addition of oxalate of ammonia to a solution of its salt.

Determination of the quantity of quinine in samples of cinchona barks.

In commerce the value of a cinchona bark depends on the quantity of *crystallisable quinine* which it will yield; it is therefore not sufficient to determine the amount of quinine which it contains, as the whole of this may not be convertible into crystallisable sulphates. In order to be accurate not less than a pound of bark should be used, and even then the result is often from ⅛th to ¼th less than can be obtained on the large scale, where the loss in the process is much less in proportion (*Pereira*).

Several processes have been employed for determining the quantities of alkaloids in cinchona barks.

Perhaps as good a process as any is, to exhaust a known quantity of bark by boiling with dilute acid; the solution is filtered, and the residue washed, the washings being added to the other liquid; it is then digested with *pure* animal charcoal, the solution again filtered, and the alkaloids precipitated by carbonate of soda; they are then collected, dried, and digested with ether to separate the quinine; after the evaporation of the ethereal solution, the quinine is dissolved in dilute sulphuric acid, the solution is evaporated, *exactly* neutralised by ammonia, and allowed to cool, when the sulphate of quinine crystallises, which is collected, dried, and weighed; the quantity of the mother liquor being, of course, a cold saturated solution of sulphate of quinine, and knowing the solubility of sulphate of quinine in water, the quantity remaining in the solution may be determined and added to the former weight.—H. K. B.

R.

RAFFAELLE WARE. A fine kind of Majolica ware. This pottery was made in the city of Urbino, and the designs for many of the pieces were "furnished by the scholars of Raffaelle from the original drawings of their great master," and hence the name. (*Marryatt.*) See POTTERY.

RAGS. The fragments and shreds of linen, cotton, or woollen fabrics. Linen and cotton rags are collected from all quarters for the purpose of making paper pulp. The quantity imported annually is seldom less than 11,000 tons. Woollen rags of every kind are worked up into *mungo* and *shoddy*. (See these terms.) Coarse cloths and druggets are made of them; and the fine dust of woollen rags is used in preparing the beautiful flock papers with which our rooms are decorated. They are also used largely for manure. All the early broccoli which are brought to the London market from the western part of Cornwall, are dressed with woollen rags in preference to any other manure.

Rags and other materials for making paper and other purposes, imported in 1858.

	Tons.	Computed real value. £
Rags, woollen	2,994	27,740
Ditto, pulp of	15	446
From Russia	1,668	35,549
Prussia	4,048	86,278
Bremen	294	6,276
Hamburg	3,073	65,488
Holland	135	2,888
Tuscany	508	12,954
Papal States	397	9,341
Austrian Italy	213	5,005
British East Indies	176	3,751
Australia	379	8,077
Other parts	488	10,526
	11,379	£246,133

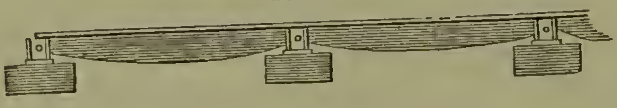
RAG-STONE. A variety of hone slate used for sharpening steel instruments upon. The Norway rag-stone is well known.

RAILS. The manufacture of iron rails has, with the extension of our railway system, increased in a remarkable manner. This is, however, rather a subject for a treatise on mechanical engineering, than for a Dictionary of Manufactures. A short notice only will therefore be given.

In 1820, Mr. Birkinshaw patented an improvement in the form of hammered iron rail. The malleable iron rails previously used were bars from two to three feet long, and one to two inches square; but either the narrowness of the surface produced such injury to the wheels, or by increasing the breadth their cost became so great, as to exceed that of cast iron, which consequently was preferred.

It was to remedy these defects in the malleable form, and at the same time to secure the same strength as the cast iron, that Mr. Birkinshaw made his rails in the form of prisms, or similar in shape to the cast-iron ones of the most approved character.

1536



1538

1537

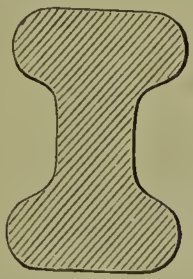
Fig. 1536 shows a side view of this kind of rail; *fig.* 1537, a plan, and *fig.* 1538, a section of the same rail cut through the middle.

These rails are made by passing bars of iron, when red hot, through rollers with indentations or grooves in their peripheries, corresponding to the intended shape of the rails; the rails thus formed present the same surface to the bearing of the wheels, and their depths being regulated according to the distance from the point of bearing, they also present the strongest form of section with the least material. See ROLLING MILLS.

Malleable iron rails are now always employed. An objection has been urged against these rails on the ground that the weight on the wheels rolling on them expanded their upper surface, and caused it to separate in thin laminæ. In many of our large stations rails may be frequently seen in this state; layer after layer breaking off, but this may be regarded rather as an example of defective manufacture than anything else. It is true, Professor Tyndal has referred to those laminating rails, as examples in proof of his hypothesis, that lamination is always due to, and is always produced by, mechanical pressure upon a body which has freedom to move laterally. Careful examination, however, convinces the writer that whenever lamination of the rail becomes evident, it can be traced to the imperfect welding together of the bars of which the rail is formed.

The weight of railway bars varies according to section and length. There are some of 40 pounds per yard, and some of 80 pounds, almost every railway company employing bars of different weight. Beside flat rails, which are occasionally still used, we have bridge rails employed, which have the form of a reversed U. These have sometimes parallel sides, or, as in dovetail rails, the sides are contracted. The ∩-rails are more easily manufactured than the I-rails, the difficulty of filing the flanges not being so great as in the latter rail.

1539



1540

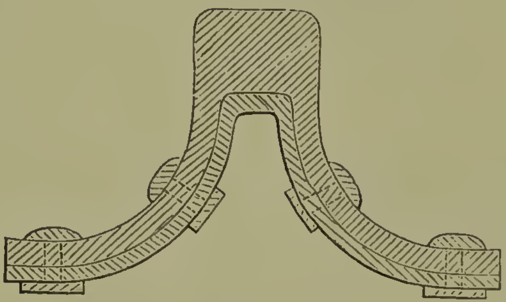


Fig. 1539 represents the old rail, and *fig.* 1540, Mr. W. H. Barlow's patent rail, which is made to form its own continuous bearing. In section this rail somewhat resembles an inverted V, with its ends considerably turned outwards. This portion forms the surface by which the rail bears upon the ballasting, the apex of the Λ being formed with flanges in the ordinary form of rails; and the rail, therefore, beds throughout on the ballast. It can be very easily packed up and adjusted when out of place, and all the fittings of sleepers, chairs, and keys, are done away with, nothing being required besides the rails themselves, except a cross or tie-rod at the joints, to hold them at the proper distance asunder, so as to keep the gauge of the line.

RAKE VEIN, *in Mining*. A vein cutting indifferently through all the strata; under some circumstances they are known as *gash veins* and *slip veins*.

RAISINS are grapes allowed to ripen and dry upon the vine. The best come from the south of Europe, as from Roqueviare, 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. These are *muscatels* or *blooms*. The raisins called *lexias*, are plucked, cleansed, and dipped for a few seconds in a boiling lye of woodashes and quicklime, at 12° or 13° 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.

Valentia raisins are prepared by steeping them in boiling water, to which a lye of vine stems has been added.

Corinthian raisins or *currants* are obtained from a remarkably small variety of grape, called the *black corinth.* They are now grown in Zante, Cephalonia, and Patras.

Our *imports*, in 1858, were as follows:—

Imports of Raisins and Currants, 1858.

Raisins.	Cwts.	Computed real value. £
Spain	287,725	393,064
Two Sicilies	1,833	3,583
Austrian Italy	1,870	2,321
Turkey Proper	56,941	109,290
Syria and Palestine	2,778	4,735
United States	1,402	2,803
Gibraltar	1,479	1,662
British East Indies	1,091	1,093
Other parts	2,366	3,296
	357,485	£521,847

Currants.	Cwts.	£
Hamburg	1,856	2,220
Holland	3,458	3,459
Austrian Italy	24,494	28,640
Greece	455,136	607,369
Turkey Proper	3,426	3,402
United States	3,132	3,843
Ionian Islands	89,458	114,862
Other parts	1,420	1,400
	582,380	£756,195

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 reacts 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. *Brassica campestris oleifera.* Summer Rape, Wild, Navew, or Colza. This and the winter rape (*B. napus*) are the only sorts cultivated to any extent in Britain for the manufacture of oil, and growers generally agree that the former of these is to be preferred from its yielding a greater quantity of seed, in the proportion of 955 to 700. (*Lawson.*) See Colza.

RAPE SEED OIL. See Oils.

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; cleaned and finished.

The manufacture of rasps and files does not belong to this work. Those interested in it will find an elaborate description of all the varieties of files, and of their manufacture, in *Turning and Mechanical Manipulation*, by Holtzapffel; and in *Manufactures in Metal*, vol. i., *Iron and Steel*, revised by Robert Hunt.

RASP, MECHANICAL, is the name given by the French to an important machine much used for mashing beet-roots. See SUGAR.

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 Teyssère*. The liquor being boiled and filtered, is flavoured, when cold with spirit of *noyeau*, 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.

RATTANS. The stems of the *Calamus rotang*, of *C. rudentum*, and various species of palms. They are used for caning chairs, as a substitute for whalebone, for walking-sticks, and many other purposes. We *imported* in 1858, 18,625,368 Rattan Canes, valued at 38,960*l.*

RAZORS. The manufacture of razors differs from the manufacture of the finer varieties of cutting instruments, only in the degree of care which is required to produce a perfect instrument.

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 tops, 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. See *Manufactures in Metal*, as revised by Robert Hunt, and *Mechanical Manipulation* by Holtzapffel.

RAZOR HONE. In the manufacturing of the razor, for the first process of setting, the Charnley Forest stone is used, but the principal part of the setting is accomplished almost invariably on the German hone. Various kinds of hones are, however, sold under this name, and they are of course of very various qualities. See HONES.

RAZOR-STROP. "Perhaps for the razor-strop a fine smooth surface of calf-skin, with the grained or hair side outwards, is best. It should be pasted or glued down flat on a slip of wood, and for the dressing almost any extremely fine powder may be used — such as impalpably fine emery, crocus, natural and artificial specular iron, black lead, or the charcoal of wheat straw; * * * combinations of these and other fine powders, mixed with a little grease and wax, have been with more or less mystery applied to the razor-strop. The choice appears nearly immaterial, provided the powders are exceedingly fine, and they are but sparingly used.

"One side of the strop is generally charged with composition; on the other side the leather is left in the natural state, and the finishing stroke is in general given on the plain side." (*Holtzapffel.*) The razor-strop requires to be kept very clean, and it should be very sparingly used.

REALGAR, *Red sulphide of arsenic.* (*Arsenic rouge sulfure*, Fr.; *Rothes 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, Solfaterra near Naples; or sublimed in the shape of stalactites, in the rents and craters of Etna, Vesuvius, and other volcanoes. Specific gravity 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 volatilises easily before the blow-pipe, emitting the garlic smell of arsenic, along with that of sulphurous acid. It consists of 70 parts of arsenic and 30 parts of sulphur. It is employed sometimes as a pigment

Nearly all the commercial realgar is an artificial product, prepared by submitting arsenical pyrites to distillation, or arsenious acid and sulphur in due proportions. It is an energetic poison, more so than the native realgar, from the fact of its containing free arsenious acid. The principal use of realgar is for fireworks, white Indian fire; often used as a signal light; contains 7 parts sulphur, 2 parts realgar, and 24 parts nitre. — H. K. B.

RECTIFICATION is a second distillation of alcoholic liquors, to free them from whatever impurities may have passed over in the first. See ALCOHOL and DISTILLATION.

REDDLE, or RED CHALK. One of the ores of iron having an earthy texture and conchoidal fracture. It is found more or less mixed with earthy matter, and is used for marking sheep in some of the western counties. A fine variety occurs not far from Rotherham, and is employed in grinding spectacle lenses in Sheffield, and Mr. Greg informs us that it is found at Wastwater in Cumberland.

RED LEAD, a pigment formed by exposing litharge to the action of the air at a temperature of about 560°, by which it absorbs oxygen, and is converted into red lead. See Lead.

RED LIQUOR, when prepared by the dyer or printer, is a liquid compound of acetate of alumina, having in it a little sulphate of alumina and potash, and is prepared by dissolving 8 pounds of alum in boiling water, and adding to this a solution of 6 pounds of acetate of lead, and stirring the whole well together. Sulphate of lead is formed and deposited as a heavy mass at the bottom of the liquid. The clear supernatant liquid is red liquor.

Red liquor of commerce is a crude acetate of alumina, prepared from pyroligneous acid (which see, and Calico Printing). Looking upon the composition of this commercial article, and supposing that alumina was the only 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:—

$$Al^2O^3 \begin{cases} +SO^3 \\ +2C^4H^3O^3 \end{cases}$$

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:—

Composition of Four Mordants per Gallon.

Substances.	Formula. $Al^2O^3SO^3,2C^4H^3O^3+NH^3SO^3,HO$.						Formula. $Al^2O^32SO^3,C^4H^3O^3+NH^3SO^3,HO$.			Formula. $Al^2O^3+SO^3,2C^4H^3O^3$.		
	Mordant A.			Mordant B.			Mordant C.			Mordant D.		
	grains.	oz.	grs.	grains.	oz.	grs.	grains.	oz.	grs.	grains.	oz.	grs.
Alumina	1680·0	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	323
Acetic acid	3369·8	7	307	3570 0	8	70	1281·7	2	406	3679·2	8	179
Ammonia and water	·674·1	1	236	·910·0	2	35	·653·1	1	215			

Nevertheless where sulphate of alumina is used, a little ammonia, soda, or potash may be added advantageously for certain colours, giving greater power to the mordant.

From these results it is easy to perceive that the composition of red liquors varies a great deal, 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. The use of the hydrometer should be confined to its legitimate purpose—taking the sp. gr., — and banished as being a test for quality. Let this be found by the chemist, — the calico printer should always know it — and 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 attribute failures to the proper source, as a slight variation in the composition of a mordant will make a great difference in the production of a colour.

RED MARL. *A geological term*, designating the upper members of the new red sandstone formation.

RED OCHRE. An earthy oxide of iron.

REDRUTHITE. A name given, very absurdly, by Brooke and Miller to the vitreous copper of Phillips, from the circumstance that some fine varieties have been found in the mines near Redruth, although much finer are produced by the St. Just mines. The *chalcosine* of Greg and Lettsom, *cuivre sulfure* of Hauy, and the *Kupferglanz* of Haidinger and Naumann. Thomson gives the analysis of a specimen from the united mines in Groennass.

Copper - - - - - - - - -	77·16
Iron - - - - - - - - -	1·45
Sulphur - - - - - - - -	20·62

RED SANDERS WOOD. A hard and heavy wood, which is imported from Calcutta in logs. It is much used as a dyewood, and occasionally for turning.

RED WOOD. A wood used by dyers, which is obtained from the Siberian buckthorn, *Rhamnus arythroxylon.*

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 *sleying*, 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 $\frac{1}{4}$, $\frac{4}{4}$, $\frac{5}{5}$, $\frac{6}{5}$; and the subdivisions by the eighths or sixteenths, or *nails*, as they are usually called, as $\frac{7}{8}$, $\frac{9}{8}$, $\frac{11}{8}$, &c., or $\frac{13}{16}$, $\frac{15}{16}$, $\frac{19}{16}$, &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, $\frac{1}{5}$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 24¼ 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 proportiou of fanciful articles.

The number of threads in the warp of a web is geuerally 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 ¼ 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 $\frac{1}{200}$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 $\frac{1}{200}$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; aud 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 linens, 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 been adopted as the regulator of her cotton manufactures.

REFINING GOLD AND SILVER. Since the object of this book is to treat more especially of the application of scientific processes to commercial undertakings, it would be out of place to give a detailed account of the processes by which gold and silver are refined, or rendered free from other metals. In the laboratory, where chemical manipulation has reached a great way to perfection, the precious metals are separated by nitric acid and other agents, but the processes are far too expensive and tedious to admit of being used upon a large scale.

For the purposes of rendering gold containing foreign metals sufficiently pure for the operations of coining, Mr. Warrington has recently described a process by which fused gold is treated with black oxide of copper, with a view to oxidising those metals which render gold too brittle for manufacture into coin. Mr. Warrington proposes to add to fused gold, which is found to be alloyed with tin, antimony, and arsenic, 10 per cent. of its weight of the black oxide of copper, which, not being fusible, is capable of being stirred up with the fused mass of gold, just as sand may be stirred up with mercury, but with this great advantage, that the oxide of copper contains oxygen, with which it parts readily to oxidise any metal having a greater affinity for oxygen than itself. The metals, once oxidised, become lighter than the fused metal, and mixing mechanically, or combining chemically with the black oxide of copper, float to the surface and are removed. In the execution of Mr. Warrington's proposition, it is imperative to use crucibles free from reducing agents, such as carbon, and it is found that half an hour is sufficient time to allow the contact of the oxide of copper with the fused gold.

It has been generally stated by those supposed to be acquainted with the subject, that gold containing tin, antimony, and arsenic is so brittle as to render it wholly unfit for coining. This requires modification, for although these metals, as well as lead, render gold so brittle that it will readily break between the fingers, yet it is not true to say that it renders gold so brittle as to be incapable of being coined. In June and July, 1859, some brittle gold, to the extent of about 64,000 ounces, passed through the Mint. The bars were so brittle that they broke with the slightest blow from a hammer, but by special treatment the gold was coined into the toughest coins ever produced. It may now be stated that if the system of manufacture be changed to suit the requirements of the case, gold cannot be found too brittle for the purpose of coining. This is simply a matter of fact, but the expense of coining brittle gold is undoubtedly very great; it is therefore wise that Mr. Warrington's plan should be adopted for all gold containing the volatile metals or tin. Osmium-iridium does not render gold brittle. Dr. Percy and Mr. Smith have demonstrated that all metallic substances found in commerce contain traces of gold, which can be separated by carefully conducted chemical processes, and it is found that silver is peculiarly liable to be in alloy with gold, and gold with silver; hence a process of refining which shall effect the separation of as little as one five-hundredth part of gold from its mass of silver, is a matter of the utmost commercial importance.

It is with regret that it is stated that the refineries of London are conducted with such secrecy as to render a full description of any one of them impossible, while the ignorance which will induce the proprietors of these establishments to attempt such quietude is much to be pitied, for, except so far as regards details of interior arrangement, their processes are as well known and understood as it is possible for any manufacture to be.

In Paris (the London refiners are known to use the "French process"), the plan adopted is founded on the fact, that at a high temperature sulphuric acid parts with one equivalent of its oxygen to oxidise an atom of a metal, while the atom of oxide so formed at once combines with another atom of sulphuric acid to form a sulphate. The atom of sulphuric acid which has parted with its atom of oxygen passes off as gaseous sulphurous acid.

If mercury be boiled with sulphuric acid (commonly called oil of vitriol), it is found that it entirely loses its metallic existence, and assumes the form of a dense white salt. This change takes place at the expense of the sulphuric acid, and is shown by the following equation. For explanation sake, call mercury Hg, and sulphuric acid SO^3; if now it is assumed that one part or atom of Hg be boiled with two parts or atoms of SO^3, we have $Hg + SO^3 + SO^3$, and for elucidation we may write SO^3 as equal to $SO^2 + O$; then we have $Hg + O + SO^3 + SO^2$, which, under the influence of heat, become $\underbrace{HgOSO^3}_{\text{a white salt.}} + \underbrace{SO^2}_{\text{gas.}}$

If now the mind substitutes silver for mercury, and so writes Ag instead of Hg, the whole matter will be understood. The silver is dissolved in sulphuric acid just as sugar would be in water, and in this fact we have a valuable means of separating it from gold. If for a moment one imagines a mass of silver alloyed with gold to be represented by a piece of sponge filled with water and frozen, it is well known that if the mass be warmed the ice is melted, and in the form of water filters from the sponge, just so, if a mass of the alloy of the precious metals be boiled in sulphuric acid, the silver is dissolved or washed away, leaving the gold in the form of a sponge, which, as it becomes exposed to the bubbling of the acid, is detached and falls to the bottom of the vessel in which it is boiled.

If by assay the silver to be refined is found to be very rich in gold, it is better to fuse the mass with more silver, so as to produce a mass containing at least 3 of silver to 1 of gold, and this alloy, in its fluid state, should be poured into cold water, by which the falling stream is suddenly chilled, and the particles become what is technically called "granulated." The stream should fall some distance (not less than 2 feet) through the air before it reaches the water, that the copper (if any be present) may be as much as possible oxidised, with a view to saving sulphuric acid.

In all cases the alloyed metals should be granulated, because the extended surface of metal presented to the hot acid saves much time.

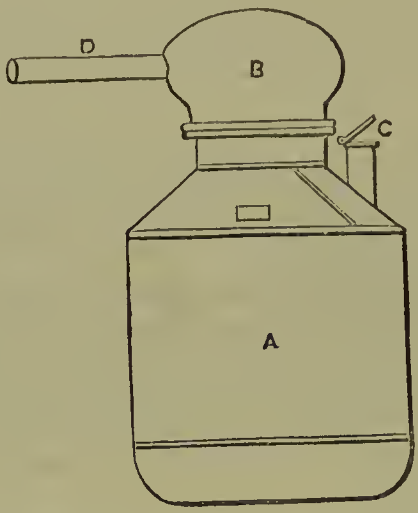
Silver containing less than $\frac{1}{500}$ part of its weight of gold is found not to pay for separation, but any which contains this amount or more is treated as follows:—

Vessels of platinum were formerly used and were deemed indispensable, but experiment has proved that these may be safely replaced by cast-iron vessels; in both cases the boilers or retorts are provided with tubes passing from the top into chambers which receive the acid gases and vapours.

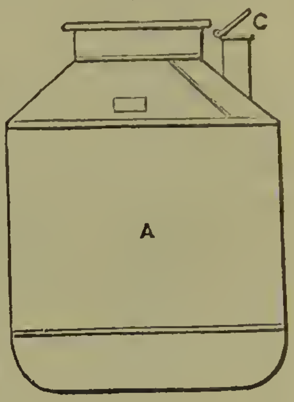
The platinum vessels used by Mr. Mathison and subsequently by Messrs. Rothschild for many years are now out off use, but as sketches of the vessels actually used cannot be obtained, it is deemed wise to give a sketch of the platinum vessels, which weigh 323·40 troy ounces, and contain, if filled to the neck, 8 gallons of water. A, the retort or boiler; B, the head, provided with a tube of platinum, D, to which is joined at the time of use a long tube of lead. C is a tube terminating on the shoulder of the boiler, and provided with a lid, and is of service to allow of the occasional stirring of the silver during solution, and of the addition of the small quantity of acid at the termination of the chemical action. The vessels became much coated with gold, which was removed with difficulty and at great risk of attacking the platinum. The sketches (*figs.* 1541, 1542, and 1543) are 1 in. to a foot.

According to convenience and requirements, the retort or boilers may be multiplied as to number, but about 5 or 6 would seem to be a convenient set for operations. Independently of the smaller prime cost of cast-iron retorts or boilers (now used in place of platinum), there is the advantage of being able to use acid which is not free from impurities, because the cost of the retorts is practically not worth consideration, if taken in relation to the extra price which must be paid for pure acid. Beside these facts, it is found that owing to some influence (is it chemical or catalytic?) which the iron exerts, less acid is required to be used in proportion to the precious metals than was used when platinum vessels were believed to be necessary.

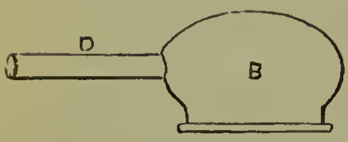
1541



1542



1543



A charge for one boiler varies from 1130 to 1300 troy ounces of the granulated mixed precious metals, and is heated with about twice or twice and a half times its weight of sulphuric acid of sp. gr. 1·7047. The heat is gradually raised until effervescence takes place, and it is then regulated with care, while at last, the temperature is raised nearly to the boiling point. As in the case of mercury so in the case of silver, it is better not to rise quite to the boiling point, else sulphuric acid distils off with the escaping sulphurous acid. According to the care with which the granulating has been effected, each charge is heated from 3 to 4 hours. When the elimination of sulphurous acid ceases the operation is known to be terminated, and chemical examination shows that exactly equivalent quantities of sulphate of silver and sulphate of copper are formed to account for the sulphuric acid. In practice the sulphurous acid is frequently lost, although in all refineries it should be used for the re-composition of sulphuric acid.

Leading from the top of the boiler or retort is an horizontal leaden tube from 8 to 10 yards long, terminating in a leaden chamber, in which sulphuric acid and sulphurous acids accumulate with some sulphate of silver, mechanically carried over by the violence of the chemical action. It is found that the acid which accumulates in this leaden chamber has a sp. gr. of from 1·3804 to 1·4493. The reduced strength of the acid from 1·7047 to this point is readily understood if the fact be remembered that sulphuric acid is really a compound of anhydrous sulphuric acid and water, and that only the anhydrous sulphuric acid is concerned, although the water performs the friendly part of leading it into action on the silver; the action having commenced, the water is done with, and passes off with the sulphurous acid as it is eliminated; but independently of this cause, it is found that sulphuric acid, by boiling, parts with water, and concentrates itself, until by and by the anhydrous acid itself distils off, and when this is seen, it is at once known that the operation is carried rather too far. When the action has quite terminated, it is customary to add to each boiler or retort from 60 to 80 Troy ounces of sulphuric acid of sp. gr. 1·6656, procured from the liquor which has deposited sulphate of copper (presently described), then to pour the whole into a leaden boiler, and boil it for a few minutes, then withdraw the fire, and allow to stand for half an hour, during which time the gold is precipitated. The object in adding this amount of sulphuric acid is to form a clear solution, that the gold may be enabled to settle to the bottom; water could not be added, because it would probably cause an explosion by the heat evolved in its combination, and because sulphate of silver is not very soluble in water, while it is soluble to a very large extent in hot sulphuric acid. At the end of half an hour the clear liquor, containing in solution the silver and copper as sulphates, is decanted and mixed with so much water as shall reduce it to a sp. gr. of from 1·2080 to 1·2605, and well stirred. Copper plates are then introduced, while the solution is kept hot or boiling by a jet of steam.

The silver salt is decomposed by the copper plates, and the copper passes into solution as sulphate of copper, so that at the end of the precipitation the solution contains the copper of the original alloy, as well as the copper which has been used to precipitate the silver. The silver precipitates or falls to the bottom in a finely divided or spongy form, and it is commonly thought that the whole of the silver is thrown down when a portion of the solution is not rendered turbid by a solution of chloride of sodium; but in the presence of a strongly acid solution this test is not to be relied on for minute quantities; therefore, in some refineries, the solution is allowed to rest for days together in leaden cisterns in which copper plates are placed, so that by these means the last traces of silver are obtained.

If the amount of gold be very minute, the original solution is well stirred and then allowed to settle for some time; when finely divided gold, mechanically mixed with crystals of sulphate of silver and crystals of sulphate of copper, is found at the bottom. This deposit is boiled with water, and is then transferred to a vessel in which it is kept hot, and is brought into contact with suspended copper-plates, by which the silver is rendered metallic, and falling to the bottom of the vessel, mixes with the gold. The mixed precipitate of silver and gold is then dried, melted, and granulated, and treated with sulphuric acid, as in the process already described. By this extra process the gold becomes concentrated by the removal of the silver, and is then thrown down in larger and more easily collected particles. When the gold is finely divided and precipitates slowly, the following plan is sometimes adopted:—The whole precipitate containing finely divided gold mixed with sulphate of silver, is washed well with warm water, and left to rest. The sulphate of silver is dissolved, but the gold settles to the bottom of the vessel, but is still mixed with a minute quantity of sulphate of silver. It is drained and placed in the retort or boiler of cast-iron, and boiled with sulphuric acid; this boiling is twice repeated, and at last a very diluted solution of sulphate of silver is obtained; but by the boiling the gold has assumed a form which enables it to precipitate rapidly; in fact, the flocculent sponge becomes a mass of dense particles, which fall readily to the bottom, are collected and well washed, to free them from silver, and are then dried ready for melting.

The solution of sulphate of silver is evaporated in leaden vessels by the agency of steam, until it becomes saturated, and is then allowed to stand for an hour that all the gold may separate, and is then drawn off either by a tap placed about half an inch from the bottom of the vessel, or by a siphon, and is then treated with copper-plates as already detailed.

In all cases the precipitated spongy silver is carefully washed to free it from sulphate of copper, and dried by heat or by hydraulic pressure; but if dried by pressure the masses obtained are found to contain from 8 to 10 per cent. of water, and are therefore dried by a gentle heat to avoid the breaking up of the masses, from the sudden formation of steam, as well as to save the chance of destroying the pot of Picardy clay in which the silver is melted when it has been dried.

After melting the silver is found to retain traces of gold, which are so minute as to be overlooked, since the cost of recovery would exceed the value of the gold to be recovered; but the silver is found to be alloyed with from 5 to 6 thousandths of its weight of copper, which appears to be left in the form of sulphate, notwithstanding the washings to which the silver has been subjected. It is practically impossible to wash away the last traces of sulphate of copper. This small amount of copper is of little importance, since it amounts to but 5 parts of copper alloyed with 995 parts of silver, yet this may be removed by fusion and treatment with nitrate of potassa.

During the whole process, even if copper be not present in the original mass of metal to be refined, it is to be observed that copper plates are used for precipitating the silver; therefore sulphate of copper is found in considerable quantities, and as this salt has a high commercial value as giving the base for many colours used in painting and paper-hangings, as well as for agricultural purposes, it becomes desirable to obtain this salt in a saleable form. The solution is therefore evaporated to a sp. gr. of 1·3804, and allowed to cool, when crystals deposit; but since sulphate of copper deposited from strongly acid solutions is mixed with the anhydrous salt, the whole mass of crystals is redissolved in warm water, and allowed to stand in leaden vessels about 6 ft. long, 3 ft. deep, and 3 ft. wide, that the crystals may deposit slowly, as slow formation produces large crystals, which are more easily collected. The sulphate of copper is represented by $CuO,SO^3,5HO$. The mother liquors are evaporated and returned to the works, being in fact free sulphuric acid, with a small amount of sulphate of copper in solution. The parts of the hydraulic presses which come in contact with the silver at the time of pressing, are coated with a compound of tin and lead, hardened by mixture with antimony. Cast-iron is very little attacked by concentrated sulphuric acid, but it is necessary to avoid wrought iron in any shape, and copper vessels would of course be rapidly destroyed.

The floors should be covered with lead of tolerable thickness. The melting pots used in France are made of Picardy clay, and hold from 2200 to 2600 Troy ounces of silver. The pots cost from 4*d.* to 6*d.* each, and if dried and used with care, very seldom crack or break.

The total cost of refining silver in Paris, inclusive of the loss by melting, is stated to be 15 centimes for 32 Troy ounces; but it must be understood that the loss of silver by melting is absolutely very minute, because the flues are swept, and the sweepings so obtained are made to yield the silver which has been volatilised, while the pots, &c., are ground and made to yield their absorbed silver.

In the event of the mass containing much copper and little silver, it is usual to granulate the mass and roast the granulated particles to oxidise the copper; the oxide of copper is then dissolved out by diluted sulphuric acid, and the remaining mass of silver, with a smaller amount of copper, is treated in the ordinary way.

If the gold contains platinum, it is found that it is apt to retain from 4 to 5 per cent. of silver, which must be separated by mixing the precipitated gold with about a fourth of its weight of anhydrous sulphate of soda (which is preferred to sulphate of potassa, on account of its greater solubility in water), and to moisten this mass with concentrated sulphuric acid, using about 6 or 7 parts of acid to every 10 parts of sulphate of soda. The moistened mass is then heated till sulphuric acid ceases to distil off, and the heat is then raised till the whole mass melts; and by extracting the sulphate of silver and sulphate of soda the gold will be found to contain 99·40 parts of gold in 100·00 parts; but if the process be repeated, the gold is obtained of a purity of 99·90.

When the silver has been removed, the gold is fused with nitre, which oxidises and removes the platinum; but the potash salt formed is found to contain gold, so that the gold and platinum are obtained from the potash salt mixed with fused nitre by the process of cupellation, for which see Assay.—G. F. A.

REFRIGERATION OF WORTS, &c. The simplest mode of refrigeration is by exposing the hot liquor or wort in shallow vessels, called coolers, to the action of the atmosphere or a current of air, sometimes accelerated by fans rotating horizontally just above the surface of the liquor; but sometimes utensils called refrigerators are employed, and so constructed that a quantity of cold water should be brought into contact with the heated fluid.

A simple form of refrigerator is that of the worm used by distillers; and the reverse process is commonly used by brewers, viz. a stream of cold water passing through pipes in a zigzag form, laid horizontally in the shallow cooler. 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.

In August, 1826, Mr. Yandall obtained a patent for an apparatus designed for cooling worts and other hot fluids, without exposing them to evaporation; and 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, so that a thin stratum of hot wort is brought into contact over a large surface with an equally thin stratum of cold water, in such manner that the heated water, when about to be discharged, still absorbs heat from the hottest portion of the wort, which as it flows through the apparatus is continually parting with its heat to water of a lower temperature flowing in the contrary direction; and however varied may be the form, the same principle should be observed.

Figs. 1544, 1545, 1546 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.

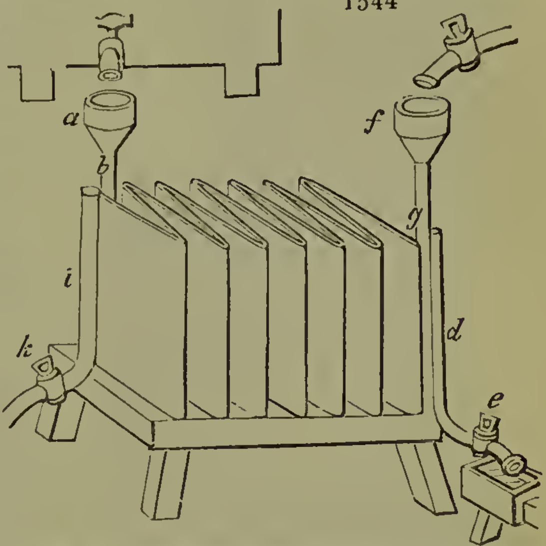
Fig. 1547 is the section of a portion of the apparatus shown at *figs.* 1544 and 1545 upon an enlarged scale; it is made by connecting three sheets of copper or any other thin metallic plates together, leaving parallel spaces between each plate for the passage of the fluids, represented by the black lines.

These spaces are formed by introducing between the plates thin straps, ribs, or portions of metal, to keep them asunder, 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 a 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.* 1544, and further developed by the section, *fig.* 1547, 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.* 1547), 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.* 1547), and from thence proceeds horizontally into the discharge-pipe *i*.

1544



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.

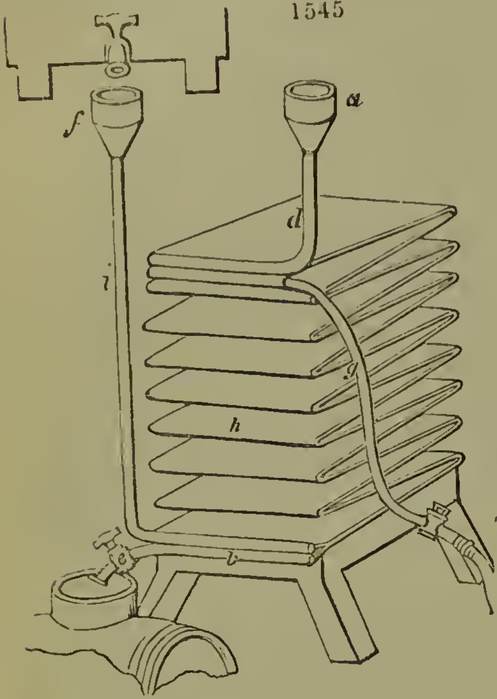
It only remains to observe, that by partially closing either of the exit-cocks, the quantity of heat abstracted from one fluid, and communicated to the other, may be regulated; for instance, if the cock *e* of the water-passage be partially closed, so as to diminish the quantity of cold water passed 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. 1545 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 *d* into the channel *c, c* (see *fig.* 1547), 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.

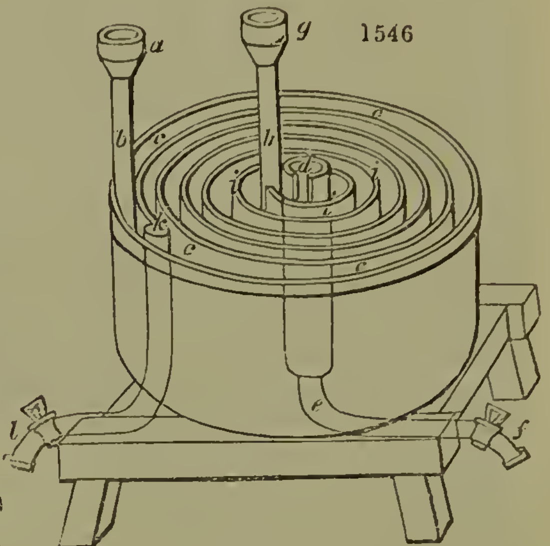
The passages of this apparatus for heating and cooling fluids, may be bent into various contorted figures; and one of the most convenient forms, being very compact and easily cleaned, is that represented at *fig.* 1546, which consists of only two sheets of thin copper, soldered together at their edges, forming a continuous spiral chamber for the passage of a thin stratum of water, and 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.

1545



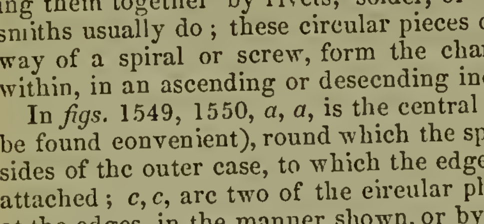
1546



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. 1548 represents the external appearance of the refrigerator, enclosed in a cylindrical case; *fig.* 1549, the same, one-half of the case being removed to show the form of the apparatus within; and *fig.* 1550, a section cut through the middle of the apparatus perpendicularly, for the purpose of displaying the internal figure of the spiral channels.

1547

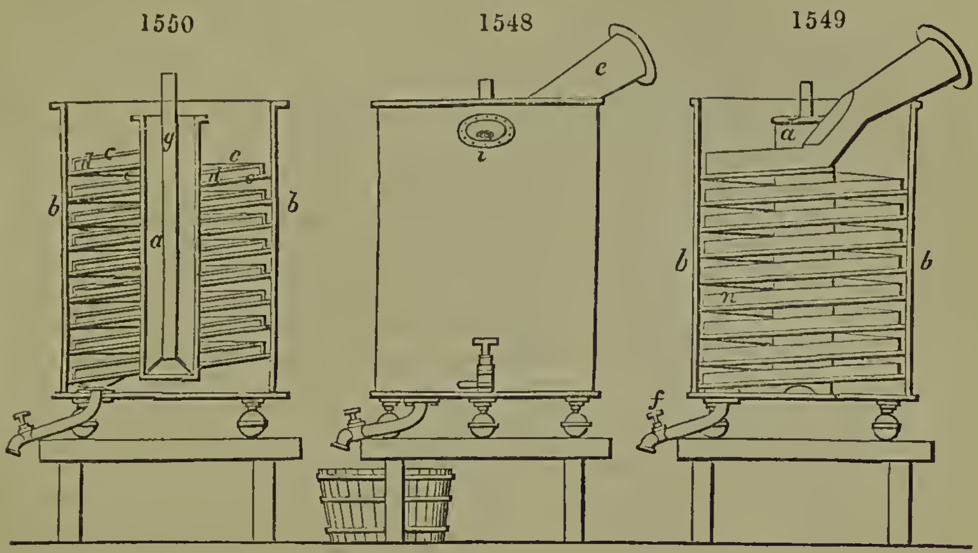


The apparatus is proposed to be made of sheet copper, tinned on its surface, and is formed by cutting circular pieces of thin copper, or segments of circles, and connecting them together by rivets, solder, or by any other convenient means, as coppersmiths usually do; these circular pieces of copper being 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.* 1549, 1550, *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.

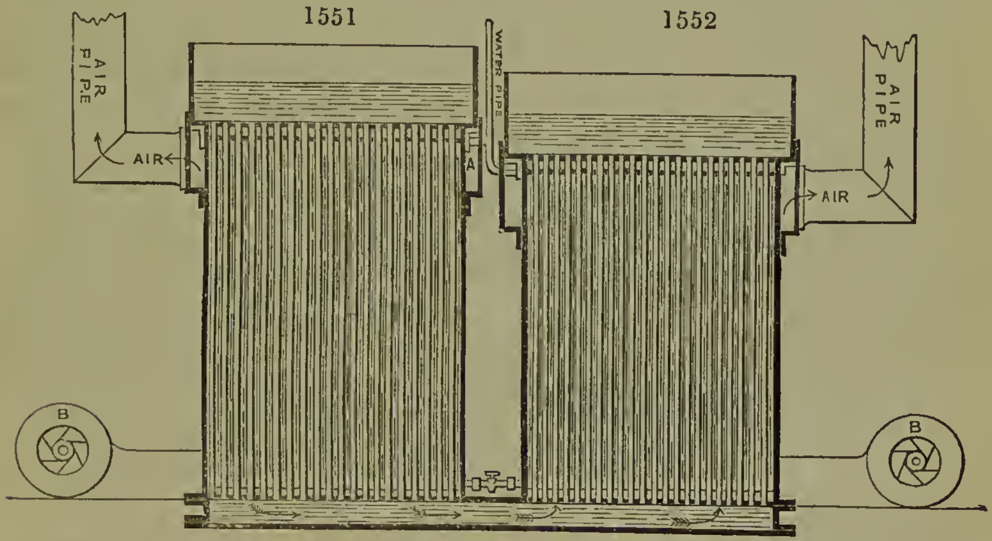
The hot fluid is admitted into the spiral chamber *d*, through a trumpet or wide-mouthed tube *e*, at top, and is discharged at bottom by an aperture and cock *f*. The cold water which is to be employed as the cooling material is to be introduced through the pipe *g*, in the centre, from whence, discharging itself by a hole at bottom, the cold water occupies the interior of the cylindrical case *b*, and rises in the spiral passage *n*, 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.* 1548.

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 caloric 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 caloric which it held having been given out to the cooling fluid.

Hodge's Patent Refrigerator for reducing the temperature of liquids.—This refrigerator is stated to be more effectual than anything yet offered to the public for cooling brewers' worts. The worts are passed down through the tubes in *fig.* 1551, and ascend through the tubes in *fig.* 1552. These tubes are of copper, and are encased in



a chamber; water is let on under a head through the pipes A, sprinkling the outer surface of the tube with a jet, keeping them moist; at the same time a blast of cold air is blown into the chambers by the fans B B impinging on the surface, carrying away the caloric as fast as it is transmitted. Worts can be brought down from 212° to the desired temperature by this process cheaper and quicker than any other refrigerator; in fact, worts may be brought down to freezing temperature.

REGULUS. A name introduced by the alchemists, and applied by them in the first instance to antimony; it signifies *the little king;* and from the facility with which antimony alloyed with gold, these empirical philosophers had great hopes that this metal *antimony* would lead them to the discovery of the philosopher's stone. The name is now applied to other metals in an impure state.

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 whey 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.

RESIN KAURI, OR COWDEE, is a new and peculiar substance, imported from New Zealand. 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 of 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.

RESINS (*Resines*, Fr.; *Harze*, Germ.) are 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 through the bark into the wood of the tree.

Resins possess the following general properties: — They are soluble in alcohol, 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. They are insoluble in water, and melt by the application of heat, but do not volatilise without partial decomposition. They are almost all translucid, 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 pulverised 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 COAL GAS.

Resins are little acted upon by acids, except by the nitric, which converts them into artificial tan. They combine readily with the alkalies 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*, *animé*, *benzoin*, *colophony* (common rosin), *copal*, *dammara*, *dragon's blood*, *elemi*, *guaiac*, *lac*, resin of *jalap*, *labdanum*, *mastic*, *sandarach*, *storax*, *takamahac*.

A memoir upon the resins has been published by M. Guibourt, from which the following extracts may be found interesting.

1. *The hard copal* of India and Africa, especially Madagascar, is the product of the *Hymenæa 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; 2ndly, this hard copal when blown out and still hot, exhales a smell like balsam copaiva or capivi; while amber exhales an unpleasant bituminous odour; 3rdly, 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.

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.

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	71
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.

RESINS, MINERAL. Petroleum, bitumen, asphalte, amber, and other mineral hydrocarbons are so called.

RETORT. Retorts may be of various shapes, and made of very different materials, according to the requirements. Some are of glass; others of clay. They may be made of any of the metals. Retorts are employed to effect the decomposition of compound bodies by the action of heat; sometimes alone, and sometimes aided by the action of other substances. They vary in shape; but generally may be regarded as consisting of a bulb and a beak. For producing coal gas, there are many modifications, varying in dimension and shape with the caprice of the constructor.

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.

2nd. The small or London D retort, so called in consequence of its having first been used by the Chartered Company in London.

3rd. The York D retort, (so called in consequence of its having been introduced by Mr. Outhit, of York). See Coal Gas.

REVERBERATORY FURNACE. See Metallurgy, Copper, Iron, and Soda, &c.

REVOLVERS. See Rifles and Revolvers.

RHINE WINES. See Wine.

RHODIUM. 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 Columbia, 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 platinum, 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. 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 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. Its chief use at present is for making the unalterable nibs of the so-named rhodium pens.

The following remarks from a recent paper by Deville and Debray, "*On some properties of the so-called platinum metals*," are full of interest. These chemists prepare rhodium by fusing platinum residues with an equal weight of lead and twice its weight of litharge. When the crucible has attained a bright red heat, and the litharge is thoroughly liquid, the crucible is shaken once or twice, and is then allowed to cool slowly. The button of lead, which contains all the metals in the residue less oxidisable than lead, is treated with nitric acid, diluted with an equal volume of water, which removes besides the lead the copper and the palladium. The insoluble powder which remains is mixed with five times its weight of binoxide of barium, weighed exactly, and is heated to redness in a clay crucible for one or two hours. After this it is first treated with water, and then with aqua regia to remove the osmic acid. When the liquor has lost all smell, sufficient sulphuric acid is added to exactly precipitate the baryta. It is then boiled, filtered, and evaporated, first adding to it a little nitric acid and then a great excess of sal ammoniac. The evaporation is carried to dryness at 212°, and the residuum is washed with a concentrated solution of sal-ammoniac, which removes all the rhodium. When the washings are no longer coloured, the liquor is evaporated with a great excess of nitric acid, which destroys the sal-ammoniac, and when only the salt of rhodium is left, the evaporation is finished in a porcelain crucible. The rhodium salt is now moistened with hydro-sulphide of ammonia, mixed with three or four times its weight of sulphur, and the crucible is heated to bright redness, after which metallic rhodium is left in the crucible. So obtained rhodium may be considered almost pure, after it has been boiled for some time, first in aqua regia, and then in concentrated sulphuric acid. To obtain it perfectly pure it must be melted with four times its weight of zinc. The alloy is treated with concentrated hydrochloric acid, which dissolves most of the zinc, but leaves a crystalline matter which is really an alloy of rhodium and zinc in definite proportions. This is dissolved in aqua regia, and the solution is treated with ammonia until the precipitate first formed is redissolved. The solution is boiled and evaporated, by which is obtained the yellow salt, or chloride of rhodium. This is purified by repeated crystallisation, and then calcined with a little sulphur, by which means rhodium is procured absolutely pure.

Rhodium melts less easily than platinum, so much so that the same fire which will liquefy 300 grammes of platinum will only melt 40 or 50 grammes of rhodium. It is not volatilised, but it oxidises on the surface like palladium. Less white and lustrous than silver, it has about the same appearance as aluminum. When perfectly pure it is ductile and malleable, at least after fusion. Its density is 12·1.

The alloys of rhodium, those at least which have been examined, are true chemical combinations, as is shown by the high temperature developed at the moment of their formation. The alloy with zinc already described resists the action of muriatic acid, but in contact with *air* and the *acid* there is soon a well marked rose coloration which reveals an oxidation of the two metals under the double influence of the air and acid. The alloy with tin is crystallised, black, brilliant and fusible at a very high temperature.

RHUBARB (*Rheum*). Thirteen species of plants have been named as yielding the medicinal rhubarb; it is, however, generally thought that the *Rheum palmatum* is the true rhubarb plant. The best rhubarb is called Turkey rhubarb, and is only procured by the Russians, at Kiachta, from the Chinese. Several species of rhubarb are cultivated in this country, for the agreeable acidity of their stems.

Imports of rhubarb, 1858.

	lbs.	Computed real value. £
Russia	6,789	4,073
Hamburg	8,325	4,957
China	252,970	28,797
United States	20,860	2,320
Other parts	3,896	1,624
	292,840	41,771

RHUS. The SUMACH, which see.

RIBBON MANUFACTURE. This differs in no particular respect from the manufacture of woven fabrics in similar materials. See SILK, and WEAVING.

RICE. (*Oryza sativa*, Linn.) This plant, originally a native of Asia, is now extensively cultivated in India, China, the islands of the Eastern Archipelago, in the West Indies, Central America, and the southern of the United States. Roxburgh informs us that there are above forty different varities. Carolina and Patna rice are the kinds most esteemed in this country. Braconnot (*Ann. Chim. Phys.*) has given the following analyses of two varieties of rice:—

	Carolina Rice.	Piedmont Rice.
Starch	85·07	83·80
Woody fibre	4·80	4·80
Gluten	3·60	3·60
Tallowy oil	0·13	0·25
Sugar (uncrystallisable)	0·29	0·25
Gum	0·71	0·10

The inorganic constituents being, as estimated from the ash of the grain, as follows:—

Potash	18·48
Soda	10·67
Lime	1·27
Magnesia	11·69
Oxide of iron	0·45
Phosphoric acid	53·36
Chlorine	0·27
Silica	3·35

Rice is used as food by a hundred millions of the inhabitants of the earth, and it is employed as an agreeable and nutritive diet in various forms by ourselves.

Our *imports* of rice were, in 1858, as follow:—

			Computed real value.
Not rough or in the husks	cwts.	3,665,765	£1,652,505
Rough and in the husks	quarters	25,877	23,727
Meal	cwts.	14,298	7,277
Dust for feeding cattle	"	11,960	3,737

RICE CLEANING. Various machines have been contrived for effecting this purpose, of which that invented by Mr. Melvil Wilson, may be regarded as a good example. 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.

RICE PAPER. A name given to the membrane of the bread-fruit tree, on which the Hindoos paint flowers, &c.

RICE STARCH. See STARCH.

RIFLES. RIFLED ORDNANCE and REVOLVERS.—Under the head of FIRE-ARMS, in addition to the general description of the manufacture of the ordinary musket barrel and the twisted barrel, with that of gun-locks of various kinds, there is an account of the mode adopted for rifling barrels, and of the methods in use at the Royal Manufactory at Enfield. Beyond this, the *carabine à tige*, the minie rifle, with the needle musket, or zundnadelgewher of the Prussians, were severally noticed; and some information given respecting the more recent Enfield rifle. So many and so important have been the improvements which have been introduced that it is necessary to return, somewhat more fully, to the consideration of this subject. Fire-arms are rifled to give rotation to the projectile round its axis of progression, in order to insure a regular and steady flight. The only practical method of doing this, hitherto adopted, has been to make the barrel of a fire-arm of such a shape in its interior, that the projectile, while being propelled from the breach to the muzzle, may receive a rotatory, combined with a forward, motion.

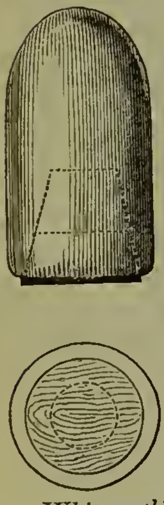
Enfield Rifle.— The dimensions, &c., of the long Enfield is given in the article already referred to. The barrel of the short Enfield is only 2 ft. 9 in. in length.

The material for the barrels of the arms made at the Government works is brought to the factory in slabs, half an inch thick, and 12 in. long, by 4 in. broad. These slabs of iron are carefully forged, to ensure the crossing of the fibres of the iron. They are heated, and first bent into a tubular form ; the yare then heated again, and, while white hot, passed between iron rollers, which weld the joining down the middle, and at the same time lengthen the tube nearly three inches. This heating is several times repeated, and the processes of rolling continued until the barrel assumes the form of a rod, about 4 ft. long, having a bore down the centre, about a $\frac{1}{4}$ of an inch in diameter.

The muzzles are then cut off, the "butts" made up, and the process of welding on the nipple lump is begun. This operation requires much care, and it is executed with great quickness and skill by the trained workmen. The barrels pass from the smithy to the boring department. The barrels are arranged horizontally, and the first-sized borer is drawn upwards from the breech to the muzzle. The second boring is effected with rapidity ; but the third slowly ; and after the fourth boring the barrel is finished to within the $\frac{3}{1000}$ of an inch of its proper diameter. The outside is ground down to its service size, and the barrel is straightened ; it is then tested by a proof-charge of 1 oz. of powder and 1 ball. The next step is to fit the nipple-screw, nipple, and breech-pin. The barrel is then bored for the fifth time, and it passes to the finishing shop. In rifling the Enfield, each groove is cut separately, the bit being drawn from the muzzle to the breech. The depth of the rifling is 0·5 at the muzzle, and 0·13 at the breech, and the width of each grove is $\frac{3}{16}$ of an inch. After rifling the barrel is again proved, with half an ounce of powder and a single ball. It is then sighted, trimmed off, milled, levelled, browned, gauged, and, at last, finished so perfectly, that the steel gauge of ·577 of an inch passes freely through, while that of ·580 will not enter the muzzle.

The system of rifling by grooves is the plan which has been generally employed, and many experiments with different numbers of groves, some of varying depths, being deeper at the breech, and with different turns ; some increasing towards the muzzle, have been tried, and thought advantageous, at various times. The Enfield rifle has three grooves, with a pitch of 6 ft. 6 in, so that the bullet receives half a turn round its axis while moving through the barrel, the length of which is 3 ft. 3 in. The bullet is cylindro-conchoidal ; it is wrapped in paper, and made of such a diameter as to pass easily down the barrel. It requires very pure lead, to allow of its being properly expanded, or "upset," by the explosion and is driven partly against the original portions of the bore, called the *lands*, and partly in the form of raised ribs, is forced into the grooves, whose spiral shape gives the required rotation. The Enfield bullet is shown in the annexed figure. It is conical in shape, and has its back end recessed for the insertion of a box-wood plug. This plug, driven forward at the first shock of the explosion of gunpowder, expands the lead until it fills the grooves at the breech. (*Fig.* 1553.)

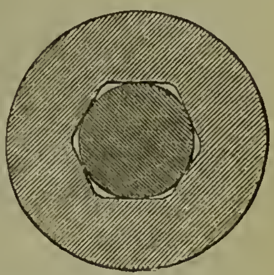
1553



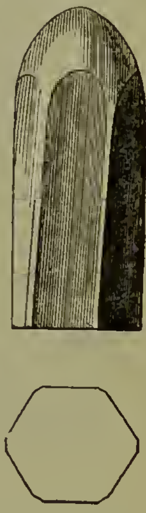
The prime cost of a finished Enfield rifle is stated to be about £2 5*s.*; and from 1,500 to 1,800 rifles per week are at present made at the Enfield rifle factory.

Whitworth's Rifle.—This fire-arm, and the principles on which it is constructed, cannot be better described than by adopting, to a great extent, the words of the inventor : In the system of rifling which I have adopted, the interior of the barrel is hexagonal, and instead of consisting partly of non-effective *lands*, and partly of grooves, consists of effective rifling surfaces. The angular corners of the hexagon are always rounded, as shown in section, *fig.* 1554, which shows a cylindrical bullet in a hexagonal barrel. The hexagonal bullet, which is preferred to the cylindrical one,— although either may be used, is shown in *fig.* 1555. Supposing, however, that a bullet of a cylindrical shape is fired, when it begins to expand it is driven into the recesses of the hexagon, as shown in *fig.* 1554. It thus adapts itself to the curves of the spiral, and the inclined sides of the hexagon offering no direct resistance expansion is easily effected. With all expanding bullets proper powder must be used. In many cases this kind of bullet has failed, owing to the use of a slowly-igniting powder, which is desirable for a hard metal projectile, as it causes less strain upon the piece; but is unsuitable with a soft metal expanding projectile, for which a quickly igniting powder is absolutely requisite to ensure a complete expansion, which will fill the bore: unless this is done the gases rush past the bullet, between it and the barrel, and the latter becomes foul, the bullet is distorted, and the shooting must be bad. If the projectile be made of the same hexagonal shape externally, as the bore of the barrel internally, that is with a mechanical fit, metals of all degrees of hardness, from lead, or lead and tin, up to hardened steel, may be employed, and slowly-igniting powder, like that of the service, may be used. As we have already stated, the Enfield rifle has one turn in 6 ft. 6 in.; that is, the bullet rotates once on its axis, in passing over this space. This moderate degree of rotation, according to Mr. Whitworth, only admits of short projectiles being used, as long ones turn over on issuing from the barrel; and, at long ranges, the short ones become unsteady. With the hexagonal barrel much quicker turns are used; and "I can fire projectiles of any required length, as, with the quickest that may be desirable, they do not 'strip.' I made a short barrel, with one turn in the inch (simply to try the effect of an extreme velocity of rotation) and found that I could fire from it mechanically-fitting projectiles, made of an alloy of lead and tin; and with a charge of 35 grains of powder they penetrated through 7 inches of elm planks."

1554



1555



"For an ordinary military barrel 39 inches long, I proposed a ·45-inch bore, with one turn in 20 inches, which is, in my opinion, the best for this length. The rotation is sufficient, with a bullet of the requisite specific gravity, for a range of 2,000 yards. The gun responds to every increase of charge, by giving better elevation, from the service charge of 70 grains up to 120 grains; this latter charge is the largest that can be effectually consumed, and the recoil then becomes more than the shoulder can conveniently bear with the weight of the service musket."

The advocates of the slow turn of one in 6 ft. 6 in., consider that a quick turn causes so much friction as to impede the progress of the ball to an injurious, and sometimes dangerous, degree, and to produce loss of elevation and range; but Mr. Whitworth's experiments show the contrary to be the case. The effect of too quick a turn, as to friction, is felt in the greatest degree when the projectile has attained its highest velocity in the barrel, that is at the muzzle, and is felt in the least degree when the projectile is beginning to move, at the breech. The great strain put upon a gun at the instant of explosion is due, not to the resistance of friction, but to the *vis inertiæ* of the projectile which has to be overcome. In a long barrel with an extremely quick turn, the resistance offered to the progress of the projectile as it is urged forward becomes very great at the muzzle, and although moderate charges give good results, the rifle will not respond to increased charges by giving better elevation. If the barrel be cut shorter, an increase of charge then improves the elevation.

Rifled Ordnance. See ARTILLERY. Whitworth's system of rifling is equally applicable to ordnance of all sizes, the principle of construction is simple, and the extent of bearing afforded by the rifling surfaces provides amply for the wear of the interior of the gun; any requisite allowance for windage may be made at the same time that the projectile is kept concentric with the bore. We have not space to enter on any examination of the rifled ordnance manufactured by Mr. Whitworth, which is in principle the same as the rifle which we have briefly described. The extraordinary results obtained in the trials of Whitworth's guns have been so remarkable, that as a matter of curious history it appears important to preserve a statement of these trials, as made at Southport, which were witnessed by many of the most eminent authorities.

Our space will not admit of our giving tables of all the experiments made; we have, therefore, chosen those which give the best and most interesting results. We have in each table given the distance of every shot fired in the series or group forming the particular experiment. In some cases average distances are calculated from the ascertained centre of the group of shots fired, and are taken longitudinally and laterally. This is, in fact, applying to the horizontal area in which the shots fell the same principles on which the "figure of merit" is determined on the vertical targets at the Hythe School of Musketry. This method of calculation is the most accurate, for, as the gun was always laid for the line of fire, and no alteration was made in its direction during the firing of a particular group, a certain amount of deviation would be given to all the shots by the wind. Therefore, the closer the shots lay, the better was the shooting, without regard to the general deviation from the line of fire, which might be greater or less according to the direction and force of the wind.

Table of Experiments.

3-POUNDER GUN, 9 shots fired at an elevation of 3°, charge $7\frac{1}{2}$ oz., Feb. 22.

Range in yards.	Deviation from line of fire in yards.	
1552	$\frac{1}{2}$	Average longitudinal deviation, $11\frac{1}{3}$ yards; average lateral deviation, $\frac{2}{3}$ yard; measured from the centre of 9 shots fired.
1568	2	
1573	$\frac{1}{2}$	
1575	$\frac{2}{3}$	
1577	$\frac{1}{3}$	
1588	1	
1589	0	
1593	0	
1607	$\frac{1}{2}$	

3-POUNDER GUN, 10 shots, at an elevation of 10°, charge $7\frac{1}{2}$ oz., Feb. 23.

3865	$9\frac{2}{3}$	Average longitudinal deviation, 48 yards; average lateral deviation 9·7 yard from the centre of the group.
3888	10	
3871	13	
3913	12	
3831	13	
3816	12	
3717	11	
3850	8	
3763	$1\frac{1}{3}$	
3905	$2\frac{1}{3}$	

3-POUNDER GUN, 11 shots, at 20° elevation, charge 8 oz., Feb. 23.

6650	22 right	Average longitudinal deviation, 33 yards; average lateral deviation 4 yards; taken from the centre of group.
6614	21 ,,	
6655	24 ,,	
6702	17 ,,	
6646	17 ,,	
6704	17 ,,	
6690	19 ,,	
6581	19 ,,	
6692	18 ,,	
6645	7 ,,	
6712	7 ,,	

3-POUNDER GUN, 5 shots at 35° elevation, charge $8\frac{1}{2}$ oz., on Feb. 16.

Range in yards.	Deviation from line of fire in yards.	
9453	52 right	Average longitudinal deviation, 81 yards; average lateral deviation 19 yards from centre of the group.
9503	72 ,,	
9611	89 ,,	
9645	31 ,,	
9688	35 ,,	

12-POUNDER GUN, 10 shots, at 5° elevation, charge $1\frac{1}{2}$ lb.

2354	$2\frac{2}{3}$ right	Average longitudinal deviation 16 yards; average lateral deviation from centre of group, 1 yard.
2352	$2\frac{1}{3}$,,	
2351	3 ,,	
2348	2 ,,	
2347	4 ,,	
2343	$2\frac{1}{3}$,,	
2337	$\frac{1}{3}$ left	
2334	2 right	
2304	5 ,,	
2288	2 ,,	

12-POUNDER GUN, 4 shots at 7° elevation, charge $1\frac{3}{4}$ lb., Feb. 21.

3098	0	Greatest difference in range, 29 yards; greatest difference in width, $1\frac{2}{3}$ yard.
3078	$\frac{1}{3}$ left	
3107	$1\frac{1}{3}$ right	
3107	0	

80-POUNDER GUN, 4 shots, at 7° elevation, charge 14 lb.

3482	$6\frac{1}{3}$ right	Greatest difference in range, 21 yards; greatest difference in width, $1\frac{2}{3}$ yard.
3487	$6\frac{1}{8}$,,	
3498	6 ,,	
3503	$4\frac{2}{3}$,,	

After this digression we return again to the Rifles. A professional writer, well qualified to judge of the matter on which he wrote, has made some striking remarks on the Whitworth rifle in the *Mechanics' Magazine*. After pointing out the small importance of a high prime cost in the case of so durable a weapon as the rifle in question, he refers to the strength of the metal used.

In illustration of its great strength, this fact is quoted. Mr. Whitworth put into a rifle barrel, one inch in diameter at the breach, with a bore of 0·49 inch, a leaden plug 18 inches long, as tightly as it could be driven home upon the charge. It was fired with an ordinary charge of powder, and the leaden plug being expanded by the explosion remained in the barrel, the gases generated by the gunpowder all passing out through the touch-hole. With such strength great durability must of necessity co-exist, unless the quick turn of the rifling should tend to its rapid deterioration. But this is not the case, Mr. Longridge's elaborate investigations having proved that the amount of the force expended upon the rifling of the Whitworth rifle scarcely exceeds two per cent. of the total force of the powder.

Perhaps the most remarkable testimony which has been borne to the merits of this rifle is that of General Hay, the director of musketry instruction at Hythe. After admitting the superiority of the Whitworth to the Enfield in point of accuracy, General Hay said there was a peculiarity about the Whitworth small-bore rifles which no other similar arms had yet produced,—they not only gave greater accuracy of firing, but treble power of penetration. For special purposes, any description of bullet could be used, from lead to steel. The Whitworth rifle, with a bullet one-tenth of tin, penetrated 35 planks, whereas the Enfield rifle, with which a soft bullet was necessary, only penetrated 12 planks. He had found that at a range of 800 yards, the velocity added to the hardened bullet gave a power of penetration in the proportion of 17 to 4 in favour of the Whitworth rifle. This enormous penetration is of the highest importance in a military weapon, in firing through gabions, sandbags, and other artificial defences. Mr. Bidder, President of the Institution of Civil Engineers, says, the Whitworth small-bore rifle, fired with common sporting powder, would never foul so as to render loading difficult. He had himself fired 100 rounds one day, 60 rounds the next, then 40 rounds, and so on, and left the gun without being cleaned for ten days, when it fired as well as it did on the first day. The words of Mr. Whitworth as to the application of his principle to the Enfield weapon must be quoted in answer to the objections of cost, &c., urged against it. "With regard to the cost of my rifled musket, which has been stated to be an impediment in the way of its adoption for the service, I may state that there would be no difficulty in adapting the machinery and plant already in operation at Enfield, or any requisite portion of it, for making rifles on my system. The change would not cause an increase in the manufacturing expenses; and, supposing the quality of the workmanship and the materials to remain the same, the advantages arising from the use of my bore and turn, and hard metal projectiles, would double the efficiency of the rifle without increasing the cost."

Amongst arms requiring some notice from us, the more remarkable, as involving some excellence in construction, or peculiarity in principle, are the following:—

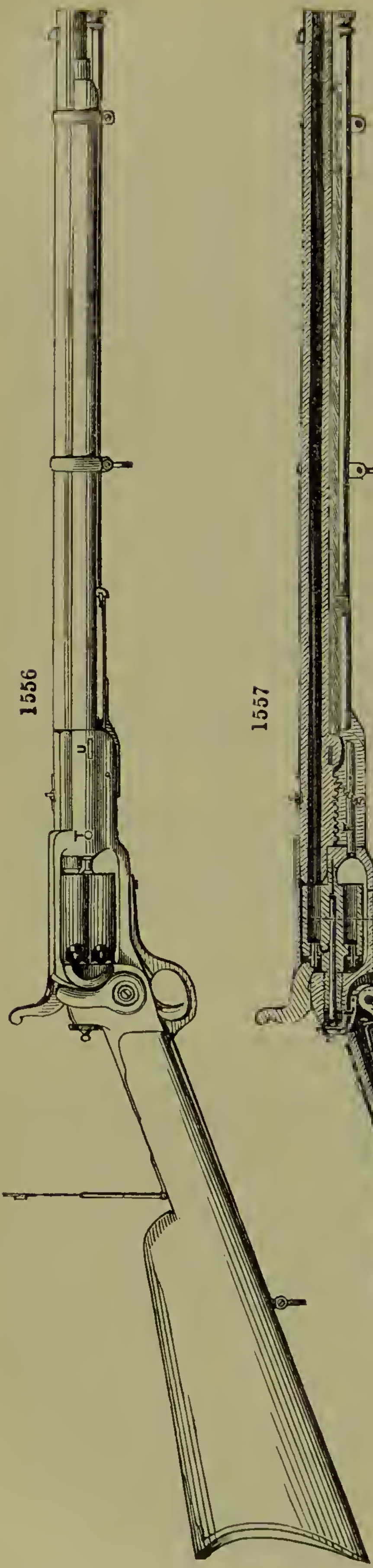
Colt's Repeating Rifle.—This weapon is constructed mainly on the principle which was introduced by Colonel Colt, in his "revolvers," to be noticed presently. The Secretary of War of the United States reports as follows on this arm, which is shown in *fig.* 1556, and in section *fig.* 1557. *Fig.* 1558 is a vertical section of the revolving barrels, and *fig.* 1559 the wiping rod.

"The only conclusive test of the excellence of the arms for army purposes is to be found in the trial of them by troops in actual service. Colonel Colt's arms have undergone this test, and the result will be found, in some measure, by reports of General Harney and Captain Marcy, who used them in Florida, against the Indians. These reports relate only to the *rifle*, but are clear and satisfactory. * * * * A board of officers recently assembled to consider the best mode of arming our cavalry, made a report, showing the present appreciation of the arm by officers of the army standing deservedly high for their services, experience, and intelligence."

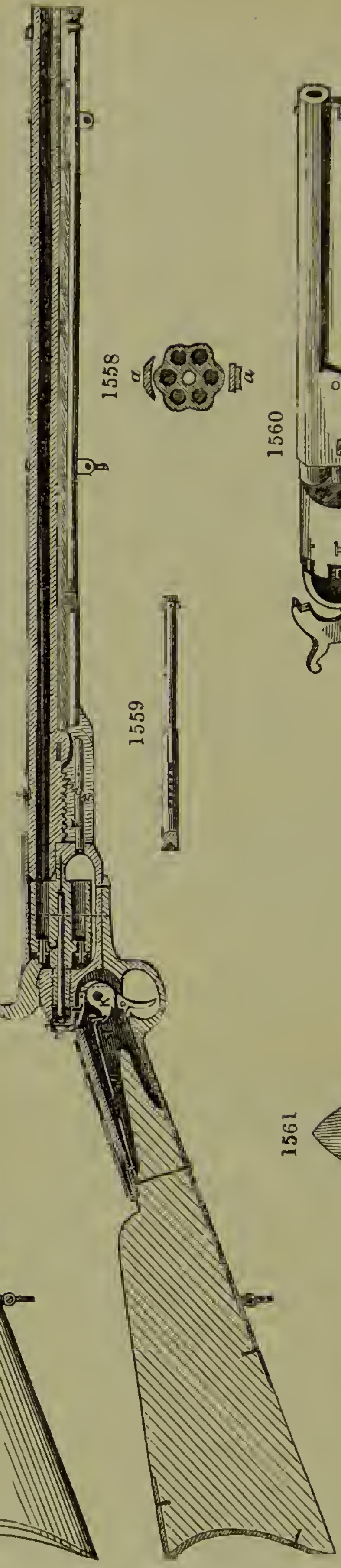
In its internal construction this rifle differs in some respects from the pistols and early revolving rifles. The catch which causes the breech cylinder to revolve, instead of acting against ratchet teeth, and on the cylinder itself, works in teeth cut on the circumference of the cylinder end of the base-pin, in such a manner, that the base-pin rotates with the cylinder itself, being locked by a small mortise in the cylinder; and the stop-bolt gears into corresponding notches, also cut in the end of the base-pin, and thus locks it when required. This is an improvement in the arrangement of these weapons, and by a simple arrangement, the small spring catch, which, by means of a circular grove in the front end of the base-pin, keeps it in place, is immediately released by pressing on a small stud, and the cylinder can be instantaneously removed or replaced. Instead of the pin, which, in the pistol, is used to let the hammer down on, when carrying it, a small recess is cut between each nipple, in the cylinder itself, into which the hammer fits when let down, and makes security doubly secure.

The rifle is provided with two sights; the ordinary leaf-sight usually employed is also provided. The hinder sight is adjustable to suit long or varying ranges, and the front sight is that known as the bead sight, which consists of a small steel needle, with a little head upon it, like the head of an ordinary pin inclosed in a steel tube. In aiming with this sight, the eye is directed through a minute hole in the sliding piece of the hinder sight, to the small bead in the tube, which bead should

1556



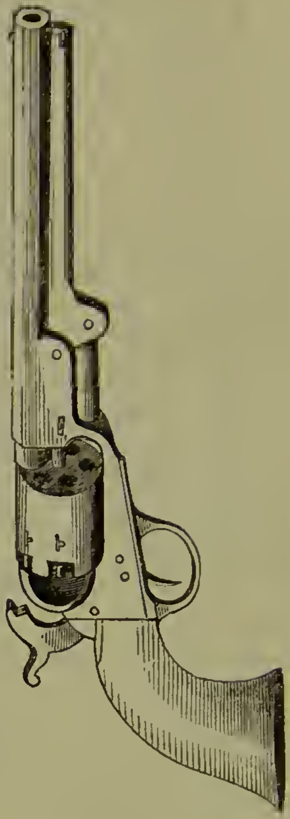
1557



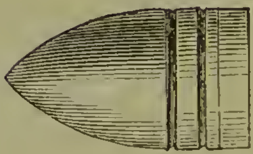
1558

1559

1560



1561



1562

cover the mark aimed at; and this sight affords great accuracy in shooting. The wiping rod, which occupies the position usually allotted to the ramrod, in muzzle loaders, is ingeniously constructed so as to admit of being lengthened. In its interior, which is hollow, slides a slight steel rod, in the end of which a screw thread is cut; on drawing out the rod, a turn or so of the hand in one direction, enables this steel rod to be drawn out to a length, as nearly as possible that of the outer case, and a few turns in the contrary direction, fastens it firmly in its place; thus enabling it to be used with as much facility as if it were solid. When done with, the reversal of the former motions enable the rod to be returned to its original dimensions, and it can then be returned to its place. This weapon has a real business-like serviceable appearance, and its weight varies, according to the length of the barrel, from 8 lb. to 10 lb. each, with five and six shots.

Colonel Colt has introduced a new shot gun, which is adapted for being loaded alternately with shot and ball. This is adapted for colonists, enabling him to use the gun as an ordinary sporting weapon for birds, &c., or for more deadly purposes. The ball for Colt's rifle is shown by *figs.* 1561, 1562.

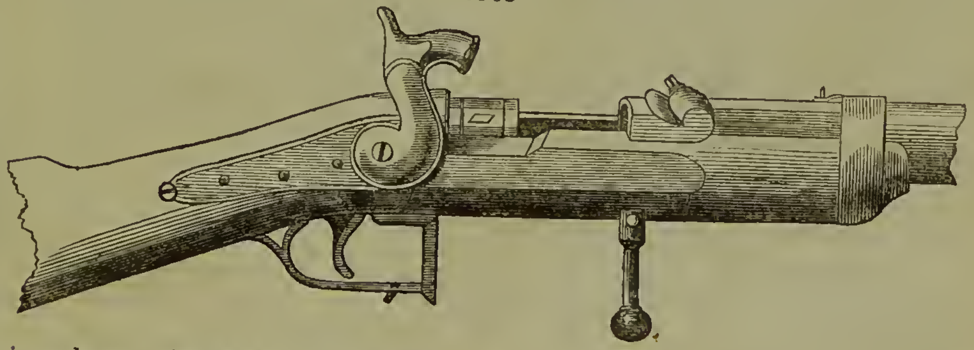
Lancaster's Elliptic Rifle. — So called, although the Elliptical rifle is very old. The bore in this rifle is slightly oblate; the twist found, by experience, to be most advantageous is one turn in 52 inches, the approved diameter of the bore ·498 inches, the length of the barrel being 32 inches. An eccentricity of ·01 inch in half an inch is found sufficient to make the bullet spin on its axis to the extreme verge of its flight. The length of the bullet found to answer best with these rifles is $2\frac{1}{4}$ diameters in length, with a windage of four or five thousandths of an inch.

Major Nuthall's Rifle.—In the ordinary mode of grooving rifles, sharp angles are left between the groove and "land" (those parts of the smooth bore left in their original state after the process of grooving has been completed). These create great friction with the projectile, both in loading and discharging. Major Nuthall removes these objections by rounding off the "lands" into the grooves, that is, making them a series of convex and concave curves, the bore assuming a beautiful appearance to the eye, for the smoothness and evenness with which the lands and grooves blend into each other.

There are also General Boileau's rifle, and some others, which our space will not admit of our noticing.

Breech-loading Rifles have been introduced, and they prove so satisfactory that the principle of breech-loading is applied to ordinary fowling pieces. Prince's breech-loader has been highly recommended. In this rifle, *fig.* 1563, the barrel has attached

1563



to it a lever with a knob at its end, kept in its place and locked by a little bolt attached to the bow of the guard. In order to load, the stock being firmly grasped under the right arm, the catch is released, and the knob attached to the lever is drawn to the right, and almost simultaneously pushed forward. The lever being firmly connected with the breech end of the barrel, the whole of the barrel is thus slipped forward in the stock, to the extent of about three inches, disclosing a steel cone, provided on either side with inclined planes, forming a segment of a screw, and locking tightly into slots at the breech end of the barrel. The cartridge is dropped into the open space at the extremity of the cone, the lever is depressed, pulled backward, and then pushed into its place. The barrel and cone are thus tightly locked together, and until they are in this position the gun cannot possibly be fired. It is, therefore, obvious, that in strength and security this rifle is not inferior to any. At a trial at Hythe, Mr. Prince fired 120 rounds in less than eighteen minutes, showing the rapidity of loading which this weapon admits of. The rifling preferred by the inventor is a five-grooved bore rather deeply cut, the twist being three quarters of a turn in three feet. The London gunmakers have certified to the great merits of Prince's breech-loading rifle.

Prince's cartridge is an ingenious invention; it can be used either with a muzzle or with a breech-loader. The cartridge is made of gun-paper, produced in the manner described for making gun-cotton. The spark fires this with the powder, and if the paper is pure there is no ash left from its combustion. Mr. Prince is bringing out a new breech-loading rifle which is simpler than any yet produced. His practical experience in such matters, extending over more than a quarter of a century, combined with the success he has already attained, causes any fresh arm emanating from him to be regarded with considerable attention. The breech is opened by a half turn of a lever, and closed by a corresponding movement. Either common ammunition or a flask can be used in loading. The barrel is a fixture; a chamber being attached to the breach end, so that existing muzzle loaders may be readily converted. For cavalry a simple addition is made to the arm, so that the caps are placed on the nipple in the act of loading.

Terry's Breech-loading Rifle differs from Prince's in having the barrel fixed. There is an opening at the base of the breech, which being lifted by a lever discloses a receptacle for the cartridge.

Mr. Westley Richards, Mr. James Leetch, and some others have introduced breech-loading rifles. Of the former, Colonel Wilford says: "The weapon manufactured by Mr. Westley Richards is a perfect wonder. I saw a small carbine, weighing only 5½ lbs., fire better at 800 yards than the long Enfield."

In the rifle by Leetch the opening for the admission of the charge is in front of the chamber; consequently the shooter has all the security that the solidity of the breech can import.

Revolvers or *Repeating Pistols.*—The fame attached to Colt's revolvers, *fig.* 1560, renders them so well known as to require but little introduction necessary. Although the invention of revolvers of course cannot be ascribed to Colonel Colt, their adaptation to modern requirements, and their general use, are undoubtedly due to his extreme energy, perseverance, and skill, and to him, therefore, every credit ought to be given. This make is now extensively used in the United States, and indeed in almost every corner of the world, and seem not to lose favour anywhere. In Turkey, Egypt, Brazil, Peru, Spain, Holland, Prussia, Russia, Italy, and Chili, as well as the United States, and our own country, they have been and are extensively used and approved; and we are given to understand that 40,000 of them have been supplied to our authorities, and have been served out and used in the Baltic, in the Crimea, in China, and in India, with the utmost effect. The shooting with Colt's arms is highly satisfactory. With Colt's revolver you can make first-rate shooting, and be perfectly satisfied with its action. As a proof that it is not liable to get out of repair, we need only state that the American Board of Ordnance had a holster pistol fired 1200 times, and a belt pistol 1500 times, without the slightest derangement. The penetration of the first named was through 7 inches of board, and of the second through 6 inches.

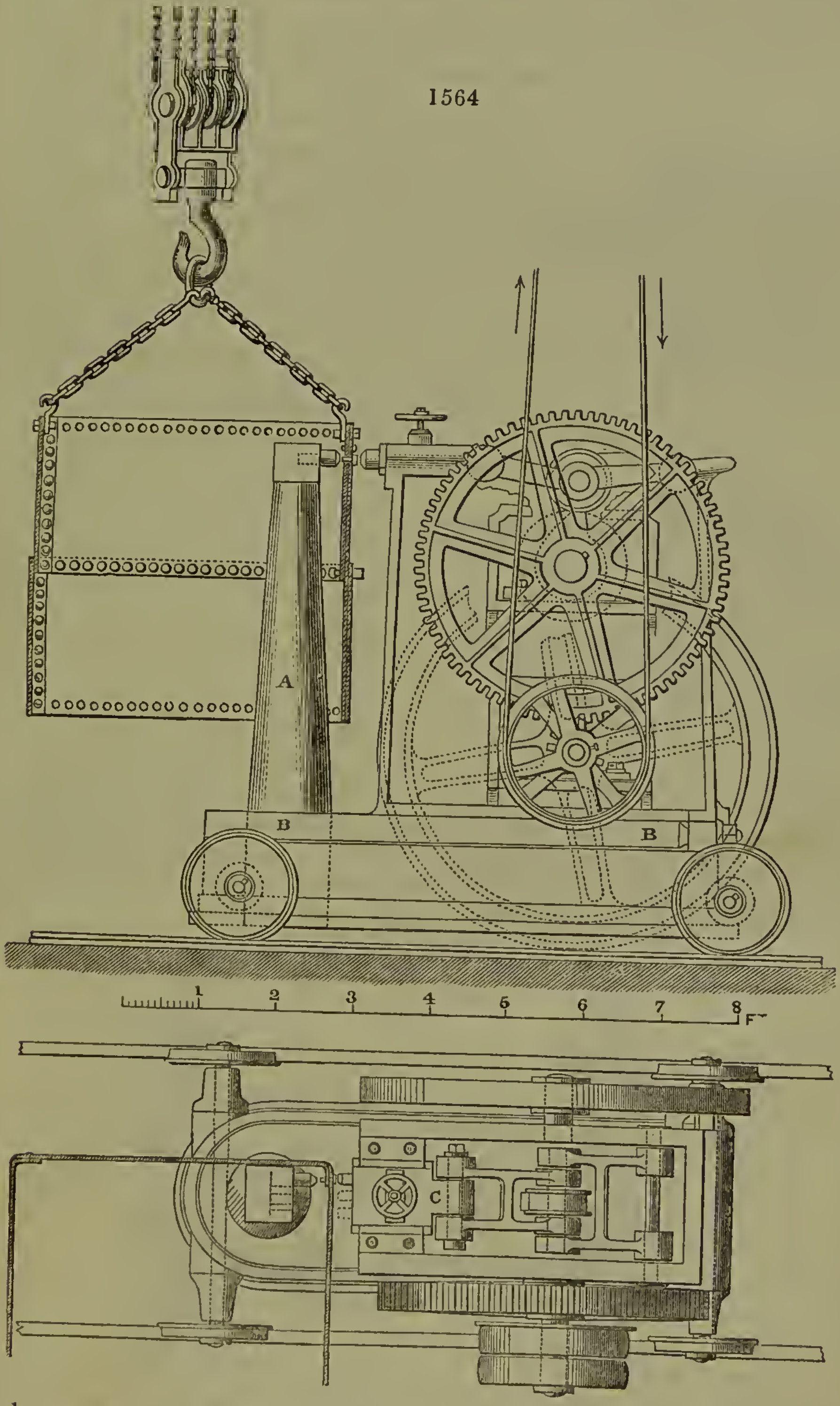
The barrel is rifle-bored. The lever ramrod renders wadding or patch unnecessary, and secures the charge against moisture, or becoming loose by rough handling or hard riding. The hammer, when at full cock, forms the sight by which to take aim, and is readily raised at full cock by the thumb, with one hand. It has been tested by long and actual experience, that Colt's arrangement is superior to those weapons in which the hammer is raised by pulling the trigger, which, in addition to the great danger from accidental discharge, the strength of the pull necessary for cocking, interferes with the correctness of aim, which is of so much importance. A very effectual provision is made to prevent the accidental discharge of this pistol whilst being carried in the holster, pocket, or belt. Between each nipple (the position of which secures the caps in their places) is a small pin, and the point of the hammer has a corresponding notch; so that if the hammer be lowered on the pin, the cylinder is prevented from revolving, and the hammer is not in contact with the percussion cap, so that, even if the hammer be struck violently by accident, it cannot explode the cap.

The movements of the revolving chamber and hammer are ingeniously arranged and combined. The breech, containing six cylindrical cells for holding the powder and ball, moves one sixth of a revolution at a time; it can only be fixed when the chamber and the barrel are in a direct line. The base of the cylinder being cut externally into a circular ratchet of six teeth (the lever which moves the ratchet being attached to the hammer); as the hammer is raised in the act of cocking, the cylinder is made to revolve, and to revolve in one direction only; while the hammer is falling the chamber is firmly held in position by a lever fitted for the purpose; when the hammer is raised the lever is removed, and the chamber is released. So long as the hammer remains at half cock, the chamber is free and can be loaded at pleasure. Revolvers by Daw, by Adams and Dean, and others, have been introduced. They are all so similar in principle that they need not be described.

RINMAN'S GREEN. Oxide of cobalt and oxide of zinc.

RIVETING MACHINE *of Fairbairn.* The invention of the riveting machine originated in a turn-out of the boiler-makers in the employ of that 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 movable 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.

1564



The large stem A, is made of malleable iron, and, having an iron strap B B, 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 workmen 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 the 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.

ROAN. The name of a common leather used for book-binding, and for slippers. It is prepared from sheep-skin by tanning with sumach. See LEATHER.

ROCCELLA, from the Italian *rocca*, a rock; a genus of lichens. See ARCHIL.

ROCK. A term used, generally, in South Staffordshire by quarrymen and miners to denote any hard sandstone.

ROCK CRYSTAL. A very fine variety of quartz.

ROCKETS. See PYROTECHNY.

ROCK SALT. See SALT.

ROE STONE. The familiar English name for *oolite*, from its being composed of rounded grains, like the roe of a fish.

ROLLERS, ELASTIC, for printing. See PRINTING ROLLERS.

ROLLING MILLS. These useful aids to many of our metallugical processes appear to have been introduced to this country in the seventeenth century; but it was not until 1784, when Mr. Cort patented "a new mode and art of shingling, welding, and manufacturing iron and steel into bars, plates, &c.," that much attention was directed to the value of the rolling mill.

1565

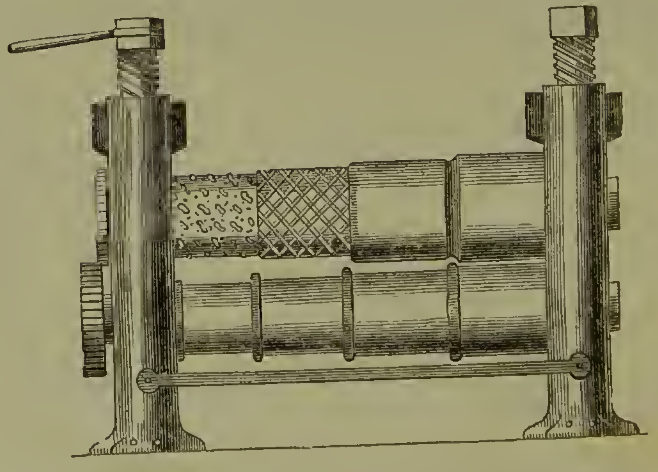
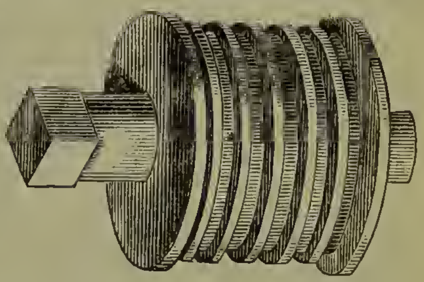


Fig. 1565 is a front view of a pair of rollers, used in the manufacture of iron in connection with the puddling furnace. They are about 4 feet long, divided into 4 parts, the largest being about 20 inches in diameter. That portion of the upper roller under which the metal is first passed, is cut in a deep and irregular manner, resembling that chiselling in stone called moveque work, that it may the more easily get hold of and compress the metal when almost in a fluid state. The plate is next passed under the cross-cut portion of the roller, and successively through the flat sections. The lower roller, it will be observed, is formed with raised collars at intervals, to keep the metal in its proper course. The rollers are connected by cog-wheels placed upon their axes; upon the lowermost of these, works also the wheel by means of which the revolution is communicated. The cheeks are of cast-iron, very massive, that they may bear the violent usage to which they are subjected.

We cannot go into the numerous purposes to which rolling mills of this kind are applied; a few may however be mentioned.

The practice of "slitting" sheets of metal into light rods, either for the use of the wire-drawers or of nail-makers, is carried out by means of two large steel rollers, channelled circularly, as in *fig.* 1566. These are so placed that the cutters or raised parts of one roller, which are exactly turned for that purpose, shall work in corresponding channels of the other roller, thus forming what may be called revolving shears, for the principle is that of clipping; so that a sheet of metal on being passed through this machinery, is separated into slips agreeing in size with the divisions of the rollers.

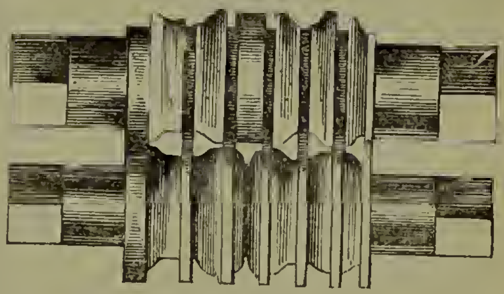
1566



Rolling mills have been patented for rolling tubes for gas and other purposes. See Tubes.

For the manufacture of rails, rolling mills are also employed, *fig.* 1567 representing a rolling mill as constructed for rolling Birkinshaw's rails. The open spaces along the middle of the figure, and which owe their figure to the moulding on the periphery of the rollers, indicate the form assumed by the iron rail as it is passed successively from the larger to the smaller apertures, till it is finished at the last.

1567



For a further description, and for the arrangement of rolling mills and slitters, see Iron, Vol. II. p. 591. Beyond these few notices the character of this Dictionary will not admit of our going; the reader is therefore referred to the works which have been published on the Metallurgy of Iron and Steel, for further information.

ROMAN CEMENTS. Under the name of Roman cement, some hydraulic mortars, varying considerably in their chemical composition, though physically possessing the same general character, are sold. Like all the hydraulic cements, it is an argillaceous lime. It is usually manufactured from a dark brown stone—a carbonate of lime with much alumina—found in the Island of Sheppy. This stone is calcined and mixed with a certain proportion of sand.

Any hydraulic limestone, that is, one containing from 15 to 20 per cent. of clay, will, when properly prepared, form this cement. Calcine any ordinary clay, and mix it with two-thirds its quantity of lime, grind to powder, and calcine again; this makes a very beautiful cement, improperly called Roman, since the preparation was entirely unknown to the Romans.

ROMAN OCHRE. A deep and powerful orange-yellow colour, transparent and durable. It is used both raw and burnt by artists. The colouring matter is oxide of iron mixed with earthy matter.

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.

ROOFING SLATE. See SLATE.

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 is that of warping the yarns, or stretching them all to one length, which is about 200 fathoms in full-length rope-grounds, 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 hanks, which are drawn by a capstan with a uniform motion through the tar-kettle. 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 that 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 the *cable-laid* and the *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 dockyard 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.

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.

Captain Huddart 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.

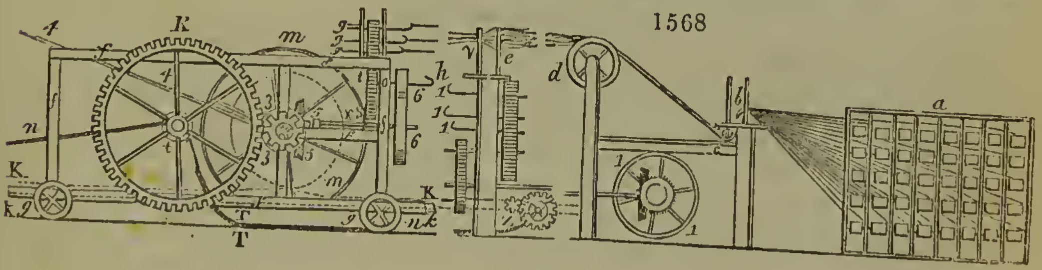
A number of yarns cannot be put together in a cold state, without considerable vacancies, into which water may gain admission; Captain Huddart, therefore, formed the yarns into a strand immediately as they came from the tar-kettle, which he was enabled to do by his registering-machine, and the result 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.

The following description of one of the best modern machines for making ropes on Captain Huddart's plan, will gratify the reader.

Fig. 1568 exhibits a side elevation of the tackle-board and bobbin-frame at the head

1568



of the ropery, and also of the carriage or rope-machine in the act of hauling out and twisting the strands.

Fig. 1569 is a front elevation of the carriage.

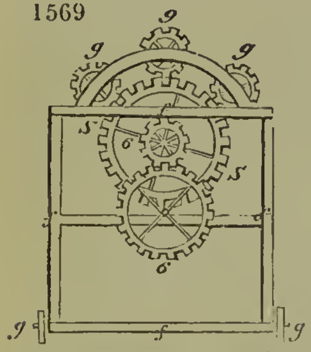
Fig. 1570 is a yarn-guide, or board, or plate, with perforated holes for the yarns to pass through before entering the nipper.

Figs. 1571 and 1572, 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; *k*, *k*, is an endless rope reaching from the head to the bottom of the railway, and is driven by a steam-engine; *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 R, 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 agoing 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 T, 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.

1569



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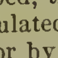
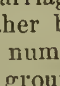
1572



1571



When the strands are drawn out by the carriage to the requisite length, the spur wheels 3, R, 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 *h*, the top put in, and the rope finished in the usual way.

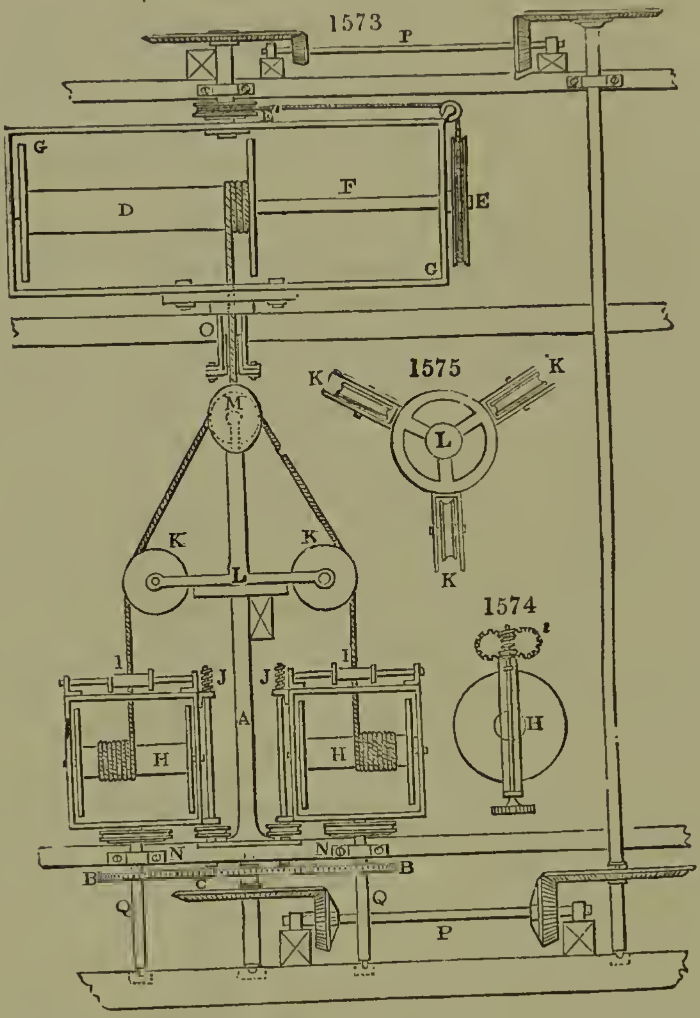
In preparing the hemp for spinning an ordinary thread or rope-yarn, it is only heckled over a large keg or clearer, until the fibres are straightened and separated, so as to run freely in the spinning. In this case the hemp is not stripped of the tow, or cropped, unless it is designed to spin beneath the usual grist, which is about 20 yarns for the strand of a 3-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; 2ndly, the complete check which the foreman has of the quantity of yarn spun in the day; 3rdly, 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, it is necessary also, in passing the yarns through the upper board, to proportion the number of centre to that of outside yarns. In ordinary sized ropes, the strand seems to have the fairest appearance, when the outside yarns form from two thirds to three fourths of the whole quantity, in the portion of twist given by the carriage in drawing out and forming the strands.

In laying cables, torsion must be given both behind and before the laying top. *Figs.* 1573 to 1575 represent the powerful patent apparatus employed for this purpose. A, is a strong upright iron pillar, supported upon the great horizontal beam N, N, and bearing at its upper end the three-grooved laying top M. H, H, are two of the three great 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 proceed over the three guide pulleys K, K, K, towards the laying top M, and finally pass through the tube O, to be wound upon the cable-reel D. The frames of the three bobbins H, H, H, do not revolve about the fast pillar A, as a common axis; but each bobbin revolves round its own shaft Q, which is steadied by a bracing collet at N, and a conical step at its 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 has a proper degree of twist put into it in one direction, while the cable is laid, by getting a suitable degree of twist in an opposite direction, from the revolution of the frame or cage G, G, round two pivots, the one under the pulley E, and the other over O. The reel D has thus, like the bobbins H, H, two movements; that in common with its frame, and that upon its axis, produced by the action of the endless band round the pulley E, upon one of its ends, and the pulley E′ above its centre of rotation. The pulley E is driven by the bevel mill-gearing P, P, P, as also the under spur wheel C. L, in *fig.* 1573, is the place of the ring L, *fig.* 1575, which bears the three guide pulleys K, K, K. *Fig.* 1574, is an end view of the bobbin H, to show the worm or endless screw J, of *fig.* 1573 working into the two snail-toothed wheels, upon the ends of the two feed-rollers I, I, which serve to turn them. The upright shafts of J, J, receive their motion from pulleys and cords near their bottom. Instead of these pulleys, and the others E, E′, bevel-wheel geering 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 D, 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 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.

His improvements consist, first, in the application of three or more tubes, two of which are shown in *fig.* 1576, placed in inclined positions, so as to receive the strands immediately above the press-block *a*, *a*, and nearly in a line with A, the point of closing or laying the rope. B[1], and B[3], are opposite side views; B[2], an edge view;



and B, 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 angular position.

Secondly, in attaching two common flat sheaves, or pulleys, C, C, *fig.* 1576, 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 B[1]. The said sheaves or pulleys are connected by a crown or centre wheel D, loose upon *b*, *b*, the main or upright axle; E, E, is a smaller wheel upon each tube, working into the said crown or centre wheel, and fixed upon the loose box I, on each of the tubes.

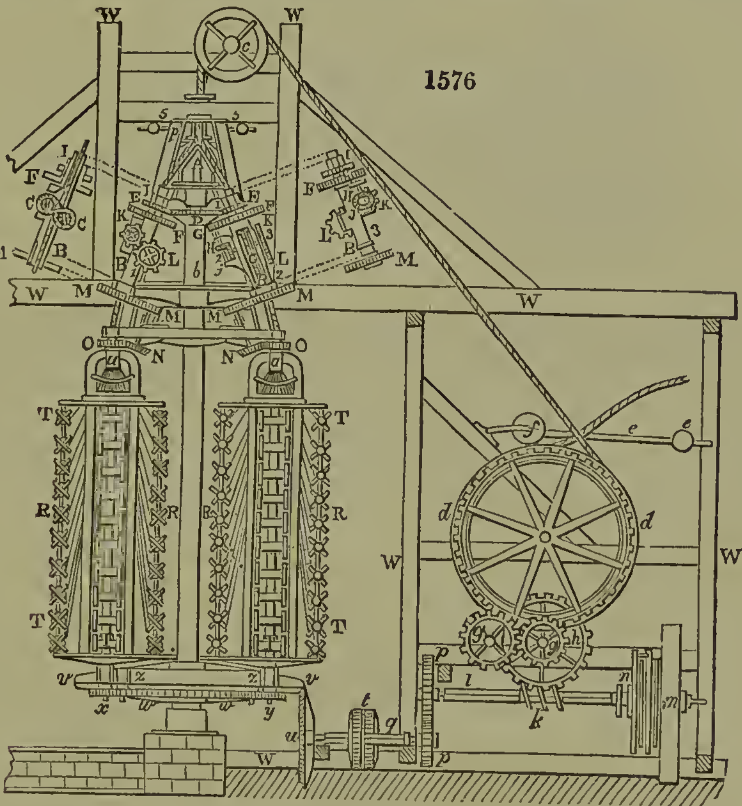
F, F, is a toothed or spur wheel, fixed also upon each of the loose boxes I, and working into a smaller wheel G, upon the axis 2, of each tube; H, is a bevel wheel fixed upon the same axis with G, and working into another bevel wheel *j*, fixed upon the cross axle 3 of each tube; K, is a spur wheel attached to the same axis with *j*, at the opposite end, and working into L, 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 or tension is put upon each strand as drawn forward over the pulley C.

Thirdly, the invention consists in the introduction of change wheels M, M, M, M, *fig.* 1576, for putting the forehard or proper twist into each strand before the rope is laid; this is effected by small spindles on axles 4, 4, placed parallel with the line of each tube B.

Upon the lower end of each spindle the bevel wheels N, N, are attached, and driven by other bevel wheels O, O, fixed immediately above each press-block *a*, *a*. On the top end of each spindle or axle 4, 4, is attached one of the change wheels, working into the other change wheel fixed upon the bottom end of each of the tubes, whereby the forehard or proper twist in the strands for all sizes of ropes, is at once attained, by simply changing the sizes of those two last described wheels, which can be very readily effected, from the manner in which they are attached to the tubes B, B, and 4, 4.

From the angular position of the tubes towards the centre, the strands are nearly in contact at their upper ends, where the rope is laid, immediately below which the forehard or proper twist is given to the strands.

1576

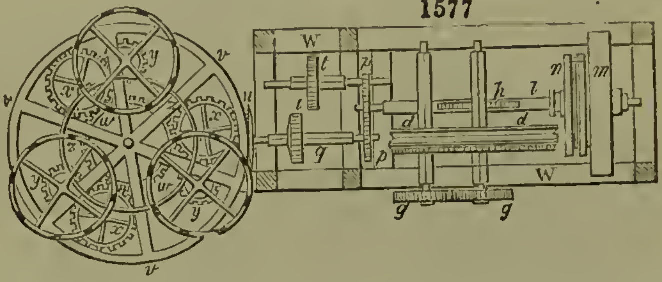


Fourthly, in the application of a press-block, P, of metal, in two parts, placed directly above and close down to where the rope is laid at A, the inside of which is polished, and the under end is bell-mouthed; to prevent the rope from being chafed in entering it, a sufficient grip or pressure is put upon the rope by one or two levers and weights 5, 5, acting upon the press-block, so as to adjust any trifling irregularity in the strand or in the laying; the inside of which being polished, gives smoothness, and by the said levers and weights, a proper tension to the rope, as it is drawn forward through the press-block. By the application of this block, ropes may be made at once properly stretched, rendering them decidedly preferable and extremely advantageous, particularly for shipping, inclined planes, mines, &c.

The preceding description includes the whole of Mr. Norvell's improvements; the remaining parts of the machine may be briefly described as follows: — A wheel or pulley *c*, is fixed independently of the machine, over which the rope passes to the drawing motion represented at the side; *d*, *d*, is a grooved wheel, round which the rope is passed, and pressed into the groove by means of the lever and weight *e*, *e*, acting upon the binding sheaf *f*, to prevent the rope from slipping. After the rope leaves the said sheaf, it is coiled away at pleasure. *g*, *g*, are two change wheels, for varying the speed of the grooved wheel *d*, *d*, to answer the various sizes of ropes; *h*, is a spiral wheel, driven by the screw *k*, fixed upon the axle *l*; *m*, is a band-wheel, which is driven by a belt from the shaft of the engine, or any other communicating power; *n*, *n*, is a friction strap and striking clutch. The axle *q* is driven by two change wheels *p*, *p*; by changing the sizes of those wheels, the different speeds of the drum R, R, for any sizes of ropes, are at once effected.

The additional axle *s*, and wheels *t*, *t*, shown in *fig.* 1577 are applied occasionally for reversing the motion of the said drums, and making what is usually termed left-hand ropes; *u*, *figs.* 1576, 1577, show a bevelled pinion, driving the main crown wheel *v*, *v*, which wheel carries and gives motion to the drums R, R; *w*, *w*, is a fixed or sun wheel, which gives a reverse motion to the drums, as they revolve round the same, by means of the intervening wheels *x*, *x*, *x*, whereby the reverse or retrograding motion is produced, and which gives to the strands the right twist. The various retrograding motion or right twist for all sizes and descriptions of ropes, may be obtained by changing the diameters of the pinions *y*, *y*, *y*, on the under ends of the drum spindles; the carriages of the intervening wheels *x*, *x*, *x*, being made to slide round the ring *z*, *z*: W, W, is the framework of the machine and drawing motion; T, T, T, are the bobbins containing the yarns; their number is varied to correspond with the different sizes of the machines.

1577



Messrs. Chapman of Newcastle, having observed that rope yarn is weakened by passing through the tar-kettle, 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 the tar 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.

The same engineers patented 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
—	27	8	1	26	23	8	2	8	13	2	3	12

The above statement is the result of several hundred experiments.

ROPE, WIRE. See WIRE ROPE.

ROSALIC ACID, discovered by Rungé, more fully examined by Hugo Müller; obtained by exhausting the crude carbonate of lime with a dilute boiling solution of carbonate of ammonia: evaporating to dryness, ammonia is evolved and a dark resinous body separates, which is the crude rosalic acid. The crude acid thus obtained was purified by conversion into a lime salt, and liberation of the acid again by acetic acid.

It is a dark green amorphous substance, possessing in a high degree the greenish lustre of cantharides. It is transparent with a fine red tint; very thin films appear of a deep orange colour in reflected light, and of a golden metallic lustre.—H. M. W.

ROSETTA WOOD. An East Indian wood of a lively red orange colour, and handsomely veined with darker marks. It is occasionally used in fine cabinet work.

ROSEWOOD. This well-known wood, which has long been fashionable for drawing-room and library furniture, is a native of the Brazils, the East Indies, the Canary Islands, and some parts of Africa. The best rosewood comes from Rio de Janeiro.

"Rosewood is a term as generally applied as iron wood, and to as great a variety of plants in different countries, sometimes from the colour, and sometimes from the smell of the woods. The rosewood of Bahia and Rio Janeiro, called also Jacaranda, is so named, according to Prince Maximilian as quoted by Dr. Lindley, because when fresh it has a faint but agreeable smell of roses, and is produced by a mimosa in the forests of Brazil. Mr. G. Loddiges informs me it is the *Mimosa jacaranda*"—*Holtzapffel.*

Rosewood is imported in large slabs, or the halves of trees, some of these logs producing as much as £150 when cut into veneers. We *imported* in 1858, 1529 tons; computed real value of which was £21,222.

ROSIN, or *common resin*. The residue of the process for obtaining oil of turpentine. While liquid it is run into metallic receivers coated with whiting to prevent adhesion, and from these laded into casks. See TURPENTINE.

When the distillation is not carried too far, the product is called *yellow rosin;* it then contains a little water. The heat being continued the water is expelled and *transparent rosin* is the result.

If the process be continued up to a point short of producing the decomposition of the rosin, it acquires a deep colour, and becomes *brown* or *black rosin*, sometimes cal ed *colophony.*

Rosin is insoluble in water, but soluble in alcohol, ether, and the volatile oils. It unites with wax and the fixed oils by heat, forming the *emplastrum resinæ* of the London Pharmacopœia.

Rosin is employed in common varnishes; it is united with tallow in the preparation of common candles. It has been proposed to employ rosin as a source from which gas might be obtained. The experiments made were not, however, of so successful a kind as to warrant the general adoption of the process.

Rosin *imported* in 1858:—

	Cwts.	Computed real value. £
Hamburgh	7,041	3,168
Belgium	2,820	1,269
France	9,110	4,099
United States	682,452	306,175
Other parts	7	4
	701,430	£314,715

ROSIN OIL. By distillation rosin separates into rosin oil and tar. (See TAR.) This oil is a mixture of four carbides of hydrogen:

$$C^{14}H^{8};\ C^{10}H^{12};\ C^{32}H^{16};\ \text{and}\ C^{20}H^{8}.$$

The rosin oil, which distils over at about 300 F., is sometimes used in the arts as a substitute for the oil of turpentine. The part which boils at 464° F., called *retinole*, $C^{32}H^{16}$, enters into the composition of some printing inks.

ROTCH, or ROCHE. A local term, used by quarrymen and miners in South Staffordshire for a soft and friable sandstone. — H. W. B.

ROTTEN-STONE. A polishing powder which is much used for giving lustre to brass, silver, and even to glass surfaces. According to the analysis of Richard

Philips, the rotten-stone of Ashford in Derbyshire consists of carbon, 10; alumina, 86·0; silica, 4·0. Rotten-stone is nearly peculiar to this country, being found principally in Derbyshire, near Bakewell, and in Carmarthenshire and Breconshire, South Wales.

It is thought by geologists to be derived in Derbyshire from the siliceous limestone, "the lime being decomposed, and the silex remaining as a light earthy mass." This does not, however, agree with the above analysis, in which alumina occupies so large a proportion. The total annual produce of the country is under 300 tons.

ROUGE. (*Fard*, Fr.) A cosmetic employed to brighten a lady's complexion. See CARMINE.

ROUGE, JEWELLERS'. An oxide of iron prepared with much care. See OXIDES FOR POLISHING.

ROYAL BLUE. (*Bleu du Roi*, Fr.) A fine deep blue prepared from cobalt, and used for enamel and porcelain painting.

RUBBLE. A local term used by quarrymen and miners for loose angular gravel, or a slightly compacted brecciated sandstone.—H. W. B.

RUBIACINE. See MADDER.

RUBIAN. See MADDER.

RUBICELLE. The name given to yellow or orange-red varieties of spinel.—H. W. B.

RUBIRETINE. See MADDER.

RUBY. A beautiful and favourite gem; it is known, according to its various colours, as the

Ruby spinel, or *Spinel ruby*, which is of a light or dark red, and, if held near the eye, a rose-red colour. Its hardness is 8; specific gravity, 3·523. Its fundamental form is the hexahedron, but it occurs crystallised 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 spinel 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 embedded 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-grey varieties occur in Südermannland in Sweden, embedded in granular limestone. Pleonaste is met with also in the diluvial sands of Ceylon. Clear and finely coloured specimens of spinel are highly prized as ornamental stones. When the weight of a good spinel 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.

Balas ruby. Pale red or rose red, with sometimes a tinge of brown or violet.

Almandine ruby, which is of a violet red colour. Spinel occurs embedded in granular limestone, and with calcareous spar in gneiss and serpentine. It also occupies the cavities of volcanic rocks.—*Dana*.

It is also found in clay and in the sand of rivers. Spinel scratches quartz; but the sapphire is harder than the ruby. As gems, the ruby is cut in the same form as the diamond, and is set with a foil of copper or gold. Pure spinel is a compound of alumina and magnesia, usually in the proportions of about 28 magnesia and 72 alumina, although we sometimes find the magnesia partially replaced by lime, and the alumina by oxide of iron.

Ruby, oriental, the red sapphire, containing 97 or 98 of alumina.

RUE (*Ruta graviolens*) produces a yellow colouring matter, similar to that obtained from BUCKWHEAT, which see.

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 sugar. 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 Dr. Ure's 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. Dr. Ure has 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 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. 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 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 cwts.) of sugar.

Rum is largely used in the navy. Its general consumption will, however, be shown by the quantities imported.

Rum imported during the 10 *years form* 1848.

Year	Gallons.	Year	Gallons.
1848 - - -	6,858,981	1853 - - -	4,206,248
1849 - - -	5,306,827	1854 - - -	8,625,907
1850 - - -	4,194,683	1855 - - -	8,714,337
1851 - - -	4,745,244	1856 - - -	7,169,005
1852 - - -	5,490,224	1857 - - -	6,515,683

Rum imported in 1858.

	Proof gallons.
From Cuba - - -	8,415
„ Porto Rico - -	50,233
„ St. Croix - - -	20,137
„ Dutch Guiana - -	74,466
„ Mauritius - - -	235,170
„ British East Indies -	241,402
„ British West Indies -	3,579,171
„ British Guiana - -	3,030,432
„ Other ports - -	71,793
	7,311,219

Colonial rum is imported into	England	at 8*s.* 2*d.*	per gallon	since	19th July, 1858.
„ „	Scotland	at 8*s.* 2*d.*	„	„	21st April, 1855.
„ „	Ireland	6*s.* 4*d.*	„	„	21st „ „
		8*s.* 2*d.*	„	„	19th „ 1858.
Foreign rum „	„	15*s.* 0*d.*	„	„	18th March, 1846.

Rum Shrub is imported at the same rate of duties.

RUSH. A common plant, extensively employed in the manufacture of mats, baskets, &c. The pith of the rush is used in making *rushlights*. Bulrushes are a different plant. These are used for polishing wood, and also by coopers. The Dutch rush is also much used for polishing metals and stone.

RUSSIAN LEATHER. See LEATHER, RUSSIAN.

RUST is the orange-yellow coat of peroxide which forms upon the surface of iron exposed to moist air. Oil, paint, varnish, plumbago, grease, or indeed any body which will shield the metal from the moist air, may be employed, according to circumstances, to prevent the rusting of iron utensils.

Iron under all ordinary circumstances effects the decomposition of water, abstracting the oxygen, and combining with it. The rusting of iron is one of the many instructive examples of chemical affinity which are constantly occurring around us.

RUTHENIUM. After osmium, ruthenium is the most refractory metal we are acquainted with. It requires a very extreme heat to melt the smallest quantity. When melting there is formed the oxide of ruthenium (RuO^2) which is volatilised, and which smells something like osmic acid. When removed from the flame ruthenium is blackish-brown on the surface, and is brittle and hard like iridium. It is only distinctly separated from this last metal by its density, which is obviously half that of iridium. The purest ruthenium obtained weighs from 11 to 11·4.

To prepare the metal mix the osmide in fine powder with 3 parts of binoxide of barium and 1 part of nitrate of baryta, and heat them to redness in a clay crucible for an hour. The black friable mass which remains is powdered with great care and introduced into a flask in which has been previously mixed 20 parts of water and 10 parts of ordinary muriatic acid. The flask must be placed in cold water to avoid the elevation of temperature which would ensue from the violent reaction which takes place. This operation should be conducted under a good chimney to avoid the escape of the osmic acid vapour into the laboratory.

When this reaction is finished 1 part nitric acid is added, and then 2 parts ordinary strong sulphuric acid. The flask is now well shaken, and the sulphate of baryta is allowed to deposit. The supernatant liquid is then poured off, the precipitate is washed by decantation, and the liquid and the washings are distilled together in a tubulated retort, until about a fourth of their volume of a liquid very rich in osmic acid has passed over. The red liquor which is left in the retort is evaporated to a small volume, 2 or 3 parts of sal-ammoniac in small pieces are added, and a small quantity of nitric acid. The whole is now evaporated to dryness at the temperature of boiling water. A crystalline violet-black precipitate remains in the capsule, which is treated with a small quantity of water partly saturated with sal-ammoniac, and wash with the same solution until it is no longer coloured. The insoluble salt left (chloro-iridiate of ammonia containing ruthenium) is heated by degrees to redness in a porcelain crucible. The mixture of iridium and ruthenium thus obtained is fused in a silver crucible with an equal weight of hydrated potash and twice its weight of nitre, and when cold the rutheniate of potash is dissolved out with cold water; the solution, which is yellow, is decomposed by means of carbonic or nitric acid, and the precipitated oxide of ruthenium is strongly calcined in a charcoal crucible. The ruthenium is then reduced in the apparatus before described. Iridium and ruthenium present many analogies; their coloured reactions are the same, and the oxide of iridium dissolves in a mixture of nitre and potash.

Ruthenium forms with zinc an alloy which will burn in the air; it crystallises in hexagonal prisms. With tin there is formed an alloy $RuSn^2$, which crystallises in cubes as beautiful in their form and lustre as crystallised bismuth.—*Deville and Debray on the platinum metals.*

RUTILE. Native oxide of titanium, coloured by iron. It is used in porcelain painting to produce a yellow colour.

RYE (*Seigle*, Fr.; *Roggen*, Germ.) is a cereal grain, supposed to be a native of Crete. It appears to have been used at a very early period by man. The culture of rye is confined to the temperate zones. 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 uncrystallisable 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.

Rye is sometimes used as a source, when fermented, of obtaining spirituous liquors. The straw has been long used and celebrated for the manufacture of straw plait.

RYE, ERGOT OF. (*Secale cornutum.*) The grain rye is subject to a disease (*spermedia clavis*) commonly known as *ergot*, which causes the grain to turn black. It is used medicinally. See Pereira's *Materia Medica*.

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 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 renewed every 15 or 20 minutes. See FREEZING MIXTURE.

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 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."

The following table shows the quantities of sugar contained in syrups of the annexed specific gravities. It was the result of experiments carefully made by Dr. Ure.

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 next table, marked *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. See BEER; MALT; FERMENTATION.

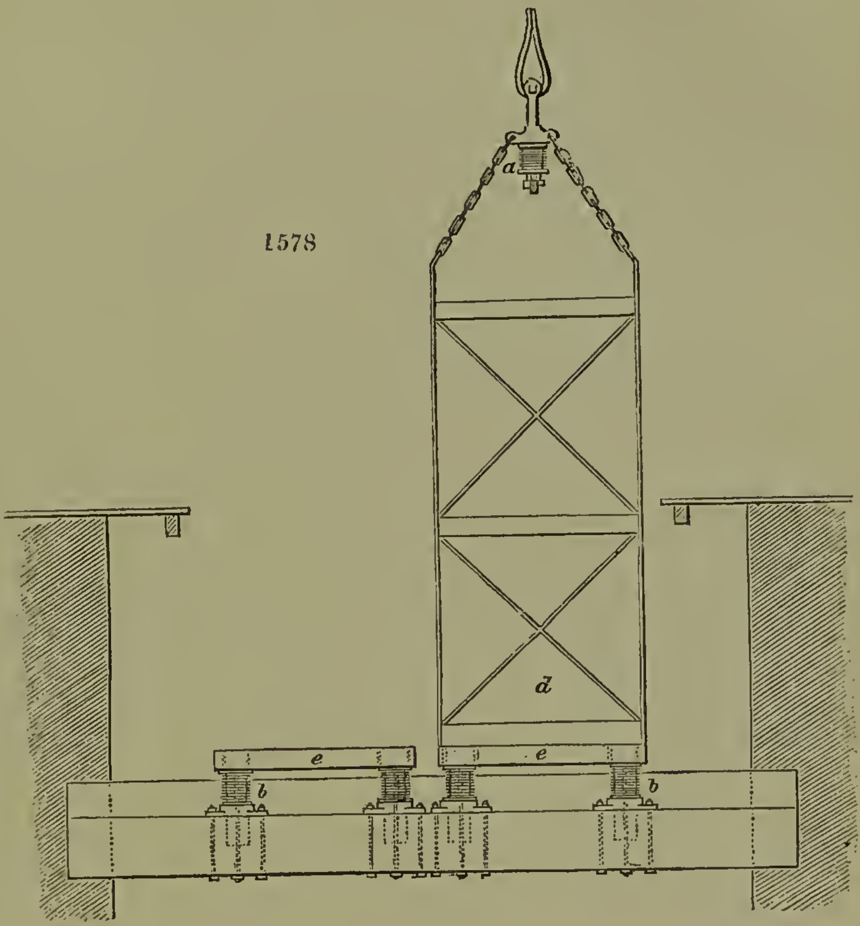
If the decimal part of the number denoting the specific gravity of syrup be multiplied by 26, the product will denote very nearly the quantity of sugar per gallon in pounds at the given specific gravity.

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	·1851	1·154	4·0880	1.231	6·1474
1·001	0·0255	·0026	1.078	2·0465	·1873	1·155	4·1148	1·232	6·1743
1·002	0·0510	·0051	1·079	2·0734	·1896	1·156	4·1319	1·233	6·2012
1·003	0·0765	·0077	1·080	2·1006	·1918	1·157	4·1588	1·234	6·2280
1·001	0·1020	·0102	1·081	2·1275	·1941	1·158	4·1857	1·235	6·2551
1·005	0·1275	·0128	1·082	2·1543	·1963	1·159	4·2128	1·236	6·2822
1·006	0·1530	·0153	1·083	2·1811	·1985	1·160	4·2502	1·237	6·3093
1·007	0·1785	·0179	1 084	2·2080	·2007	1·161	4·2771	1·238	6·3362
1·008	0·2040	·0204	1·085	2·2359	·2029	1·162	4 3040	1·239	6·3631
1·009	0·2295	·0230	1·086	2·2627	·2051	1·163	4·3309	1·240	6·3903
1·010	0·2550	·0255	1·087	2·2894	·2073	1·164	4·3578	1·241	6·4152
1·011	0·2805	·0280	1·088	2·3161	·2095	1·165	4·3847	1·242	6·4401
1·012	0·3060	·0306	1·089	2·3438	·2117	1·166	4·4115	1·243	6·4650
1·013	0·3315	·0331	1·090	2·3710	·2139	1·167	4·4383	1·244	6 4902
1·014	0·3570	·0356	1 091	2·3987	·2161	1·168	4·4652	1 245	6·5153
1·015	0·3825	·0381	1·092	2·4256	·2183	1·169	4·4923	1·246	6.5402
1·016	0·4180	·0406	1·093	2·4524	·2205	1·170	4·5201	1·247	6·5651
1·017	0·4335	·0431	1·094	2·4792	·2227	1·171	4·5460	1·248	6·5903
1·018	0·4590	·0456	1·095	2·5061	·2249	1·172	4·5722	1·249	6·6152
1·019	0·4845	·0481	1·096	2·5329	·2270	1·173	4·5983	1 250	6·6402
1·020	0·5100	·0506	1·097	2·5598	·2292	1·174	4·6242	1·251	6·6681
1·021	0·5351	·0531	1·098	2·5866	·2314	1·175	4·6505	1·252	6·6960
1·022	0·5602	·0555	1·099	2·6130	·2335	1·176	4·6764	1 253	6·7240
1·023	0·5853	·0580	1·100	2·6404	·2357	1·177	4·7023	1·254	6·7521
1·024	0·6104	·0605	1·101	2·6663	·2378	1·178	4·7281	1·255	6·7800
1·025	0 6355	·0629	1·102	2·6921	·2400	1·179	4·7539	1·256	6 8081
1·026	0·6606	·0654	1·103	2 7188	·2421	1·180	4·7802	1·257	6·8362
1·027	0 6857	·0678	1·104	2·7446	·2443	1·181	4·8051	1·258	6·8643
1·028	0·7108	·0703	1·105	2·7704	·2464	1·182	4 8303	1·259	6·8921
1·029	0·7359	·0727	1·106	2·7961	·2486	1·183	4·8554	1·260	6·9201
1·030	0·7610	·0752	1·107	2·8227	·2507	1·184	4·8802	1 261	6·9510
1·031	0·7861	·0776	1·108	2 8485	·2529	1·185	4·9051	1·262	6·9822
1·032	0·8112	·0800	1·109	2·8740	·2550	1·186	4·9300	1·263	7·0133
1·033	0·8363	·0825	1·110	2·9001	·2571	1·187	4·9552	1·264	7·0444
1·034	0·8614	·0849	1·111	2·9263	·2593	1·188	4 9803	1 265	7·0751
1·035	0·8866	·0873	1·112	2·9522	·2614	1·189	5·0054	1·266	7·1060
1·036	0·9149	·0897	1·113	2·9780	·2635	1·190	5·0304	1·267	7·1369
1·037	0·9449	·0921	1·114	3·0045	·2656	1·191	5·0563	1·268	7·1678
1·038	0 9768	·0945	1·115	3·0304	·2677	1·192	5·0822	1·269	7·1988
1·039	1·0090	·0969	1·116	3·0563	·2698	1·193	5·1080	1·270	7·2300
1·040	1·0400	·0993	1·117	3·0821	·2719	1·194	5·1341	1·271	7·2601
1·041	1·0653	·1017	1 118	3·1080	·2740	1·195	5 1602	1·272	7·2902
1·042	1·0906	·1041	1·119	3·1343	·2761	1 196	5·1863	1·273	7·3204
1·013	1·1159	·1065	1·120	3·1610	·2782	1·197	5·2124	1·274	7 3506
1·044	1·1412	·1089	1 121	3·1871	·2803	1·198	5·2381	1·275	7·3807
1·045	1·1665	·1113	1·122	3·2130	·2824	1·199	5·2639	1·276	7·4109
1·046	1·1918	·1136	1·123	3·2399	·2845	1·200	5·2901	1·277	7·4409
1·047	1·2171	·1160	1·124	3·2658	·2865	1·201	5·3160	1·278	7·4708
1·048	1·2424	·1184	1·125	3·2916	·2886	1·202	5·3422	1·279	7·5007
1·049	1·2687	·1207	1·126	3·3174	·2907	1·203	5·3681	1·280	7·5307
1·050	1·2940	·1231	1·127	3·3431	·2927	1·204	5·3941	1·281	7·5600
1·051	1·3206	·1254	1·128	3·3690	·2948	1·205	5·4203	1·282	7·5891
1·052	1·3472	·1278	1·129	3·3949	·2969	1·206	5·4462	1·283	7·6180
1·053	1·3738	·1301	1·130	3·4211	·2989	1·207	5·4720	1·284	7·6469
1·054	1·4004	·1325	1·131	3·4490	·3010	1·208	5·4979	1·285	7·6758
1·055	1·4270	·1348	1·132	3·4769	·3030	1·209	5·5239	1·286	7·7048
1·056	1·4536	·1372	1·133	3·5048	·3051	1·210	5·5506	1·287	7·7331
1·057	1·4802	·1395	1·134	3·5326	·3071	1·211	5·5786	1·288	7·7620
1·058	1 5068	·1418	1·135	3·5605	·3092	1·212	5·6071	1·289	7·7910
1·059	1·5334	·1441	1 136	3·5882	·3112	1·213	5·6360	1·290	7·8201
1·060	1·5600	·1464	1·137	3·6160	·3132	1·214	5·6651	1 291	7·8482
1·061	1·5870	·1487	1·138	3·6437	·3153	1·215	5·6942	1·292	7·8763
1·062	1·6142	·1510	1·139	3·6716	·3173	1·216	5·7233	1·293	7 9042
1·063	1·6414	·1533	1·140	3·7000	·3193	1·217	5·7522	1·294	7·9321
1·064	1·6688	·1556	1·141	3·7281	·3214	1·218	5·7814	1·295	7·9600
1·065	1·6959	·1579	1·142	3·7562	·3234	1·219	5·8108	1·296	7·9879
1·066	1·7228	·1602	1·143	3·7840	·3254	1·220	5·8401	1·297	8·0158
1·067	1·7496	·1625	1·144	3 8119	·3274	1·221	5·8680	1·298	8·0448
1·068	1·7764	·1647	1·145	3·8398	·3294	1·222	5·8962	1·299	8·0719
1·069	1·8033	·1670	1·146	3·8677	·3314	1·223	5·9242	1·300	8·1001
1·070	1·8300	.1693	1·147	3·8955	·3334	1·224	5·9523		
1·071	1·8571	·1716	1·148	3·9235	·3354	1·225	5·9801		
1·072	1·8843	·1738	1·149	3 9516	·3374	1·226	6·0081		
1·073	1·9116	·1761	1·150	3 9801	·3394	1·227	6·0361		
1 074	1·9385	·1783	1·151	4·0070		1·228	6·0642		
1·075	1·9653	·1806	1·152	4·0342		1·229	6·0925		
1·076	1·9928	·1828	1·153	4·0611		1·230	6·1205		

SAFETY CAGE. In all our collieries the men descend to their labour and are raised from the depth of the mine by the winding machinery. This may be described in general terms as a stage travelling in guides fixed to the sides of the shafts. The rapidity with which these stages are moved up or down is very great, and consequently, if anything occurs to engage the attention of the man in charge of the

1578



winding-engine, the stage with its living load is either landed with injurious violence at the bottom of the pit, or it is carried over the pulley, and thus the lives of the men are sacrificed. The above drawing, *fig.* 1578, shows an ingenious contrivance for obviating the blow which arises from reaching the bottom at too great a speed. *e e*, are platforms placed on Indian-rubber springs (see Caoutchouc) *b b*, on the landing at the bottom of the pit; *d*, is one of the cages which has descended, the other being supposed to be at the surface. The elasticity of these springs certainly serves to protect the men from the violence of the concussion in the event of the rope breaking, or if from any other cause they suddenly reach the bottom.

Many safety cages, so called, have been invented, the principles of which are to allow them to travel freely on their guides, so long as the rope by which they are suspended remains entire; but, in the event of its breaking, the arms, levers, or catches seize the guide-rods, and thus suddenly stop the cage. Experience has not satisfactorily confirmed the value of these arrangements.

A simple arrangement for a safety cage was published by Mr. Andrew Smith, in 1852. According to Mr. Smith's invention, the drawing rope is connected with the chain-work supporting the cage by a strong elastic tube, which gives the cage an easy motion until an accident takes place. Immediately the rope breaks, the weight of the cage forces the end of a lever against the guide-rods, which extend from top to bottom of the shaft. The following description may render the invention more intelligible:—A horizontal bar is provided with a slot at each end, through which the guide rods pass; at the inner end of each slot is a pin, which forms the fulcrum of a lever, the shorter arm of which is towards the guide-rod. While the machinery is working properly, each lever forms as it were a link of the chain by which the cage is suspended; the bar and the connecting levers forming about an equilateral triangle. To the extremity of the longer arm of the lever are connected the rods by which the cage itself is suspended; these rods cross each other, and the cage is hooked upon the end. It will readily be understood that, while all is in order, the short arms of the lever are held back from the guide-rods, and the slot of the cross-bar is sufficiently large to admit the rise and fall of the cage without impediment; but upon the breakage of the rope the long arms of the levers are depressed, and the short arms forced, as stated, against the guide-rods, preventing the further fall of the cage. The cost of the contrivance is comparatively trifling, which is another recommendation to its use. Among the more prominent patented inventions are those of Mr. F. Emery, of Cobridge, Staffordshire, of Messrs. White and Grant of Glasgow, and of Mr. Foudriner. Messrs. White and Grant's cage is simple and inexpensive, no rack-work being required upon the guide-rods, and the suspending power depending upon the simple turning of an eccentric, which is only kept from revolving by the tension of the suspending rope or chain. An eccentric is placed on each side of each guide-rod, and while the tension is sufficient, the narrow parts of the eccentrics being towards the rods, there is just room for the guide-rod to pass between them. The breakage of the rope, however, releases the eccentrics, and in their attempt to revolve they grip the guide-rods and prevent the descent of the cage.

Again, a variety of contrivances have been introduced to release the cage from the rope or chain in the event of its being drawn up to the pulley: some of these have been adopted with apparent advantage. Humane care, however, whatever may be the mechanical appliances adopted, is necessary to ensure safety.

SAFETY FUSE. A woven cylinder containing gunpowder, employed in blasting rocks, especially in our mines. The safety fuse is also prepared for blasting under water.

SAFETY LAMP. The dangerous nature of the accumulation of fire-damp renders it necessary that some means should be employed to produce light, under such circumstances that the risks of explosion are greatly reduced.

The contrivance of *a steel mill* was long known, and it afforded a tolerable gleam, with which the miners were obliged to content themselves in hazardous atmospheres.

The steel mill consisted of a small frame of iron, mounted with a wheel and pinion, which gave 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 inflame 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 in 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 principles upon which these lamps are constructed, dependent as they are upon some of the most refined researches of science, must be briefly described. Flame is gaseous matter in a state of combustion, that is, it is under all the ordinary circumstances carburetted hydrogen gas in active combination with oxygen. During the intense chemical action there is a great increase of volume, carbonic acid and water vapour escaping. Fire-damp is light carburetted hydrogen or marsh gas. This is formed by the changes which are going on in the carbonaceous compounds of which our fossil fuel is constituted, and is condensed in the coal.

A few of the analyses which have been published by different chemists will show the composition of the fire-damp of our coal mines.

	Carburetted Hydrogen.	Light Air.	Nitrogen.	Oxygen.	Carbonic Acid.	Name of Chemist.
Wallsend, Bensham seam	77·50	- -	21·10	- -	1·30	Playfair.
Jarrow, Bensham seam	83·10	- -	14.20	0·40	2·10	Ditto.
Killingworth -	66·30	23·35	6·52	- -	4·03	Richardson.
Gateshead - -	94·20	- -	4·50	1·30	- -	Graham.

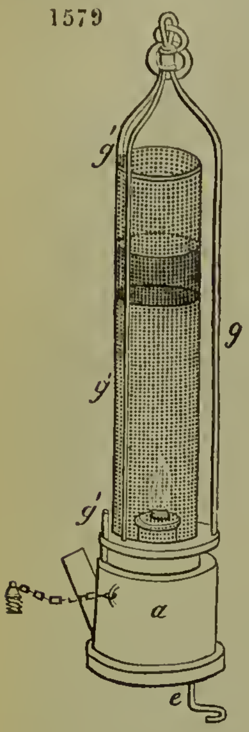
The theories which have been devised by chemists to explain the formation of fire-damp have not been consistent with themselves, nor have they satisfied the conditions under which the gas is found in "fiery seams."

Mr. Tennant, in his *Researches on Flame*, first noticed that burning gases would not pass through tubes of a certain diameter. Dr. Paris says, Davy was not aware of Tennant's researches. Be this as it may, he greatly extended the inquiry.

The first full account of Davy's beautiful researches was published in the *Philosophical Transactions* for 1816, his memoir being entitled "An account of an invention for giving light in explosive mixtures of fire-damp in coal mines, by consuming the fire-damp." In January 1817, the principle was announced in a paper on "Some new experiments and observations on the combustion of gaseous mixtures, with an account of a method of preserving a continued light in mixtures of inflammable gases and air without flame."

The lamp of Davy, *fig.* 1579, consists therefore 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.

1579



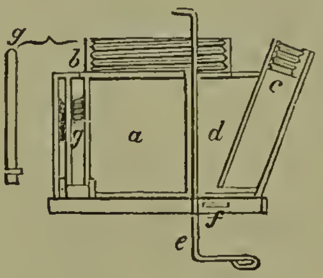
The gauze cylinder should be fastened to the lamp by a screw, *b*, *fig.* 1580, of four or five turns, and fitted to the screw by a tight ring. All joinings in the lamp should be made with hard solder; as the security depends upon the circumstance, that no aperture exists in the apparatus larger than in the wire-gauze.

The parts of the lamp are,

1. The brass cistern *a*, *d*, *fig.* 1580, 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 *e* 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*.

1580



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.* 1579, which should not have less than 625 apertures to the square inch.

5. The second top, ¾ of an inch above the first, surmounted by a brass or copper plate, to which the ring of su pension 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.* 1580 is drawn upon a larger scale than *fig.* 1579, to show its minuter parts.

When the wire-gauze safety-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 1-3rd 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. This, however, is rarely employed.

The late Mr. John Buddle, one of the most experienced of coal miners, writes as follows, in the *Journal of Science*, on the general use of the safety lamp: "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 safety-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." The two first safety lamps used in a colliery are preserved in the Museum of Practical Geology.

The action of the wire-gauze has been supposed to depend upon a cooling process, but many experiments tried by the editor of the present work tends to convince him that the cooling hypothesis will not explain the phenomenon. He conceives the impermeability of wire-gauze to flame to be due to a repulsive power established between the hot metal and the ignited gas, similar in character, although differing in condition, to that which prevails between water and a white-hot metal. The gas undergoing combustion and the metal appear to repel each other in a similar manner. Frequently, from the intensity of the explosion going on within the lamp, the iron wires of the gauze will become red-hot,—so hot, indeed, that, as Mr. Buddle says, coal dust would be ignited by it, and yet the flame would not pass through.

Previously to the introduction of the "Davy," as it is commonly called, Dr. Clanny in 1813 proposed a lamp, the flame of which was carefully guarded from the external atmosphere, air being supplied by means of a bellows, and made to pass through a vessel containing oil. George Stephenson, proceeding not improbably upon the data furnished by Mr. Tennant, as Davy, notwithstanding Dr. Paris's statement, may have done, with that peculiar aptitude in mechanical design which ever characterised that remarkable man, at once, and without any knowledge of the researches of the chemist, devised a lamp by which air was admitted to the flame through "apertures of wire-gauze." This lamp is said by Mr. Brandling to have been tried in "the Killingworth pits on Saturday, October 21st, 1815." The result, however, of a very careful examination of the question as between George Stephenson and Humphry Davy by a meeting of coal-owners was, on the 11th October, 1816, a decision that the merits of discovering a real safety lamp belonged to Davy; and on the 13th of September, 1817, a service of plate was presented by the coal-owners at Newcastle, "as a testimony of their gratitude for the services you have rendered to them and to humanity." It is to be regretted that the repose which is ever so necessary to the progress of science, and the discovery of truth, should be invaded by the influences of jealousy and assailed by the shafts of malevolence. Two mighty minds, gifted beyond their brethren, discover a principle. One of these minds, as a mechanic, gives his idea a visible expression in a mechanical manner, and he is not completely successful; the other, trained as an analyst, seeks out the laws of action involved; dives further into the mysteries of nature; and when he develops his idea to the world, it is a success. These two giants in intellect should have been friends at heart; they were both equally discoverers, and their names shine as "beacons to the abodes where the Eternals are."

Numerous modifications of the Davy safety lamp have been from time to time introduced. A few of the more important must be named:—

1. George Stephenson modified his original plan. His modified lamp consisted of a wire gauze cylinder about $2\frac{1}{4}$ inches diameter, and about 6 inches high, with a glass shield inside. The air for combustion was admitted through a series of perforations in the bottom, and a metal chimney, full of small holes, is fixed inside on the top of the glass cylinder.

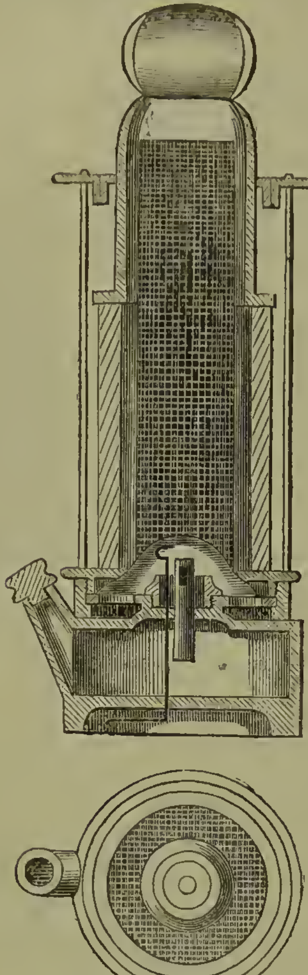
2. Mr. Smith, of Newcastle, improved this by covering all the perforations in the metal with wire gauze.

3. Newman, to meet the objection that strong currents of air, or of gas, could be forced through the gauze, made a lamp with a double wire gauze, commencing from nearly the top of the flame of the lamp, leaving the lower portion with one gauze only; there was no obstruction to the light, and it has not been found possible to light a gas flame by the Newman double gauze lamp, whereas this may be done by suddenly driving the flame through the single gauze of the Davy.

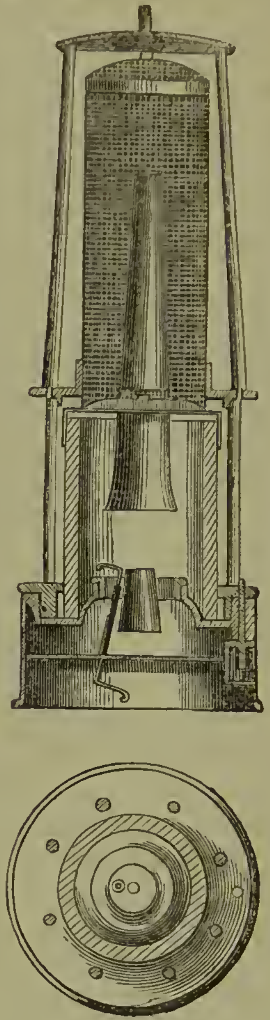
4. Upton and Roberts, *fig.* 1581. Their lamp consists of a wire gauze-cylinder $5\frac{1}{2}$ inches long and $1\frac{1}{2}$ inch in diameter, which is attached to the cylinder in the

usual manner. The lower half is protected by a thick glass cylinder, and the remaining portion by one of copper, screwed to the upper ring of the frame. The air for combustion passes through a range of small openings in the upper part of the cistern

1581



1582



into a space protected by a double shield of closely compressed wire-gauze. A cone of sheet metal stands above this shield and conducts the air directly upon the wick.

5. Martin's lamp was, in many respects, similar to Upton and Roberts's, but so constructed that the flame was extinguished as soon as an explosive mixture was within the glass cylinder.

6. Dumesnil sought to increase the quantity of light, at the same time as he protected the flame against any rapid current. The glass shield surrounding the flame is of carefully annealed glass, and is protected from mechanical injury by curved metal bars; a chimney of sheet metal being above the glass, and all the air being compelled to pass through apertures rendered safe by the use of wire gauze.

7. Dr. Clanny, who had for so many years directed his attention to safety-lamps, introduced a new lamp, with an impervious metal shield, having glass and lenses in its sides, only open at the highest part of the gauze cylinder for about 1½ inches. Thus there is no admission of air to the lamp, or of the products of combustion from the lamp, except over the top of the shield. This in many respects resembles Mueseler's lamp, to be next described.

8. Muesler's lamp is shown in section, *fig.* 1582. The cistern opening for the wick, &c., are precisely the same as we find them in the "Davy." A glass shield occupies about two-fifths of the entire height, the lower edge resting in an annular recess on the upper surface of the cistern. A conical tube of metal carries off the products of combustion. Upon the bars which protect the glass rests the gauze cylinder above it. When this lamp is brought into an explosive mixture the flame is first lengthened and then extinguished. It unfortunately happens that by turning the lamp on one side the flame is often put out, and in the mines of Liège boys are employed to relight the extinguished lamps. It is, however, stated that not less than 12,000 of these lamps are in daily use in Belgium.

9. Combe's and Boty's are modifications of the preceding.

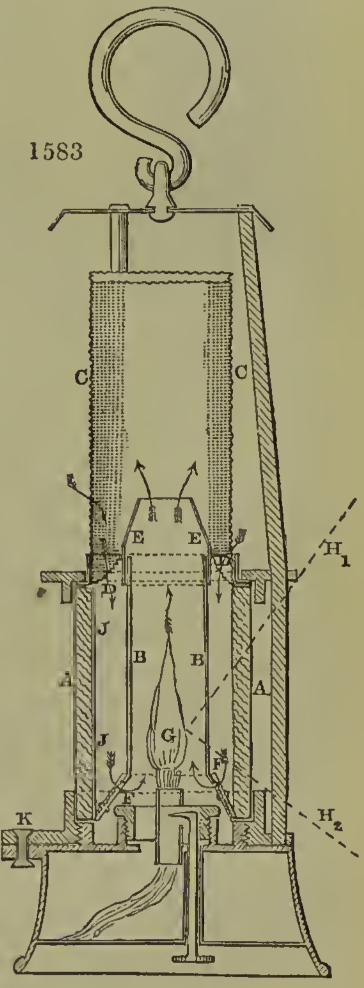
10. Parish's lamp, one by Dr. Fyfe, and some others by Mr. Hewitson and by Mr. Biram, involve the use of talc in the place of gas.

11. Eloin's lamp consists of a cylinder fixed upon the upper surface of the cistern and the glass shield, which is pierced with several holes covered with wire gauze, through which the air enters. As in Upton and Roberts's lamp, a cone assists the combustion. A copper chimney is connected with the base, pierced in the upper end with small holes, through which the products of combustion escape. The light is improved by means of a reflector, which slides upon the bars, by which the glass is protected.

12. Dr. Glover, Mr. Cail, and Mr. T. Y. Hall have recently introduced lamps which are so similar to those already named that they need not be described.

13. Mackworth's safety lamp. This safety lamp was contrived by one of the Government Inspectors of coal mines, to meet the objections raised in resisting the general introduction of the Davy lamp into fire-damp mines. The objections were the small light given by the Davy, which is an inconvenience in working high seams of coal, or in picking out the shale and pyrites from the small coal of dirty seams. 2ndly, that the Davy was not safe in a rapid current of air and gas, and that glass lamps were not safe in places where the glass might become cracked, besides being heavy to carry; and, 3rdly, that the ordinary locks of Davy lamps could be easily picked and opened by the workmen to obtain more light, and light their pipes. The lamp differs from other glass lamps in having a thick outer glass, A A, *fig.* 1583, and a thin inner chimney, B B. The air enters to the flame, as shown by the arrows, through three wire gauzes; 1st, the cylindrical gauze, C; then through the gauze D, which supports the brass cover E, of the glass chimney B; and, 3rdly, through the conical wire gauze F, which, with its frame, acts as a support to the glass chimney B. This conical frame throws the air on to the flame G, so as to produce a more perfect combustion and a whiter light. A wire gauze may be placed on the top of the cover E, but it is unnecessary, as the products of combustion passing through the contracted aperture, prevent any explosion passing up into the cylindrical gauze C.

1583

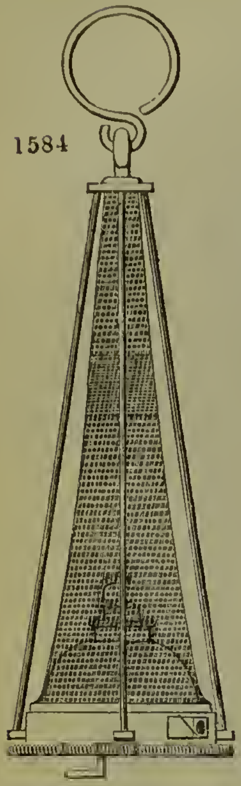


The objects sought to be obtained in this lamp are, the production of from twice to three times the light of the Davy, by a more perfect combustion of oil, throwing the light more up and down, as shown by the lines H_1 H_2. The reflector, J, placed between the glasses, where it is untarnished by smoke, adds to the light. This lamp burns with a steady flame, in currents of air which extinguish other lamps. It is $1\frac{1}{4}$ lb. heavier than a Davy, and $1\frac{1}{2}$ lb. lighter than a Mueseler or a Clanny lamp. The outside glass does not get so hot as in the two latter lamps, which renders the glass liable to be cracked by cold water; and if the outside glass is broken by a blow or otherwise, there is still a perfect safety lamp inside. The mode of locking or riveting the lamp detects any attempt of the workman to tamper with it. The lead rivet K, is clinched by nippers, leaving a die-mark on the lead. This lamp can be locked and unlocked in a shorter time than other locks, which is an object when several hundred lamps have to be given out every morning to workmen.

Some other lamps have been brought forward, the chief object being to prevent the lamp being opened by the miner, one of the most ingenious being the *miners' safety lamp*, invented by Mr. W. P. Struve, of Swansea.

The sketch on next page will convey a better notion of it than any written description, and it is only needful to add, that although the diameter of the gauze cylinder at its base is considerably more than that of the Davy, yet owing to the oil-box being placed within the gauze cylinder, instead of below it, and thus occupying a considerable portion of the internal space, the cubical contents of the cylinder does not exceed that of an ordinary Davy. The greater amount of cooling surface near the flame, and the less obstructed admission of air thus obtained, renders it practicable and perfectly safe to use a larger wick than in the Davy, whilst the combustion of the oil is much more perfect, and the smoke very considerably diminished. The light emitted from this lamp has been carefully ascertained to be equal to that from three Davys, and owing to the conical form of the cylinder and the shape of the oil-box, it diffuses the light both upwards and downwards, as well as in every other direction, with less shadow than any other lamp that has been offered to the miner. From the more perfect combustion, the consumption of oil in this lamp but slightly exceeds that of the Davy, whilst its simplicity of construction gives great facilities for keeping it in order and for repairs. It barely weighs 1½ lb. We learn that this lamp has been extensively introduced into many of the fiery collieries in South Wales.

1584



Illuminating Power of Lamps.

STANDARD. — A wax candle, 6 to the lb.	Average number of lamps required to equal wax-candle standard.
Davy's lamp, with gauze	8·00
Stephenson's lamp	18·50
Upton and Roberts's	24·50
Dr. Clanny's (glass)	4·25
Mueseler's (glass)	3·50
Parish's lamp, with gauze	2·75
Davy's lamp, without gauze	2·50
Common miner's candle, 30 to the lb.	2·00

SAFFLOWER. This dye-stuff has been fully described under CARTHAMUS.

SAFFLOWER DYEING. See CALICO PRINTING.

SAFFRON. (*Saffran*, Fr. and Germ.) The leaves of the saffron crocus. *Hay saffron* is the only kind now found in the shops—*cake saffron* rarely containing any of that flower. *Hay saffron* consists of the stigmas with part of the style of the flowers, which have been very carefully dried. Spanish saffron is the best which is imported. It is stated that 4,320 flowers are required to produce an ounce of saffron. True cake saffron, no longer to be found, was a filamentous cake, composed of the stigmata of the flowers of the *Crocus sativus*. It is now, however, generally the leaves of the safflower (*carthamus tinctorius*). True saffron contains a yellow matter called *polychroïte*, because of its being susceptible of numerous changes of colour. 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 scarlet red colour, transparent, and of the consistence of honey. It has no smell, with the bitter pungent taste of saffron. It is slightly 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. 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 in cookery. It is also used to colour confectionery articles, liqueurs, varnishes, and especially cakes in the west of England. It was formerly used to such an extent in Cornwall, that that one county consumed more saffron than all the rest of England.

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. In this state it is known as *sago meal*. A factitious sago is prepared in France and Germany with potash starch.

SAL AMMONIAC. See AMMONIUM CHLORIDE.

SALANGANA. See SWALLOW and ALGÆ.

SALAMSTONE. A variety of corundum of little value.

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. Semolina is sometimes sold under this name.

SALICINE is a 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. It has a very bitter taste. It has been employed for the purpose of adulterating the sulphate of quinine. Its composition is $C^{26}H^{18}O^{14}$, quinine being $C^{38}H^{22}N^{2}O^{4}$. The presence of nitrogen in the latter renders the salicine essentially different in its chemical as in its medicinal relations.

SAL MARINE. Common salt (chloride of sodium).

SAL MARTIS. Protosulphate of iron.

SAL MIRABILE. Sulphate of soda.

SAL PRUNELLA is fused nitre cast into cakes or balls.

SAL VOLATILE is carbonate of ammonia.

SALT, EPSOM, is sulphate of magnesia.

SALT, FUSIBLE. Phosphate of ammonia.

SALT, GLAUBER'S. Sulphate of soda.

SALT, GLAZER'S. Sulphate of potash.

SALT, MICROCOSMIC, is the triple phosphate of soda and ammonia.

SALT OF AMBER is succinic acid.

SALT OF LEMERY. Sulphate of potash.

SALT OF LEMONS is citric acid and binoxalate of potash.

SALT OF SATURN is acetate of lead.

SALT OF SODA is carbonate of soda.

SALT OF SORREL is binoxalate of potassa.

SALT OF TARTAR is carbonate of potassa.

SALT OF TIN. Protochloride of tin.

SALT OF VITRIOL is sulphate of zinc.

SALT PERLATE is phosphate of soda.

SALTPETRE is nitre, or nitrate of potassa, which see.

SALT, ROCK, SEA, or CULINARY. These terms are used to designate different forms of a substance which is composed, chemically speaking, of single equivalents of sodium and chlorine, or of 39·4 parts of sodium and 60·6 of chlorine in 100 parts by weight: it is known also by the names of chloride of sodium and muriate of soda. (*Chlorure de sodium; Hydrochlorate de Soude*, Fr.; *Chlornatrium*, Germ.)

Chloride of sodium generally occurs crystallised in the cube, and occasionally in other forms belonging to the regular system; among these varieties, the octahedron, the cubo-octahedron, the dodecahedron, have been observed; but there is another which at first sight appears singular, and deserves notice on account of its frequent occurrence. It is called the funnel or hopper-shaped crystal; and is a hollow, rectangular pyramid, forming on the surface of a saline solution in the course of its evaporation: it appears to commence with the formation of a small floating cube, to the edges of the upper face of which lines of other little cubes attach themselves by the edges of their lower faces. By a repetition of this proceeding, the sides of a hollow pyramid are formed, the apex of which, the single cubical crystal, is downward: the crystal sinks by degrees as the aggregation goes on above, until a pyramidal boat of considerable size is constructed.

The crystals of chloride of sodium are anhydrous, but generally contain a little water entangled in their interstices, the expansion of which causes them to decrepitate when heated. This salt is fusible at a red heat, and at a white heat volatilises. Its crystals are white, frequently perfectly transparent, of a specific gravity of 2·13, and a hardness of 2·5. A remarkable feature in this salt is, that its solubility in water increases but slightly as the temperature of the latter is raised, for, according to the experiments of M. Gay-Lussac, 100 parts of water dissolve

35·81	parts of the salt, at a	temperature of	57·0°	Fahr.
35·88	,,	,,	62·5°	,,
37·14	,,	,,	140·0°	,,
40·38	,,	,,	229·5°	,,

This must be understood to apply only to the pure substance, for the presence of other salts frequently increases its solubility.

Chloride of sodium, when perfectly colourless and transparent, is also perfectly diathermanous, i.e., it allows the rays of heat to pass through its substance almost without perceptible interception. It stands first among solid bodies in this respect, all others absorbing a very considerable portion of the heat which passes through them, and some almost the whole:

Of 100 rays of heat	Clear rock salt transmits - -	92
"	Muddy ditto - - - -	65
"	Plate glass - - - -	24
"	Clear ice - - - - -	0

The source of heat in these experiments was red-hot platinum.

Chloride of sodium occurs in nature chiefly in two forms, either as rock-salt, forming extensive deposits, or disseminated in minute quantity through the mass of the strata which form the earth's crust. Water penetrating the layers of rock-salt, and exerting there a solvent action, gives rise to the brine springs which are found in various countries; whilst streams and rivers dissolving the same substance out of the strata through which they flow, carry it down to the sea, where, from its great solubility, it has gone on gradually increasing, and now constitutes the principal saline ingredient in the waters of the ocean.

Even in mass, i.e., as Rock-salt (*Sal gemme*, F.; *Steinsaltz*, Germ.), this substance possesses 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. Its lustre is vitreous, and its streak white. It is not so brittle as nitre; its hardness =2·5, which is nearly that of alum; a little harder than gypsum, but softer than calcareous spar. Its specific gravity varies between 2·1 and 2·257. It is white, occasionally colourless, and perfectly transparent, but usually of a yellow or red, and more rarely of a blue or purple tinge. A few analyses will show the general purity of this substance.

	Wieliczka white.	Vic red.	Virginia, U.S.	Hall, Tyrol.	Algeria.	Cheshire.	Marennes red.	Vic grey.
Chloride of sodium	100·00	99·80	99·55	99·43	99·30	98·30	96·78	90·3
" calcium	- -	- -	trace	·25	- -	- -	-	- -
" magnesium	- -	- -	- -	·12	- -	·05	·68	- -
Sulphate of soda	- -	- -	- -	- -	- -	- -	- -	2·0
" lime	- -	- -	- -	·20	·50	1·65	1·09	5·0
" magnesia	- -	- -	- -	- -	- -	- -	·60	- -
Carbonate of magnesia	- -	- -	·45	- -	- -	- -	- -	- -
Alumina and sesqui-oxide of iron	- -	- -	- -	- -	·20	- -	- -	- -
Clay	- -	- -	- -	- -	- -	- -	·85	2·0
Water	- -	·20	- -	- -	- -	- -	- -	·7
	100·00	100 00	100·00	100·00	100·00	100·00	100·00	100·00

The principal impurities occurring in rock salt are sulphate of lime, oxide of iron and clay, but the chlorides of potassium, calcium, and magnesium, the sulphates of soda and magnesia, and bituminous matters, are sometimes found in it; and occasionally shells, and insect and infusorial remains, exist enclosed in the mass. To the presence of infusoria, indeed, is attributed the red or green colour with which some varieties are tinted, which, upon analysis, are found to be absolutely pure chloride of sodium, as in the case of the second specimen quoted in the above table. Carburetted hydrogen gas in a state of strong compression is met with in some varieties, and these when dissolved in water emit a peculiar crackling sound, caused by the expansion and escape of the confined gas.

The geological position of rock salt is very variable; it is found in all sedimentary formations, from the transition to the tertiary, and is generally interstratified with gypsum, and associated with beds of clay. When the latter is present in large quantity, the term "saliferous clay" is applied to the deposit. The great British deposits of this substance in Cheshire and Worcestershire are found in the new red sandstone. At Northwich, in the Vale of the Weaver, the rock salt consists of two beds, which are not less than 100 feet thick, and 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 gypsum, 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 between them. The lowest bed of salt was excavated to a depth of 110 feet, several years ago. Many of the German deposits of rock-salt occur in their *bunter sandstein*, which is the representative of our new red sandstone, and is so called because its colours vary from red to salmon and chocolatic. In the Austrian Alps salt is found in oolitic limestone; at Cardonna, in Spain, in the greensand; and the famous mines of Wieliczka, in Galicia (excavated at a depth of 860 feet, in a layer 500 miles long, 20 broad, and 1200 feet deep), occur in tertiary strata. But in addition to these concealed deposits, this substance presents itself in vast masses upon many parts of the earth's surface: in the high lands of Asia and Africa are often extensive wastes, the soil of which is covered and impregnated with salt, which has never been enclosed by superimposed deposits; near Lake Oroomiah, in the N.W. of Persia, it forms hills and extended plains; it abounds in the neighbourhood of the Caspian Sea, and penetrates the entire soil of the steppes of the south of Russia.

The beds of rock salt are sometimes so thick, as at Wieliczka and Northwich, that they have not yet been bored through, although mined for many centuries; but in ordinary cases the thickness of the layers varies from an inch or two to ten or fifteen yards. When the strata are thin, they are usually numerous, and throughout a certain extent parallel, but when explored at several points such enlargements and diminutions are observed, as to destroy this appearance of parallelism.

It has been remarked that the plants which generally grow on the sea-shore, such as the *Triglochinum maritimum*, the *Salicornia*, the *Salsola kali*, the *Aster trifolium*, or farewell 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. It is also generally found that the interior of salt mines 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 insalubrious.

Much discussion has been raised concerning the origin of these rock-salt deposits; some asserting that they were the result of igneous agency, and others that they have been in every case deposited from solution in water. The great argument in favour of the former view appears to rest upon the fact that chloride of sodium and hydrochloric acid gas are among the substances erupted by volcanoes; whilst on the other hand it is urged that the specimens of erupted chloride of sodium which have been analysed always differ much from rock salt, since they contain a large amount of chloride of potassium; and in addition to this, the frequent occurrence of bodies such as bitumen and organic remains, and of cavities containing liquids, and in some cases gases, in almost all varieties of rock salt, are held to furnish indisputable proof of the deposition of this substance from its aqueous solution. The occurrence of sandstone pseudomorphs in the cubical form of rock salt, also favours this opinion; and so also does the general character of these deposits; they are usually lenticular, or irregularly shaped beds, having a great horizontal extension, and but rarely occur in the form of dikes, or masses filling vertical fissures, which is the usual form assumed by a molten mass projected upwards from the interior of the earth. The method of its formation was, according to those who hold the aqueous theory, somewhat as follows:—A sea, such as the Mediterranean, is, by an elevation of the land at Gibraltar, cut off from communication with the ocean,—the rate of evaporation from its surface is greater than the supply of water by rain and rivers, consequently the amount of salts which it holds dissolved, increases; now chloride of sodium is the principal saline constituent of sea water, and Bischof's experiments have shown that when a solution of this salt is allowed to be at rest, the particles of salt sink, so that the lower layers soon become more saturated than the upper; concentration is then supposed to go on until at the undisturbed bottom of this inland sea a saturated solution of chloride of sodium exists, from which masses of rock salt are slowly deposited. Its great purity is accounted for by the fact, that the other salts existing in sea water are either far less or far more soluble than chloride of sodium; thus the carbonate and sulphate of lime would be almost wholly precipitated before the solution became sufficiently concentrated to deposit rock salt, whilst at that degree of concentration the sulphate and chloride of magnesium would still remain for the most part in solution.

The principal European mines of rock salt are those of Wieliczka, in Galicia, excavated at a depth of 860 feet below the soil; at Hall, in the Tyrol, and along the mountain range through Aussee, in Styria, Ebensee, Ischl, and Halstadt, in Upper Austria; Hallein in Salzburg, 3300 feet above the sea level, and Reichenthal in Bavaria; in Hungary, at Marmoros; in Transylvania and Wallachia; at Vic and Dieuze in France; at Bex, in Switzerland; in the Valley of Cardonna, and elsewhere, in Spain; and in the region around Northwich, in Cheshire, in our own country. Some of these deposits, as at Wieliczka and Northwich, are almost pure chloride of sodium; others, again, as many of the Austrian beds, are only saliferous clay; whilst others, as at Arbonne in Savoy, elevated 7200 feet above the level of the sea, and in the region of perpetual snow, are masses of saccharoid gypsum and anhydrite, which are imbued with chloride of sodium, and which become quite light and porous when the salt has been removed by water.

The natural transition from the consideration of these strata of rock salt is to those brine springs which generally accompany them, and which have frequently first called attention to the deposits below. It has been noticed that salt springs issue, in general, from the upper portion of the saliferous strata; cases, however, occur in which the brines are not accompanied by rock salt, and in which, therefore, their whole saline contents must be derived from the ordinary constituents of the strata. Thus, in England, besides the strong brines of the new red sandstone, we have salt springs issuing from the carboniferous rocks. The purest and most saturated brines are, however, found to be those which can be traced to rock salt beds, and in the foremost rank of these stand the English springs of the Northwich, Middlewich, and Sandbach districts in Cheshire; of Droitwich and Stoke, in Worcestershire; and of Weston and Shirleywich, in Staffordshire; and the continental brines of Würtemberg and Prussian Saxony. The following is the composition of these saturated brines.

Solid contents in 100 *parts of brine.*

	England.				Würtemberg.		Prussian Saxony.
	Cheshire.		Worcestershire.				
	Marston.	Wheelock.	Droitwich.	Stoke.	Friedrichshall.	Hall.	Artern.
Chloride of sodium -	25·222	25·333	22·452	25·492	25·563	25·717	25·267
„ potassium	- -	- -	- -	- -	- -	- -	·119
Bromide of sodium -	·011	·020	trace	trace	- -	- -	- -
Iodide of sodium -	trace	trace	trace	trace	- -	- -	- -
Chloride of magnesium	- -	·171	- -	- -	·005	- -	·421
Sulphate of potassa -	trace	trace	trace	trace	- -	- -	·291
„ soda - -	·146	- -	·390	·594	- -	·038	- -
„ magnesia -	- -	- -	- -	- -	·023	- -	- -
„ lime - -	·391	·418	·387	·261	·437	·171	·400
Carbonate of soda -	·036	- -	·115	·016	- -	- -	- -
„ magnesia	·107	·107	·034	·034	- -	- -	- -
„ manganese	trace	trace	- -	- -	- -	- -	- -
„ lime -	- -	·052	- -	- -	·010	·002	- -
Phosphate of lime -	trace	trace	trace	trace	- -	- -	- -
„ sesquioxide of iron -	trace	trace	trace	trace	- -	- -	- -
Alumina - - -	trace	trace	- -	- -	- -	- -	- -
Silica - - - -	- -	- -	trace	trace	- -	- -	- -
Solid contents -	25·913	26·101	23·378	26·397	26·038	25·928	26·498

Compared with these may be some weaker and less pure brines, which rise from other geological formations. The brines in the United States come for the most part from Silurian sandstones, but those in the Alleghany Mountains spring from the coal; and the weak salt springs of Nauheim and Homburg, which can only be called brines because chloride of sodium is their largest constituent, rise from transition strata.

Solid contents in 100 *parts of brine.*

	America.		Hesse.	
	New York. Salina.	Alleghany Mountains.	Nauheim.	Homburg. Kaiserquelle.
Chloride of sodium -	13·239	3·200	2·7302 -	1·6000
„ potassium -	- -	- -	- -	·0027
„ barium -	- -	·038	- -	- -
„ calcium -	·083	·568	- -	- -
„ magnesium	·046	·293	·2655	·1300
Bromide of potassium -	- -	trace	- -	- -
„ magnesium	- -	- -	·0097	- -
Sulphate of lime - -	·569	- -	·0047	·0018
Carbonate of lime -	·014	- -	·1277	·1024
„ iron -	·002	- -	·0015	·0096
Silicate of soda - -	- -	- -	·0006	·0031
Solid contents - -	13·953	4·099	3·1399	1·8496

These weak salt springs are supposed to have no connection with beds of rock salt, but to obtain their chloride of sodium, in common with the other salts which they contain, from the strata which they permeate. The singular brines of the Alleghany Mountains must obviously pass through strata containing little if any soluble sulphate, otherwise their chloride of barium would be separated as insoluble sulphate of baryta; and all indeed may be regarded as coming more under the head of ordinary mineral waters, which happen to contain rather a large quantity of chloride of sodium.

The next source of chloride of sodium which demands notice is found in the inland seas, salt lakes, pools, and marshes, which have their several localities obviously independent of peculiar geological formations. They appear to owe their origin to two causes, being due, firstly, to the formation of lakes upon, and the passage of rivers through, some of the surface deposits of salt already alluded to; and, secondly, by the cutting off of a portion of the ocean by the elevation of the land, and the consequent formation of an inland lake. To the former cause are probably due the existence of the Lake Oroomiah in the N.W. of Persia, the numerous brine pools of Southern Russia, and the Great Salt Lake of N. America. The Lake Oroomiah is 82 miles long by 24 wide, and elevated 4000 feet above the level of the sea; it is surrounded, especially on the east and north, by some of the most remarkable surface deposits of rock salt in the world, and through these salt streams are continually flowing into the lake. The Russian brine pools are situated in the salt-impregnated steppe between the rivers Ural and Wolga, and doubtless derive their saline constituents from thence. The Great Salt Lake is a saturated solution of almost pure chloride of sodium, but whence the salt is derived appears at present to be but a matter of conjecture. To the second cause the origin of the Dead Sea is frequently attributed; its surface is about 1300 feet below that of the Mediterranean, and it is thought to have lost a column of water of that height by evaporation. The Crimean lakes also have probably originated thus.

Bischof has shown that in proportion as chloride of magnesium increases in a solution, it renders chloride of sodium and sulphate of lime more and more insoluble; he is therefore of opinion that at the bottom of the Dead Sea, and similar lakes, an impure rock-salt deposit, interstratified also with mud, is forming, similar to the saliferous clays or clayey marls which are frequently met with on the continent.

The three following analyses exhibit the peculiarities of two classes of salt lakes: Lake Oroomiah, formed by the solution of pure rock salt, contains but little magnesia salt, whilst the Crimean Lake and the Dead Sea, produced probably by the evaporation of sea water, show how the very soluble salts of magnesia increase as the water concentrates.

Solid contents in 100 parts of water.

	Dead Sea.	Lake Oroomiah.	Siwasch, or Putrid Sea, Crimea.
Chloride of sodium - - - -	6·578	19·05	14·20
— potassium - - -	1·398	- -	- -
— calcium - - - -	2·894	- -	·04
— magnesium - - -	10·543	·52	1·93
— aluminum - - -	·018	- -	- -
Bromide of magnesium - - -	·251	- -	- -
Sulphide of calcium - - - -	- -	- -	trace.
Sulphate of lime - - - -	·088	·18	- -
— magnesia - - -	- -	·80	1·21
Organic matter - - - -	trace.	- -	trace.
Solid contents - - - -	21·770	20·55	17·38

Finally, to compare with the above results, the composition of the sea may be given: numerous analyses have been made of the water taken at widely distant points, and at different depths, and the difference in composition has been small. The water of some partially enclosed seas, as the Baltic and Black Seas, into which numerous rivers pour, is below the average concentration, and that of others again, as the Mediterranean, is above that point. The deep sea water is also more concentrated than that at the surface, as Von Bibra has shown that the Pacific Ocean, in 25° 11′ S. and 93° 24′ W. contains 3·47 of saline matter in 100 parts, at a depth of 11 feet, whilst at a depth of 420 feet it contains 3·52. Bischof's experiments, before alluded to, would lead to this supposition. The following analyses are by Von Bibra, except the last, which is by Laurent :—

Solid contents in 100 parts of sea-water.

	English Channel.	Pacific Ocean.	Atlantic Ocean.	Mediterranean.
Chloride of sodium - - -	2·595	2·587	2·789	2·719
— potassium - -	·067	·116	·154	·001
— magnesium - -	·280	·359	·233	·613
Bromide of sodium - - -	- -	·039	·052	- -
Sulphate of lime - - -	·111	·162	·155	·015
— magnesia - -	·225	·204	·184	·701
Carbonate of lime - - -	- -	- -	- -	·001
— magnesia - -	- -	- -	- -	·019
Solid contents - - -	3·278	3·467	3·567	4·069

The average specific gravity of sea water is from 1·029, to 1·030.

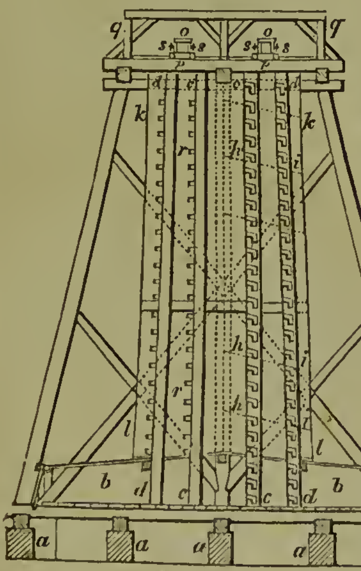
Culinary salt is prepared from each of the four sources above mentioned; it but rarely happens that rock salt is sufficiently pure for immediate use, and when employed, as in some places on the continent, and formerly in Cheshire, it is dissolved in water, the insoluble impurities allowed to subside, aud the solution treated as a concentrated brine. From its other sources, salt is obtained by evaporation, and this is effected in two ways; 1. Entirely by the application of artificial heat; 2. By natural evaporation preceding the application of artificial heat.

The first method is employed invariably in this country, and also on the continent when the brines contain more than 16 or 20 per cent. of chloride of sodium, the cost of fuel at different places of course regulating the application of this method. The manufacture of salt at Droitwich in Worcestershire, is said to have existed in the time of the Romans, and in Cheshire, the "Wiches" were very productive in the reign of Edward the Confessor; some time elapsed before the method of evaporation was devised, and the original mode of obtaining the salt was by pouring the brine upon the burning branches of oak and hazel, from the ashes of which the deposited salt was afterwards collected. The process of evaporation was first conducted in small leaden vessels, which were afterwards exchanged for iron ones, having a surface of about a square yard, and a depth of six inches; the size of these pans increased but slowly, for only a century since the largest pans at Northwich were but 20 feet long by 10 broad. The pans now in use in Cheshire, Worcestershire, and Staffordshire have a length of 60 or 70 feet, with a width of from 20 to 25, and a depth of about 18 inches; they are made of stout iron plates riveted together, are supported on brickwork, and have from one to three furnaces placed at one end, the flues of which are in immediate contact with the bottom of the pan. In the works of Messrs. Kay of Winsford, the brine is heated to its boiling point in a small iron reservoir, and from thence caused to circulate through a series of brick-lined channels until it is again, by a simple arrangement, pumped into the first iron vessel, and heated afresh. The brine is generally raised by steam power, and its supply appears inexhaustible. The shafts are lined with wooden or iron casings to prevent the admixture of fresh-water springs with the brine; the depth of the borings is in Cheshire usually from 210 to 250 feet, but at Stoke, in Worcestershire, a shaft of 225 feet was constructed, but no satisfactory supply of brine obtained until a further boring of 348 feet was made. At Droitwich the borings are only to a depth of 175 feet, and so abundant is the supply of brine, that if the pumps cease working, it speedily rises to within nine feet of the surface, and if left unremoved soon overflows. The freedom of the brine from dilution by fresh-water springs is from time to time tested by the hydrometer. From the pumps the brine is directly conveyed by means of pipes to reservoirs, from which, as the evaporation proceeds, it is admitted into the pans. As the water is vaporised, the salt is deposited and falls to the bottom of the pan; it is then drawn to the sides by the workmen, until a heap is accumulated, and from this portions are ladled out into rectangular wooden boxes with perforated bottoms, allowed to drain and solidify, removed from the boxes, and placed in the drying room; the salt of coarser grain is simply drained roughly in baskets and dried. The grain of the salt, *i.e.* its occurrence in larger or smaller crystals, is entirely the effect of temperature; the fine grained or table salt is produced by rapid heating, and is formed at that end of the pan next the fire-place; the coarse or bay-salt is formed by the slow evaporation which goes on at the other end; whilst an intermediate variety, common salt, is produced in the middle. A pan may sometimes be slowly evaporated for the express purpose of obtaining bay-salt.

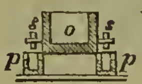
In the preparation of salt various substances have been added to the brine with a view of improving the quality of the product: these have been chiefly bodies containing albuminous matters, which, coagulating upon the application of heat, entangle all solid impurities and carry them to the surface; blood, white of egg, glue, and calves' feet have thus been extensively used. There is also another class of substances employed for a different purpose. When a concentrated solution of any saline matter is evaporated, much annoyance is caused by a layer of the solid salt forming on the surface of the liquid and impeding evaporation: this is called a "pellicle"; to obviate this, and to avoid the loss of labour entailed by constant stirring, oils, butter, or resin, have been added to the brine. The effect of the latter is said to be perfectly magical, the introduction of a very few grains being amply sufficient to clear the largest pan, and to prevent any recurrence of the "setting over."

When it is required to prepare salt from the weak brines which are of common occurrence in France and Germany, the second method is resorted to, and the brine is concentrated by natural evaporation previous to the application of artificial heat: this concentration was formerly effected by distributing the brine over flat inclined wooden surfaces, but it is now brought about by allowing the brine to trickle in a continuous stream through walls of thorns exposed to the sun and wind. This, which is called the method of graduation, is employed, among other places, at Moutiers in France, and at Nauheim, Dürrenberg, Rodenberg, and Schönebeck, in 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, 2nd, and 3rd graduation. A deposit of gypsum incrusts the twigs, which requires them to be renewed at the end of a certain time. *Figs.* 1585, and 1586, represent the graduation-house of the salt-works at Dürrenberg. *a*, *a*, *a*, are low stone pillars for supporting the brine-

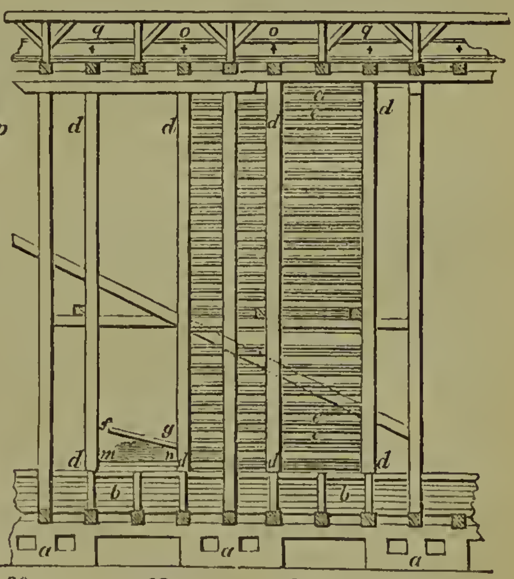
1585



1587



1586



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.* 1586, 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 1½ foot thick, from 5 to 7 feet long, and are piled up in the following way:— Guide-bars are first placed in the line *k*, *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.* 1587. 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 *b*, 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.

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.
		1·010	0·000
1 and 2 - - - -	5158 square feet - -	1·023	0·540
3, 4, 5, 6, 7, 8, and 9 -	2720 - - - - -	1·072	0·333
10 - - - - -	550 - - - - -	1·140	0·062
Total evaporation - - - - -			0·935
Water remaining in the brine at the density of 1·140 -			0·065
Water assigned at the density of 1·010 - - - - -			1·000

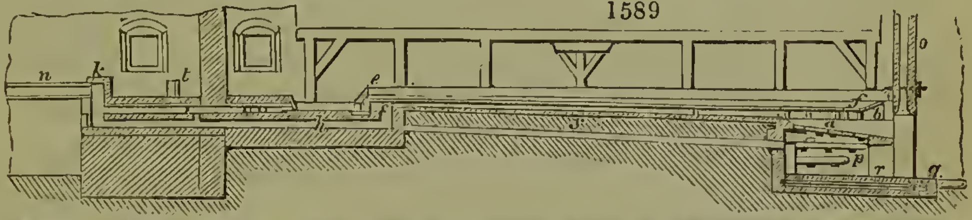
From the above table it appears that no less than 10 falls of the brine have been required to bring the water from the specific gravity 1·010 to 1·140, or 18° Beaumé. The evaporation is found to proceed at nearly the same rate with the weaker water, and with the stronger, within the above limits. When 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 boilers constructed at Rosenheim, in Bavaria, evaporate 3½ pounds of water for every pound of wood burnt: this is reckoned a favourable result; but some of the boilers described under Evaporation would throw off much more.

Figs. 1588, 1589, 1590, represent the construction of a salt-pan, its furnace, and the salt store-room of the works at Dürrenberg; *fig.* 1590, being the ground plan, *fig.* 1589, the longitudinal section, and *fig.* 1588, the transverse section. *a*, is the fire-grate, which slopes upwards to the back part, and is 31½ 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 *c*, in *fig.* 1588. Upon this bed the pillars *d*, *d*, &c., are built in a radiated direction, being 6 inches broad at the bottom, and tapering to 1½-inch at top. The pan is so laid that its bottom has a fall towards the middle of 2½ inches: see *e*, *f*, *fig.* 1589. The fire diffuses itself in all directions under the pan, proceeds thence through several holes, *g*, *g*, *g*, into flues *h*, *h*, *h*, which run round three sides of the pan; the burnt air then passes through *i*, *fig.* 1590, 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.

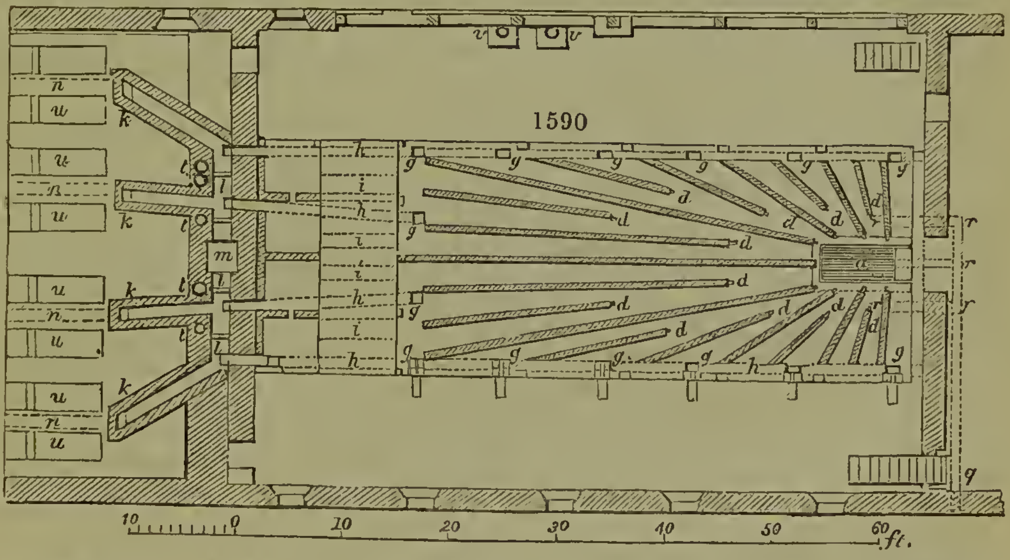
1588

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*. 1588, and 1589), into which cold air is admitted

1589



1590

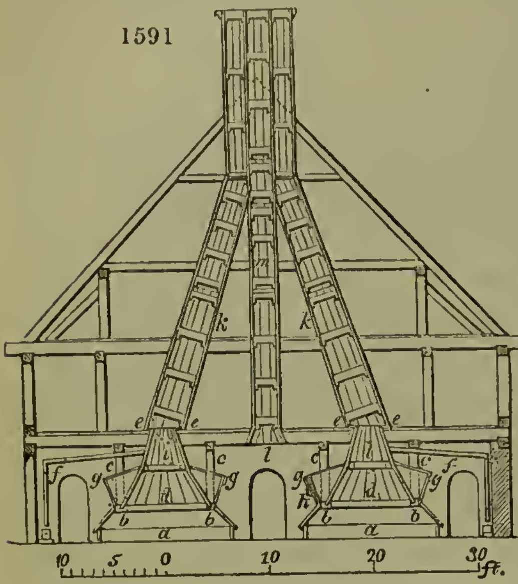


by the flue *q*, *r*, where, becoming heated, it is conducted through iron pipes *s*, and thence escapes at *t*, into the stove-room. Upon both sides of the hot flues in the stove-room, hurdle-frames *u*, *u*, are laid, each of which contains 11 baskets, and every basket, except the undermost, holds 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. 1591.

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.

1591



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-pan, 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.

In summer the saturated boiling brine is crystallised 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 2½ 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 five or six days in the pan, is completed in this way in seventeen hours, and the salt is remarkably pure, but the mother-waters are more abundant.

The mother-water contains a large quantity 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 crystallises, and chloride of magnesium, which remains dissolved, the mother-water may with this view be exposed in tanks to the frost during winter, when it affords three successive crystalline deposits, the last being nearly pure sulphate of soda.

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 be removed, and converted into chloride of sodium by the following simple expedient: Let quicklime be introduced in equivalent quantity to the chloride of magnesium present; double decomposition will take place, resulting in the precipitation of magnesia, and the formation of chloride of calcium; the latter will then react upon the sulphate of soda in the mother-water, producing sulphate of lime and chloride of sodium, the former of which, being sparingly soluble, is almost entirely separated.

In those countries, as Portugal and the coasts of the Mediterranean, where sea water is used as the source of salt, a peculiar method of natural evaporation is resorted to, in what are called "Salt Gardens." Large shallow basins, the bottom of which is very smooth and is formed of clay, are excavated along the sea-shore; they consist of—

1stly. A large reservoir, of from two to six feet in depth, communicating with the sea by means of a channel provided with a sluice. Advantage is taken of the high tide to fill this basin; and the water is allowed to remain here for some time to deposit any suspended impurities; it is then drawn off into the brine-pits.

2ndly. The brine-pits are divided into a large number of compartments by means of little banks; these all have a communication with each other, but so arranged that the water has a long circuit to make in its passage from one set to another; it frequently flows 400 or 500 yards before it reaches the extremity of this sort of labyrinth. The various divisions are distinguished by a number of technical names. They should be exposed to the north, north-east, or north-west winds.

In the month of March the water of the sea is let into these reservoirs, where a vast surface is exposed to evaporation from the first or clearing reservoir; the others are refilled as their contents decrease. The salt is considered to be on the point of crystallising 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; but generally, 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 as it forms is raked out, and left upon the borders to drain and dry. To get rid of the chloride of magnesium, which is one of the principal impurities of this kind of salt, it is frequently heaped up under sheds, where it is just protected from the rain, and the chloride of magnesium being a very deliquescent salt, attracts moisture from the air and drains away. The salt thus obtained partakes of the colour of the bottom on which it is formed, and is hence white, red, or grey.

The following table shows the composition of several varieties of culinary salt:—

Analyses of several varieties of culinary salt; composition in 100 *parts.*

	Cheshire stoved.	Lymington cat. salt.	Scotch common.	Königs-born, West-phalia.	St. Malo. sea-salt.	Moutiers.	
						des cordes.	boilers.
Chloride of sodium	98·250	98·8	93·55	95·90	96·00	97·17	93·59
— magnesium	·075	·5	2·80	—	·30	·25	·61
— calcium	·025	—	—	·27	—	—	—
Sulphate of soda	—	—	—	—	—	2·00	5·55
— magnesia	—	·5	1·75	—	·45	·58	·25
— lime	1·550	.1	1·50	1·10	2·35	—	—
Clay and insoluble matter	—	—	—	—	—	—	—
	99·90	99·9	99·60	97·27	99·10	100·00	100·00

The specific gravity of a saturated solution of large-grained cubical salt, is 1·1962 at 60° F. 100 parts of this brine contain 25·5 of salt (100 Water + 34·2 Salt.)

From mutual penetration 100 volumes of the aqueous and saline constituents form rather less than 96 of the solution.

In Great Britain the rock-salt mines and principal brine springs are in Cheshire; and the chief part of the Cheshire salt, both fossil (rock) 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 the Worcestershire salt chiefly supplies the London Market.

According to M. Clement Desormes, engineer and chief *actionnaire* of the great salt works of Dieuze, in France, the internal consumption of that kingdom is rather more than 200,000 tons per annum, being at the rate of 6½ kilogrammes for each individual of a population estimated at 32,000,000. As the retail price of salt in France is ten sous per kilogramme (of 2½ lbs. avoirdupois), while in this country it is not more than two sous (one 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.—A. B. N.

The Salt produce of the United Kingdom in 1857, was as follows:—

	Tons.
CHESHIRE.—White salt carried by Weaver Navigation - -	647,437
Rock salt " " - -	65,773
Salt carried by rail from Winsford and Northwich -	525,000
WORCESTERSHIRE.—Stoke and Droitwich - - - - - -	195,500
IRELAND.—Duncone, near Carrickfergus - - - - - -	27,335
	1,461,045
Of this we exported - - - - - - - - - -	651,766

Hunt's Mineral Statistics.

SALTS. It is not possible, even were it advisable, to introduce into this work any discussion on the subject of the chemical compounds which are included under the name of salts. Within the range of science there are not many terms to which more varied meanings have been given.

It may be sufficient to state here that, at present, salts are generally grouped as follows:—

1. Those formed by the union of simple bodies, as chlorine and sodium, iodine and iron, or the like.

2. Those formed by the union of substances already compound, as sulphuric acid (sulphur and oxygen), with soda (sodium and oxygen), &c., or, in the case of many of the salts formed from the organic acids exhibiting a yet more complex constitution.

Salts may be either *neutral*, or such as do not exhibit any acid or alkaline properties, or *acid*, *i.e.* those in which there is an excess of acid in its hydrated form, or those in which dry acid is in excess; and *basic salts*, in which there is present more than one equivalent of base for each equivalent of acid. For a further account of salts see EQUIVALENTS, HALOGENE, the several metals and alkalies, and consult *Ure's Chemical Dictionary.*

SALT, SEDATIVE, is boracic acid.

SALT WATER, DISTILLATION OF. See WATER.

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 primary crystalline rocks, and are abundantly distributed over the globe; as in the immense plains known under the names of 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, 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 ameliorating dense clay soils, for moulding, and many other purposes.

Specimens of the finer kinds of sand, from the Isle of Wight, and the neighbourhood of Lynn, are remarkably white and beautiful. Ryegate also furnishes pure siliceous sand. By far the finest samples of sand ever seen in this country were in the American department of the Great Exhibition of 1851, and did not fail to attract the notice of those interested in such matters. This sand was totally free from iron and every other source of contamination. It was as white as snow, and so far as the making of glass is concerned, no sand is equal to it: considerable quantities have been imported since that period. The principal sources of sand for the manufacture of glass are Charlton, Hastings, Derbyshire, Alum Bay, Yarmouth. Isle of Wight, Reigate, Limerick, Cork, Landudno, and Hartwell, near Aylesbury. These sands 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 modify 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 volatilised 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. 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.

The sand from Alum Bay, in the Isle of Wight, is composed of

Silica	97·
Alumina, with trace of oxide of iron and magnesia	2·
Moisture	1·
	100·

The French, or Fontainebleau sand, now used in glass-making very extensively, is—

Silica	98·8
Alumina and trace of iron	0·7
Moisture	0·5
	100·

—T. T. H.

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 transmitted, 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 *Cæsalpinia 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 an 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.

According to Togler, wool, silk, cotton, and linen mordanted with a salt of tin, and dipped in a cold alcoholic tincture of the wood, became of a superb ponceau-red colour. With alum they took a scarlet-red; with sulphate of iron a deep violet or brown-red. Unfortunately, those dyes do not resist the influence of light.

SANDERS WOOD. See SANDAL WOOD.

SANDARACH, or JUNIPER RESIN, 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. It is imported from Mogadore.

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 spirits of wine, somewhat resembling *pinic 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.

Sandarach is softer and less brilliant than shell-lac, but much lighter in colour; it is therefore used for making a pale varnish for light coloured woods. See VARNISHES.

SANITARY ECONOMY. This term is used to express and to include everything which is done or can be done towards the preservation of health, but in its more restricted and usual sense it is the method of preserving the health of communities. It therefore interests the largest communities, such as nations, and the smallest, such as families, whilst of necessity the interest of the individual is not forgotten; and there is a point at which it merges into medicine or medical economy. It is sometimes called sanitary science, but it is not well to be very lavish of the word *science*, which, although originally only knowledge, is now better confined to cases in which nature herself has pointed out a definite system of laws. Now all the facts brought into prominence by sanitary economy are more or less connected with some science the laws of which are investigated in other relations; but so wonderfully does nature act, that isolated facts from all the sciences frequently come out and form a series so connected, that for a time the judgment is in favour of believing that they may be so arranged as to form a true science; and in some cases this is an open question. Many sciences, perhaps every science, assists in the art of true sanitary economy. Its necessity has arisen from that class of misfortunes to which man has been subject affecting his health; or, as some would say, from certain defects of nature which man is required to supplement. Many of these defects are told in a long series of the greatest miseries; some in a long series of more limited but constant sorrows; and others have been sufficiently small to be considered rather as annoyances. In "Bascombe's History of Epidemic Pestilences" we may read of many hundreds that have attacked man in every known country, and, we may almost add, in every age. In the East we have frequent mention of plagues.

Plagues have frequently followed the track of great, and especially of defeated armies, as well as taken refuge in beleaguered cities.

Hecker's "Epidemics of the Middle Ages" shows few years in which some part of the world has not been suffering under an epidemic. In our own times cholera has long been known to be seldom quite extinct. As an instance of the mode in which these epidemics travel, let us follow the track of cholera. It first appeared at Jessore, on the Delta of the Ganges, reached Jaulnah and Java, and the Burmese Empire in 1818; Bombay, in August of the same year, Arracan and Malacca: in 1819, Penang in Sumatra, Siam, Ceylon, Mauritius, and Bourbon; in 1820, in Tonquin, Cambogia, Cochin-China, South China, Philippines; in 1821, Java, Bantam, Madura, Borneo, &c., Muscat in Arabia, and Persian shores; in 1822–23–24, Tonquin, Pekin, Central and North China, Moluccas, Amboyna, Macassar, Assam; in 1822–23, Persia, Mesopotamia, Judæa; in 1823, Astrachan, part of Russia; in 1827, Chinese Tartary — in all these countries committing ravages hitherto unheard of. In 1830 it went back to Russia, to Poland, Moldavia, and Austria. In 1831 it appeared in Riga and Dantzic, Petersburg, Berlin, Vienna, Sunderland, Leith, and Calais; in 1832, in London; 1834, Spain, the Mediterranean, and North America. In Arabia, one-third in the chief towns died; in Persia, one-sixth; in Mesopotamia, one-fourth; in a province of Caucasus, 10,000 died out of 16,000; in a province of Russia, 31,000 out of 54,000. Plagues are, therefore, still capable of exercising a fatal influence equal to that of the most ancient times. In European towns generally the greatest number of deaths was found to be in the districts least provided with means of cleanliness. It was found among the poor and ill-fed, among the dark races, and the grades of lowest constitutional power. (*Copland's Dictionary: — Pestilence.*) It is also to be remarked, that in all the places where cholera was most violent, civilisation had not attained its European maximum. Cholera is an attack of the chemical forces on the vital forces; vital force even in the form of moral confidence repels it to a great extent, as it does other infectious diseases; but, for the same reason, fatigue and depression of mind hasten the action. The ordinary chemical forces act in the viscera instead of the chemico-vital. The lungs are gorged with blood, unable to send it away oxidised; the gall increases because carbon is not burnt, and urea is not secreted as there is no normal decomposition of the food. Vital force therefore fails, and a kind of putrefaction or fermenting action begins. This is only one instance of the many evils that have followed man. This is not the place to speak of black death, sweating sickness, and the other diseases, down to milder influenzas, which are continually infesting some of our race.

Diseases of this kind are believed to be caused by decomposing matter; they seem to rise from fœtid cities or fœtid land. Deltas have been chiefly blamed; that of the Ganges for cholera, that of the Nile for plague, that of the Mississippi for yellow fever. Although from this view diseases would be considered as under the power of mankind to suppress, their cause seems too widely diffused to place them under the direct control of limited communities, much less of individuals.

About 1350 the whole world was thrown into violent commotion. The change may be said to have begun in 1333, when floods, earthquakes, and sinking mountains are spoken of as occurring in China. Plague and parching drought covered much of the East: Cyprus was nearly destroyed. In that island the earth opened and sent out a fœtid vapour which killed many. A mist, thick and putrid, came to Italy from the East. Earthquakes occurred all along the Mediterranean. Noxious vapours and chasms seem to have extended hundreds of miles. (*Hecker.*) Diseases from these causes are of course out of our control.

Another natural source of disease is the existence of marsh land, producing malaria. Malaria may also be produced from woody land and moist land, especially if there be many impurities. Deltas, or low lands, at the mouths of rivers, land flooded either by salt or by fresh water, especially if alternately by one and the other, not forgetting the great alluvial deposits, which are kept moist in hot climates. Numerous as are the cases of malaria where it is difficult to see the cause, the connection of the marshes with some febrile diseases is beyond any question. The fevers from this source seem in their worst states to pass into yellow fever. This class of fevers is not epidemic, and does not travel far from its source. There are of course many cases of its being carried by the winds to a great distance, and the distance seems to depend on the amount of marshy land, or, in other words, on the extent of the poison produced. If little exist, it is dispersed before the wind travels far.

Conditions of the weather may cause vegetation to putrefy instead of growing. In 1690, a striking example of this occurred at Modena, although other examples might be taken much nearer if there were not such multitudes of opinions upon them. Four or five years of unusual dryness had occurred; fruit was abundant, however, and health satisfactory. A wet winter came, cloudy and calm, without cold. This state continued through summer, with much rain. The numerous and noisy grasshoppers of Italy almost ceased, and frogs, that belong to a country of marshes, took their place. The corn had ceased to grow, and its place was supplied by fishes, so abundant was the water on the land; whilst also organic matter was driven into the streams in unusual quantities. Vegetation was attacked with *rubigo*,—a rusty withered appearance,—which increased in spite of all precaution; beginning with the mulberry, it attacked the corn, and then the legumens, and especially the beans. This extended over the higher spots as well as the lower. It was melancholy to look on the fields, which, instead of being green and healthy, were everywhere black and sooty. "The very animals returned the food which they had eaten. . . . . The sheep and the silkworms perished. . . . . The bees made their honey with timidity. . . . . The waters became corrupt, and fevers attacked the inhabitants, chiefly the country people, such as lived on the wet lands. This state produced intermittent fevers." — *Bern. Ramazzini.*

Again, there are causes purely artificial arising from the state of our towns in manufacturing districts.

It has been proved that diseases may be produced artificially of a kind closely resembling the great world epidemics. When persons live closely crowded together health gradually begins to fail, and loathsome diseases rapidly grow. These diseases vary immeasurably, and the variation seems to be as great as the modes of decomposition of animal matter. After a time these diseases attain virulence sufficient to be infectious or contagious through the atmosphere.

These various conditions are not perfectly understood, but even the statement of our ascertained knowledge has been most widely misunderstood by the public, and sometimes even by professional men, many of whom, if they have conceived the matter clearly, have not expressed it well.

There are at least three principal methods by which the air is rendered impure. 1st. By noxious gases, dust, and ashes, produced by geological, atmospheric, or artificial causes, sulphurous gas, carbonic acid, sulphuretted hydrogen, and perhaps many others. 2. Epidemic or travelling causes to all appearance reproducing themselves as they advance, as in plague and cholera. Similar diseases produced by artificial or neglected accumulations of filth. 3. Malaria, or diseases caused by the disturbed or badly-regulated relation between the soil and the atmospheric conditions, whether from natural or artificial causes. It would be difficult to include all the various evils arising from too much heat, cold, &c. &c.; knowing these things, we are able to a considerable extent to guide ourselves. When the disease or nuisance is caused by processes of manufacture the law sanctions interference. The judicious management of this branch of the subject is of the greatest importance to the community.

There are also causes of disease relating more to the condition of the atmosphere; for example, from the prolongation of a current of air or wind from one particular district, without due mixture; and from conditions of moisture, and of electricity.

Sanitary economy devises a method of avoiding the diseases spoken of. As to the first, those produced by geological phenomena, our chief protection lies in the choice of place: this remark may also apply to those diseases produced by atmospheric stagnation and electrical condition. All we can do is to choose places which are known to be free from disturbances or irregularities; when such occur, we are then able only to remove or to suffer. Such diseases are but little understood. When the disease is epidemic, some trace its origin to causes which may be termed cosmic. One may be an excess of the decomposing agent, or by conditions of the atmosphere unfavourable to the continuation or tenacity of delicate chemical compounds. Take, as illustration, milk during a thunderstorm; this action is probably caused by a very rapid oxidation, which oxidation begins the phenomena of putrefaction. To bring such an analogy to explain the condition generally of organic matter, is legitimate, and we may either suppose the action to begin in living animals themselves, or on substances external to them. The belief may be said to be established by a long host of great observers, that putrefying matter produces diseases under certain not very well known conditions, and that it reacts unfavourably on the health in every condition, and as a cause of instant death in concentrated forms. In Cairo, where houses are crowded with the living, and where the dead are buried with slight covering, underneath the living, there seems to be a periodic clearing out of the population by plague, reducing the number until there be enough of air to allow of healthy life. In our own prisons at one time the same thing occurred, and in many of the prisons of the world imprisonment is death; such as in Turkey, China, and places not civilised by modern sanitary knowledge. Prisons in Europe, also, might readily be mentioned as most unwholesome; and prisons and workhouses in England itself, where the greatest care must be taken to prevent want of cleanliness, as it produces an immediate result in disease. This is merely on a small scale what takes place on a great scale in nature. It is similar to what we every day see, that man lays hold of some of the facts of nature, and under his hand they act by the same laws as they do in their cosmic manifestations. So in his diseases, man produces them by causing circumstances so to concur that the laws of nature act under his hand as they do when he has not interfered. Sanitary inquirers have ultimately been compelled to attribute many of the greatest effects on health to decomposition of organic matter. Almost all ages have referred to putrefaction or fermentation as an evil. The words have been used synonymously. For various opinions on this subject see DISINFECTION and PUTREFACTION. M. Place, in 1721, says that *in putrefaction a body works another to conformity with itself.* This is believed to be the case in many diseases. One erroneous opinion is very common. Gases which might be prepared in the chemist's laboratory have been blamed as the causes of infectious diseases. Sulphuretted hydrogen and carbonic acid are spoken of as if they were infections, and productive of fevers. Permanent chemical compounds, gaseous or otherwise, are not capable of acting as infections. The idea of infection given is that of a body in a state of activity. But any gas, the atmospheric mixture excepted, is capable sooner or later of causing death. A true gas diffuses itself in the air, and is rapidly removed from any spot; to render a place long unwholesome the gas must be continuously generated at the spot. The movements of plagues are not similar to anything we know of gases; on the contrary, we know that gases could not move in the manner that cholera and plague do. Sulphuretted hydrogen is not miasma, it is poisonous; it may destroy the constitution and produce diseases which may be deadly enough, but the sources of it are resorted to by invalids; this would never be the case were it a miasm. It has occasionally an internal beneficial action, and although in using it a little be taken into the lungs, this momentary breathing is not found prejudicial; but an amount of cholera infection, such as we could perceive by the nose as readily as sulphuretted hydrogen, would no doubt be a most deadly dose: we probably know of no such amount. The same may be said of carbonic acid and other gases. Some persons are capable of smelling the miasms of certain places—no doubt very fine senses could detect them wherever they existed; but generally bad air may injure very important organs without any effect being perceived by the senses until the evil has become very great. The chemical action is not one that the senses fully observe. Fermentation and putrefaction exhaust their powers after a short time, and cease; so do infections, but not so pure gases, which act only by combining. The fermenting substances lose their power not by combination so much as a change of condition, a transformation of their particles. All these actions, similar to fermentation, are connected with moist bodies: dried bodies cannot ferment, putrefy, or infect. Infection, like fermentation, is most violent at an early stage, gradually spending its strength, and frequently changing a portion of the substance into analogous forms. It has been argued that putrefaction cannot produce disease; but there are no facts in nature better established than the production of disease by the presence of dead animals or vegetables, especially the first. The production of fever by crowding hospitals, barracks, and ships, is as easy as the formation of many other artificial organic actions, although no exact form of fever can be produced at will; cases depending no doubt on time, place, climate, and constitution. The knowledge of these facts concerning zymotic diseases leads to this conclusion: in order to avoid the evil effects of decaying matter, it is necessary to have all our surroundings as clean as possible. Sanitary economy resolves itself at last chiefly into cleanliness. Individuals may learn personal cleanliness, but to render a town or a county clean many difficult arrangements are needed. Impurities arise from the conditions of animal life. Life is generated by the activities of certain substances which compose animals. When the activity is over the substances are dead and unpleasant, and they pass into their former condition through a number of stages. In some of these stages the substances are gaseous, some liquid, some solid; we may add, some in the state of vapour. Some of these substances are exhalations, some excretions. Exhalations come from the surface of the whole body, but from the lungs principally. The lungs give out air with about 4, 6, and even 8 per cent. of carbonic acid in it, and the amount respired is about 380 cubic feet in 24 hours, about 31 cubic inches per respiration, and 15 respirations per minute. The amount of air proposed as the supply for an individual varies greatly. Dr. Reid gave 30 cubic feet per minute = 1800 feet per hour, and even 3600. Liebig supposes 216 feet per hour. Dr. Reid gave more than was considered agreeable. Brennan supposes about 600, and calculates the following for every room per minute and per individual, the air being at 64°, and dew point at 50°.

For supply to the lungs	0·83 feet.
To carry off insensible perspiration	10·2 „
For each common-sized candle	0·25 „

If heated air is used for warming—

For each square foot of glass in the window	1·0 „
Each window to make up for leakage	8·5 „
Each door for the same	5·2 „
Each 200 square feet of wall and ceiling	1 „

Allowing this to be excessive, the advantage of pure air is still to be urged, and it is desired most by the healthiest specimens of men.

In speaking of the impure gases of the air, carbonic acid is generally referred to. This carbonic acid has been considered to be the great cause of disease in crowded localities, but the conclusion is contrary to our knowledge of the effects of carbonic acid when pure. There can be little doubt that there is a considerable amount of organic matter in the air of crowded places, and to that organic matter must be attributed most of the evil. It may be true that 1 per cent. of carbonic acid may be observed by the senses, but this is generally tried with carbonic acid given out from the lungs. In the case of a prison in Germany, 2 per cent. of carbonic acid was found in the air. Skin diseases appeared rapidly, and deaths were excessive. But we do not know the action of the pure gas; there must have been a large amount of corrupt matter in air which contained 2 per cent. of carbonic acid escaped from persons. It shows also great general filth. Amounts of organic matter, which are wonderfully less than even an hundredth of a per cent., are known to make the air unhealthy. In Manchester it seems to be the sulphurous acid which is chiefly felt, and that when it is less than one in a million, although it rises up in some places close to chimneys to 1, and even 4, in 100,000.

It is not intended here to give statistics of disease, but it will be right to refer to the enormous amount of disease amongst miners in Cornwall. The depths being great, above 1800 feet in some, and the temperature rising to about 100°, the difficulty of working is extremely great. Candles are burnt, and the air has become so deteriorated that it contained less than 18 per cent. of oxygen. The amount of carbonic acid had not risen above 0·085 per cent., which is not very high. Mr. R. Q. Couch, Sir J. Forbes, and Mr. Mackworth, have successively reported on this subject and given some interesting details. Mr. Roberton, of Manchester, remarks on the great cleanliness of the women; but they do not enter the mines, and their lives are longer. Consumption destroys the men rapidly in many of the deep mines.*

Exhalations from the skin are abundant, both acid and oleaginous.

Dr. Vogel found organic matter in the air of his class-rooms after a lecture. Dr. Angus Smith has shown that the exhalations may be traced on the walls of crowded rooms, which become coated with organic matter; and he adds that the furniture becomes coated with a similar substance, which must be continually removed. Thus furniture and walls which are never touched in time become impure, and give out noxious exhalations when these substances begin to decompose. Again, these substances are caught in our clothes and are retained there in a decided manner, on account of a peculiar faculty of retention in the fibre. This necessitates constant washing. Long custom has shown, that when retained by the cloth, a certain amount of it becomes innocent; that is, different fibres have the power of retaining matter so firmly that it is imperceptible and incapable of acting on the air. Wool has this faculty to a great extent; linen and cotton to a less extent. For this reason wool can be worn longer next the skin, remaining in reality clean. Clothes that are to be kept in good condition, if made of wool, as men's coats, cannot be washed: for this reason the custom has gradually been formed of wearing under clothing, which absorbs condensible substances especially, and is then washed, keeping the exterior clothing for a long time clean. As porous substances have an oxidising power, it is probable, that if not too much organic matter is supplied, the exterior clothing, well aired, may be kept absolutely clean, not merely by our ordinary practice of brushing and dusting, but also by oxidation, in the same way as Dr. Stenhouse has shown oxidation to take place in pores of charcoal. The instant removal of the breath and other exhalations is of great importance. This properly comes under the head of warming and ventilating. Walter Brennan, C.E., in his "History of Warming and Ventilating," gives a remarkable amount of information. There have been many mistakes as to the effect of overcrowding; its evils have actually been denied. The facts are very decided. Isolated houses may be crowded so much as to produce diseases, or they may be so badly ventilated without crowding as to have the same result. In this way persons in the country may have all the disadvantages of a crowded town. Again, a town-house well ventilated may have many of the advantages of the country, because, although the air is not of the purest, it may never be allowed to sink below the average purity of the external air. Indeed, freedom from disease is obtained in towns better in all cases than where there is a malarious atmosphere outside the town: this, of course, is well known; and at the same time diseases from putrefaction, caused by want of space and cleanliness, are cured by leaving a town. Persons slightly exposed to the odour of water-closets in towns are frequently subjected to disease, the unoxidised air poisoning them, whilst persons working in the open air escape, although labouring amongst the excreta themselves. Again, persons living in the house are exposed to the excreta a day or two old, whilst, in the case of nightmen, it has frequently passed its worst stage when they approach it. The stage giving off sulphuretted hydrogen is by no means the worst, perhaps one of the most innocent of the unpleasant stages, unless this gas be very strong, when it is fatal. But even in the minutest quantity this gas is hurtful to persons continuously exposed.

* "*Miner's consumption*," as the disease which destroys the miner is named, prevails also in the lead mines of the northern counties, which are usually shallow.—(*Ed.*)

The mode of removing excreta is an important point. Most inquirers have decided against leaving them in a town, and against allowing them near a house. These conclusions are especially valuable for town houses. We have in some towns whole streets of middens behind the houses, and the air behind is always inferior to the front air. The process of carting refuse is also a great evil in a town. No plan removes filth so rapidly as that with water. Many people object to it, because we have not yet learnt to make good sewers. Sewers should be tight. The Board of Health introduced small and rapid streams in the sewers, objecting to the canal-like sewers, which are as bad as cesspools, on account of the enormous amount of deposit in them, and are reservoirs of foul air from the amount of putrefaction going on within them. Many persons, not seeing this evil, have desired again to return to the no-plan of middens, not seeing what a deplorable result has been attained in Paris, where although using air-tight vessels to remove the refuse, they render most of the houses redolent of night-soil. The towns treated on the rapid removal system are models of cleanliness, and we do not doubt the speedy increase of the plan, especially as carried out by Robert Rawlinson, C.E. It must be confessed, however, that the great objection to the plan is one which is not to be despised. There is too much water used; if the water flows into the streams they are spoiled, and it is scarcely possible to put it on land. This difficulty must be met, or the plan so admirable for towns will be found destructive to countries. There is one way of meeting it, that is, by making the liquid denser, and so having it so strong as to be a valuable manure. By a double system of drainage this might be effected, the rain water going in a separate sewer. *F. O. Glassford* proposes a water-closet which shall hold the excreta till they are mixed up to a thickish liquid with water; he then removes it by pipes to certain reservoirs, and makes solid manure from it by sulphuric acid and evaporation, a plan which he has found to answer. Dr. Joule proposes large iron tanks for each block of houses, to be emptied daily, and disinfected on being emptied. All such plans must be inferior to the cleanliness caused by abundant water. We must learn to remove our filth from our towns, or they will be as unwholesome as they once were. Nothing but abundant water can make the largest city in the world (London) the healthiest of large cities.

The assertion of the Board of Health is that combined works, comprising a water-pipe for the service of each house, a sink, a drain, and a waste-pipe, and a soil pan or water-closet apparatus, may be laid down and maintained in action at a cost not exceeding on the average three halfpence per week, or less than half the average expense of cleansing the cesspool for any single tenement. This seems borne out by the example of several towns under the care of engineers penetrated with the spirit which dictated the changes. To the above amount has been added water supply, which has increased the sum to threepence per week.

Sewers must certainly not leak, or they must be disinfected. Dr. Angus Smith proposed long ago that they should be disinfected nearly from their sources. In other words, disinfectants should flow through all the great sewers, and so bring them to the rivers in a state where putrefaction is impossible. The advantage of this would be great. When Mr. McDougall was showing his plan of disinfecting sewers to the Board of Works, the smell of the substance he used when he tried it in excess was perceived in the houses along the line of the sewer, showing clearly that the present sewers allow their filthy smells to go into the air of houses. He completely destroyed the sewer smell. To prevent bad air in sewers, some persons, and amongst others some in the Board of Health, have proposed ventilation, and have thus polluted towns with the air which, after all, may be better where it was. To obviate this, they sometimes filter the air through charcoal before allowing it to escape. No plan will succeed but that which, by preventing putrefaction, prevents entirely the formation of foul air. At present all the lines of sewers are unclean; they may all be cleaned by antiputrescent substances. If every family used them, even the smallest drains would be disinfected with universal benefit. Of course the Thames would cease to putrefy if the larger sewers were all treated in this way.

When the excretions are allowed to accumulate in a town behind the houses, as in Leeds and many other large manufacturing towns, they must of course be periodically removed, as the amount of impure vapour is very much in proportion to the surface exposed. There is little improvement caused by slightly diminishing the solid contents. When removed, it must be taken either to deposits in the town, as at Manchester, or deposits out of the town, as at Paris. It cannot, except in small towns, be removed directly to the land, as the demand is not regular. In both cases the removal is a great grievance, and the places of deposit are unseemly, especially near Paris, at Bondy, where a great district becomes uninhabitable. If removed by water, either the streams must be polluted, or sewers must be carried along the streams very far. If the sewer matter is first disinfected in the sewers, it will flow without disturbing any one; and if not so much diluted with surface matter as at present, it might be put at once on the land, without any one knowing by the smell that it differed from pure water.

Since Edwin Chadwick, C.B., and Dr. Southwood Smith, whether under the name of the Board of Health, or Sanitary Commissioners, or other name, stimulated the country to sanitary purposes, the supply of water and every other progress relating to health has undergone a great change. Professor Clark first showed the advantages of soft water; and, wherever it can be obtained, it is now used in towns. Every town which can obtain it has now a supply of water; and the supply in many is constant. The loss of labour to a family where water is obliged to be carried from a well is sometimes equal to that of one person for at least one third of a day. And even with this loss there is an insufficient supply, which adds to the inconveniences of a household, and the loss of comfort and of health. As towns enlarge, and as houses become higher, the necessity for a supply being introduced into houses increases. In Glasgow there is a supply from Loch Katrine, 34 miles distant. The supply in Scotch houses must be taken to the highest storey of the houses, on account of the system of living in flats, and because in the large towns almost every family has a water-closet and a bath.

The cleaning of the surface of streets is another important point in sanitary economy. Abundance of water for this purpose would be a great advantage; but the plan is not introduced here. The Whitworth sweeping machine was a good cleanser, but it was very heavy, and the cartage became expensive. Hand sweeping is still resorted to. If disinfecting agents were put into the water-carts which watered the streets, the putrefaction going on there in great abundance would be arrested, and the disinfected matter would flow into the sewers, which would then be free from impure air, and would run into the river in a state that would not corrupt. This was also proposed, in addition to the method alluded to of disinfecting sewers, and by the same persons. After the towns and their immediate neighbourhoods have been purified, it is needful to purify the land. The great sources of malaria are not known; but it is abundantly known that badly-drained land, especially at a high temperature, is productive of malaria; and that even at a moderate temperature malaria causes intermittent attacks. Drainage has greatly removed ague from this country; it has cleared the land; and the atmosphere has become brighter, because the dried land has not produced so many fogs as that which was cold and wet. The clearing of swamps was a labour of Hercules, no less valuable now. The agricultural or money value of land has, at the same time, greatly increased.

Towns.—It has been shown that a death-rate of 22 per thousand yearly prevails in England, but that in large manufacturing towns it rises to 34, and in certain parts of them even to 45, whilst in small and healthy places it is as low as 17, and in some cases even less so. The loss of life is great, and the loss of property also. A great object of sanitary reformers has been to show that to improve health has been to improve property. There can be no doubt of it. Disease causes much loss of time and labour, and diminishes the power of a country in which it exists. We may very fairly calculate from the amount of deaths the amount of disease. To improve our health is to improve our happiness and our wealth, as well as our capacities for both. Although in some country places malaria may cause illness, and ignorance may in various ways induce most unwholesome habits, there is less fear of disease on an average far from a town, because of the tendency of persons to live out of doors, breathing pure air, for in most places it is pure. In towns we are not only apt to be more shut up, and to have less exercise, but we are exposed to all the impurities which arise from the neighbourhood of multitudes, as well as from the vapours and gases from manufactures. Many chemists have found it difficult to tell the difference between town and country air, and have denied any difference; but it is now proved abundantly. The very rain of towns where much coal is burnt is so acid, that a drop falling on litmus renders it red. Blood shaken with the air of towns takes a different shade from that shaken with pure air. The air of Manchester contains about 0·0000934 of sulphurous acid, partly sulphuric, into which the first changes. Dr. Angus Smith has shown a method of measuring the amount of impurity in the air by means of a very dilute solution of permanganate of potash. His results are obtained by filling a bottle with the air of the place, merely by pumping the air out and allowing the air around to enter. A little permanganate is poured into the bottle, and it is decolorised; more is added until the colour remains. By this means comparative amounts of oxidisable matter are readily measured. A pigstye required 109 measures; air from the centre of Manchester air, on an average 58; air over the Thames, when the putrid stage had just passed, 43; London, 29; after a storm at Camden Town, 12; fields near Manchester, 13·7; German Ocean, 3·3; Hospice of St. Bernard, in a fog, 2·8; Lake of Lucerne, calm, 1·4. When sulphurous acid and sulphuretted hydrogen are present, the action is instantaneous: when organic matters only are present, the result is obtained more slowly. The difference between town and country air is remarkable. The author hopes to make the experiment suitable for daily use in hospitals. The bottle used contains about 100 cubic; the solution of permanganate is graduated by a standard solution of oxalic acid, of which 1000 grains contain 1 of anhydrous oxalic acid. 5 grains of this solution decompose 600 grains of the solution of permanganate.

To prevent impurities in the air of towns is extremely difficult. Manufactures must not be crippled; certain noxious operations are not allowed, and complaints well substantiated against any offensive works compel their removal. The method of absorbing noxious gases of some kinds is now becoming usual. The coke towers for absorbing muriatic acid began a great change in this respect. They have been used for sulphuric acid itself, nitrous fumes, sulphurous acid, sulphuretted hydrogen, &c. In manufacturing towns there is little sulphuretted hydrogen — it is decomposed rapidly by the sulphurous acid. A mode of absorbing this latter acid from coal smoke would be a great blessing to all. But this would not remove all the evil; coals send out black soot in such abundance that the whole of a town is darkened, everything clean is made impure, and the people find that cleaning is a hopeless task. This might readily be burnt, but even then we have other difficulties. Ashes rise up in great amount, and fall down again in a perpetual shower of dust. It is these solid matters as well as the gases which render our towns unwholesome. If the smoke could be washed it would remove all these evils, but the loss of a draught to the fire is then a consequence not yet practically overcome. When coals are burnt with abundance of lime, no sulphur is given off, but the use of this cannot become general. We are very much in want of a more economical and wholesome method of obtaining from coals the power which is in them.

Mr. Spence of Manchester, proposes to connect all the furnaces of the city with the sewers, and thereby to burn the gases and to ventilate the sewers at the same time. He believes that one chimney will ventilate readily 500 houses, including the house drains and sewers also.

The following advantages to be derived from the drainage of suburban land have been mentioned by the Board of Health: — 1. The removal of that excess of moisture which prevents the permeation of the soil by air, and obstructs the free assimilation of nourishing matter by the plants. 2. Facilitating the absorption of manure by the soil, and so diminishing its loss by surface evaporation, and being washed away by heavy rains. 3. Preventing the lowering of the temperature and the chilling of the vegetation, which diminishes the effect of solar warmth, not on the surface only, but at the depth occupied by the roots of plants. 4. Removing obstructions to the free working of the land, arising from the surface being at certain times, from excess of moisture, too soft to be worked upon, and liable to be poched by cattle. 5. Preventing injuries to cattle or stock, corresponding to the effects produced on human beings by marsh miasm, chills and colds, inducing a general low state of health, and in extreme cases the rot or typhus. 6. Diminishing damp at the foundations of houses, cattle sheds, and farm steadings, which cause their decay and dilapidation, as well as discomfort and disease to inmates and cattle.

The Board of Health, in its excessive desire to remove all refuse by water, has often exaggerated the evils of every other aid to cleanliness. Water is unquestionably the best, but it cannot always be obtained. In some climates it is not to be found in abundance, and in some weather it is only to be had by the use of heat. When the cold is great there is no fear of putrefaction or putrid gases; in warm places, or even in temperate, the use of disinfectants before removing the putrid matter is much to be desired. The Board of Health has not feared to send putrid matter into a river, believing it better there than in the town; it desires the water to be put instantly on the land, and to be disinfected by the land. It is well known that the process of doing this is often offensive. It is also known that large quantities of this matter cannot be disposed of at all times. It has been said that if the liquid were diminished by the rain-fall, it might be manageable. There is another method of diminishing its amount. At Carlisle it was found that the water was almost pure at certain hours of the day, and at all hours of the night. By allowing the more impure only to run into the sewers, the quantity not only becomes manageable, but the quality becomes more valuable. This is an important point, but one which will probably be less apparent in such a place as London, where the changes occurring from hour to hour cannot be so great as in smaller places. In Carlisle the sewage is deodorised and used on the meadows, and a great problem seems there and elsewhere to have begun its solution.

Sanitary economy has proceeded chiefly under the impression that the pollution of the air is the evil most to be dreaded. That this idea is correct there are very many proofs; but that there are numerous other evils affecting our large towns, it is unwise to deny. Polluted air causes damp and close cellars, and unventilated garrets and other rooms, to be unwholesome, as well as all rooms without proper openings, without chimneys, and without opening sashes to the windows. In a word, polluted air rises from close places and dirty places; want of light, too, is an evil under which all living creatures suffer. Great and crowded towns are subject most to all these evils, but in them also the habits of the people come into consideration. In many of the manufacturing towns the people obtain much larger wages than in the country places, but their houses are badly furnished, and their clothes, for every-day at least, are extremely filthy, whilst their love of pleasure is excessive. It is commonly supposed that the love of pleasure exists among the rich, but it is unquestionably one of the greatest evils *oppressing* the poor in all large towns, because their cultivation of mind has not kept pace with their knowledge of the external appliances of civilisation.

A deficient intellectual and moral condition are the great causes both of poverty and bad health, for both go together in almost exact proportions. It must never be expected that pure air alone can make men healthy. The mind, as well as the body, must be freed from irregularities. Abundant wages, which are equal to facilities of health, have rendered our working classes inferior in some cases, both in body and in mind, because they have not had education to resist indulgence. These classes will often contrast badly with a poor but cleanly rural population, calm in mind, without a desire for excitement. The subject is here only slightly touched, it needs a volume: sanitary economy, or the method by which man best adapts his place of abode to the conditions of external nature, must ever be a study of the most absorbing interest.—R. A. S.

SAPAN WOOD, or EAST INDIAN DYE WOOD, or BUCKUM WOOD, is a species of the *Cæsalpinia* genus, to which Brazil wood belongs. It is so called by the French, because it comes to them from Japan, which they corruptly pronounce Sapan. It is imported in pieces like the Brazil wood, to which it is far inferior for dyeing. The decoction under the name of sapan liquor is used in calico printing for red colours. In general, sapan wood is too unsound to be employed for turning.

SAP GREEN. The juice of the berries of the *Rhamnus catharticus*, or common buckthorn.

SAPPHIRE. 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 *curundu 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 3½ carats is more valuable than a diamond of the same weight. If it weigh 1 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 four 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 Brazil 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 topaz 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.

SARD. A variety of chalcedony of a dark reddish-brown colour, almost approaching to black by reflected light, and very deep red, inclining to blood-red, by transmitted light. It is found under the same conditions as cornelian, but is rarer and more highly esteemed, and therefore fetches a higher price. The name is derived either from Sarx (*Greek*, flesh), in allusion to its colour, or from Sardis in Lydia, whence it is said to have been first brought. It should be remarked, however, that the sard presents, in its interior and in the middle of its ground, concentric zones, or small nebulosities, which are not to be seen in the red cornelian, properly so called. The ancients certainly knew our sard, since they have left us a great many of them engraved, but they seem to have associated under the title *sarda* both the sardoine of the French, and our cornelians and chalcedonies. Pliny says that the sarda came from the neighbourhood of a city of that name in Lydia, and from the environs of Babylon. Among the engraved sards which exist in the collection of antiques in the Bibliothèque Royale of Paris, there is an Apollo remarkable for its fine colour and great size. When the stone forms a part of the agate-onyx, it is called sardonyx. For further details upon Gems, and the art of cutting and engraving them, see LAPIDARY.—H. W. B.

SARDONYX. A variety of onyx, composed of alternate layers of sard and white chalcedony.—H. W. B.

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 treddles. 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. 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. See TEXTILE FABRICS.

SATURATION is the term employed to express the condition of a body which has taken its full dose or chemical proportion of any other substance with which it can combine: as water with a salt, or an acid with an alkali. See *Ure's Dictionary of Chemistry* for a development of the principles and peculiarities attending this process.

SATURN, EXTRACT OF. The old name of the acetate of lead.

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 equalised 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. Consult *Holtzappfel* on this subject.

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 brickwork, 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 Sienna*, chrome yellow, &c. The surface, if it be that of a column, is turned smooth upon a lathe, polished with stones of different fineness, and finished with some plaster-pap, to give it lustre. Pilasters 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. See STONE, ARTIFICIAL.

SCARLET DYE. (*Teinture en écarlate*, Fr.; *Scharlachfârberei*, Germ.) Scarlet is usually given at two successive operations. The boilers (see DYEING) are made of block tin, but their bottoms are 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, 1 pound of cochineal in fine powder. An instant afterwards, pour in 5 pounds of the clear mordant (see MORDANT), 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 winced in a current of pure water.

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 (muriate of tin) are to be added. Should the liquor be likely to boil over the edges of the kettle, a little cold water is to be added. 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.

Below will be found the tables of the composition of the *bouillon* and the *rougie*.

M. Lenormand states that he has made experiments of verification upon all the formulæ of the following 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.

Tables of the Composition of the Bouillon and Rougie 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.	oz.	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

Composition of the Rougie.

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
Poerner - {	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

M. Robiquet has given the following prescription for making a *printing scarlet*, for well-whitened woollen cloth. Boil a pound of pulverised cochineal in 4 pints of water down to 2 pints, and pass the decoction through a sieve. Repeat the boiling three times upon the residuum, mix the 8 pints of decoction, thicken them properly with 2 pounds of starch, and boil into a paste. Let it cool down to 104° F., then add 4 ounces of the solution of tin, and 2 ounces of ordinary muriate of tin. When a ponceau red is wanted, 2 ounces of pounded turmeric should be added.

A solution of chlorate of potassa is said to beautify scarlet cloth in a remarkable manner. See Lac Dye, Aniline, Murexide.

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 crystallised 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, and edulcorated 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. Much discussion has arisen relative to the use of this salt in paper-hangings, it having been supposed by many persons to have produced ill effects on those exposed to the atmosphere of such rooms. Under Arsenic, this question has been discussed. The editor was then under an impression that Dr. Alfred S. Taylor supposed the arsenite of copper to escape from the paper by volatilisation. Dr. Taylor writes to correct this, —it is his impression that dust is mechanically removed; and from his own experience he advances no further than this.

SCHMELZE. A kind of glass prepared in Bohemia, chiefly for the purpose of receiving the red colour imparted by the oxide of gold. See Glass.

SCHWEINFURTH GREEN is a more beautiful and velvety pigment than the Scheele's green. It was discovered in 1814, by MM. Rusz 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 increase, 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 prevent the formation of any such pellicle on the surface, as might by falling to the bottom, excite premature crystallisation. 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 31st *Bulletin de la Societée Industrielle Mulhausen*, consists 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 *bonbons*, by the *conseil de salubrité;* since which the confectioners were prohibited from using it by the French government. The Prussian government have also enacted a law against the use of the arsenical greens in paper-hangings.

SCOPARINE. $C^{42}H^{22}O^{20}$ (?). A base found by Stenhous in the broom plant, *Spartium scoparium.*

SCOURING. This art is that which is employed for removing grease spots, &c., from clothes and furniture, which require skill beyond that of the laundry. It is divided into two distinct branches, viz. French and English cleaning. We will first give an outline of English cleaning, although the other (French) has no more to do with the French than the English, except in name; and that is kept because many people would not fancy the things were done properly if done by an English process.

Gentlemen's clothes, such as trowsers, coats, &c., are treated in the following manner. They are stretched on a board, and the spots of grease, &c., first taken out by rubbing the spots well with a brush and cold strong soap liquor; they are then done all over with the same, but the grease spots are done first, because they require more rubbing, of course, than the other parts, and when all the substance was wet they would not be so easily distinguished. After treatment with the strong soap liquor, the soap is worked by a weaker soap liquor; the articles are then well washed off with warm water, and treated with ammonia (*if black*), solution of common salt, or dilute acid, according to circumstances. They are then drained, beaten out with a little size, pressed and dried.

Ladies' articles of dress, as shawls, and woollen dresses.—The spots are first removed by rubbing them on the board with very strong soap liquor; they are then put into a strong soap liquor, and well worked about in it; then taken out and treated with a weaker soap liquor, to work out the soap, &c.; rinsed with warm and cold water alternately; treated with solution of common salt or very weak acid, to maintain the colours. They are starched, if necessary, and ironed. Woollen dresses that are taken to pieces are calendered instead of ironing.

Silk dresses, &c., are always taken to pieces, and each piece done separately, and as quickly as possible. If there are any spots of grease, they are taken out first, as above mentioned. Each piece, after the spots are removed, is immediately placed in a strong soap liquor, and well worked about in it, and then into a thinner soap liquor; well washed out with cold water, and treated with solution of common salt, or very weak acid, or both, as required; each piece is then neatly folded and wrung separately, again folded smoothly and placed in dry sheets, and pressed, so as to remove all dampness from them; they are then put into a frame, a little size or sugar and water used to stiffen and glaze; lastly, dried while on the frame by a charcoal fire.

Furniture, as curtains, &c.—These things are put into a tub, with a strong cold soap liquor, and well punched about with a large wooden punch made on purpose; and a great deal depends upon this being properly done. They are then treated in the same manner in a weaker soap liquor, well rinsed with water, treated with common salt or weak acid, as required, wrung out, and dried. Woollen furniture will generally require to be treated several times with the first strong soap liquor, to remove the dirt, but for cotton furniture once will be generally sufficient.

Carpets.—These are well beaten, then laid down on the floor of the dye-house, and *well* scrubbed with strong cold soap liquor, by means of a long-handled brush or broom; then treated with a weaker soap liquor; well rinsed with water, by throwing pails of water over them, and still rubbing with the brush; treated with water, to which a *very small quantity* of sulphuric acid has been added, to retain the colours; rinsed again, hung up to drain, and then hung up in a warm room to dry.

A great point in this kind of cleaning is to use *strong cold soap liquors;* and this cannot be done with ordinary soaps, as they congeal when cold, and on this account

Field's soap is the principal soap which is used, because it is made from oil and does not congeal, and I rather expect is made from the *olein* obtained in the manufacture of composite candles.

French cleaning is what is called *dry cleaning*. In this process the articles are put into camphine and worked about in it, drained, sheeted, and dried. The camphine dissolves the grease, &c., and does not injure the colours; but when things are very dirty, it does not clean so effectually as the English method. It is, however, the only process that can be employed in some cases, as in cleaning kid gloves.—H. K. B.

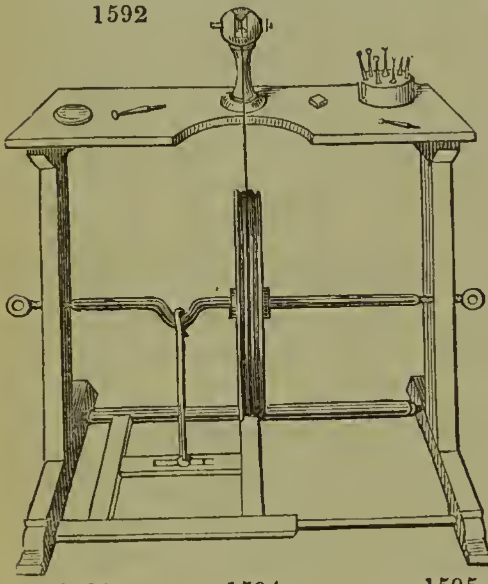
SCREWS. The elementary idea of the form of the screw is obtained by regarding it as a continuous circular wedge; and it is readily modelled by wrapping a wedge-formed piece of paper around a cylinder; the edge of the paper then represents the line of the screw.

The use of the screw is well known to all; and the system of cutting a rod of iron or steel into a screw scarcely requires any description. The manipulatory details and the tools used in their manufacture are admirably and most fully described in *Holtzapffel's Turning and Mechanical Manipulation.*

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. 1592 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.* 1593 a hollow cylinder, for describing circles, and for boring; *fig.* 1594 a knobbed tool, or rod terminated by a small ball; *fig.* 1595 a stem terminated with a cutting disc, whose edge may be either rounded, square, or sharp; being in the last case called a saw.

1592



1593 1594 1595

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 ancient.

Several varieties of machine have been of late years introduced to facilitate the processes of engraving gems. Many of them involve the pentagraph, so that a seal may be engraved by the machine at once, either larger or smaller than the original from which it is copied. Most of these engraving machines are upon the principles described under CARVING BY MACHINERY.

SEAL; SEAL OIL; SEAL FISHERY. See OILS.

SEALING-WAX. (*Cire à cacheter*, Fr.; *Siegellack*, Germ.) The Hindoos 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 shell-lac 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 shell-lac is to be selected for bright-coloured sealing-wax, the dark kind being reserved for black.

The following proportions may be followed for making red sealing-wax :—Take 4 ounces of shell-lac, 1 ounce of Venice turpentine, 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 viscidity 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 proportions are stated to form good sealing-wax : —

Red No. 1.— 4 oz. Venetian turpentine, 6 oz. shell-lac, ¾ oz. colophony, 1¾ oz. cinnabar, &c.

Red No. 2. — 4 oz. turpentine, 5½ oz. shell-lac, 1½ oz. colophony, 1¼ oz. cinnabar, magnesia to colour.

Fine Black — 4½ oz. Venetian turpentine, 9 oz. shell-lac, ½ oz. colophony, lamp-black mixed with oil of turpentine as much as is required.

Black — 4 oz. Venetian turpentine, 8 oz. shell-lac, 3 oz. colophony, lamp-black, and oil of turpentine.

Yellow — 2 oz. Venetian turpentine, 4 oz. shell-lac, 1¼ oz. colophony, ¾ oz. king's yellow.

Dark Brown — 4 oz. Venetian turpentine, 7½ oz. shell-lac, 1½ oz. brown English earth (ochre).

Light Brown — 4 oz. Venetian turpentine, 7½ oz. shell-lac, 1 oz. brown earth, ½ oz. cinnabar.

Dark Blue — 3 oz. Venetian turpentine, 7 oz. fine shell-lac, 1 oz. colophony, 1 oz. mineral blue.

Green — 2 oz. Venetian turpentine, 4 oz. shell-lac, 1¼ oz. colophony, ½ oz. king's yellow, ¼ oz. mountain blue.

Gold — 4 oz. Venetian turpentine, 8 oz. shell-lac, 14 sheets of genuine leaf gold, ½ oz. bronze, ½ oz. magnesia with oil of turpentine.

SEA WATER. The following has been given as the average composition of sea-water in 100 parts :—

Chloride of sodium	2·50
Chloride of magnesium	0·35
Sulphate of magnesia	0·58
Carbonates of lime and of magnesia	0·02
Sulphate of lime	0·01

Dr. John Davy informs us that carbonate of lime is chiefly found in sea-water near the coast. Dr. George Wilson proved the existence of fluorine in the waters of the German Ocean, and Foret Lammr obtained it from sea-water collected near Copenhagen; Malaguti and Durocher have detected silver in sea-salt, and Mr. Field has shown that the copper sheathing of ships separates silver, in the process of time, from the waters of the ocean.

Lead and copper have also been detected in sea-water, and in the ashes of some marine plants. These metals are said to exist in the sea-water in the form of chlorides, and to arise from the native sulphides of the metals by the action of the chlorine in the water (?). See Water, Distilled; Waters, Mineral.

SECRETAGE. A process in which mercury or some of its salts is employed to impart to the fur of animals the property of felting, which they did not previously possess. See Fur; Mercury.

SEGGAR, or SAGGER, is the cylindric or oval case of fire-clay, in which fine stoneware is enclosed while being baked in the kiln.

SELENITE. Hydrated sulphate of lime. See Alabaster and Gypsum.

SELENIUM, from Σελήνη, the moon, is a peculiar 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-grey colour, with a glistening surfaec; but it is a 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 consistency 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 cinnabar-red colour. See Ure's *Dictionary of Chemistry*.

SELTZER WATER. See SODA-WATER, and WATERS, MINERAL.

SEMOULE. The name given in France 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 semoule is obtained from the wheat of the southern parts of Europe. With the semoule the fine white Parisian bread called *gruau* is baked. Skilful millers contrive to produce a great proportion of semoule from the large-grained wheat of Naples and Odessa.

Granular preparations of wheat deprived of bran are known in this country as *semolina*, *soujee*, and *manna-croup*.

SENEGAL GUM. This gum is produced from the *Acacia Senegal*, a tree or shrub found in Arabia and the interior of Africa. See ACACIA.

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 ioligo*, 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 alkalies 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 blanches 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 (from septum, *a division*), called anciently *ludus Helmontii* (the *quoits* of Van Helmont, from their form), are calcareous concretions intersected by veins of calc spar, which, when calcined and ground to powder, form an excellent hydraulic cement. See MORTAR, HYDRAULIC. They are calcareous mudstones, which appear to have accumulated around decomposing animal and vegetable matter; and the veins of calc spar are the resnlt of a subsequent infiltration of water holding lime in solution into the cracks which were caused by the shrinking of the mass, during the process of solidification.

From the regular arrangement of these cracks, which generally assume pentagonal forms, resembling in appearance the divisions in the shell of a tortoise, septaria have received the common name of turtle-stones or fossil tortoises. The turtle-stones found in the Oxford Clay at Weymouth, when cut into slabs and polished, form very handsome tables. The number of veins of calc spar, upon which their beauty depends, renders these turtle-stones unfit for forming an hydraulic cement, in consequence of their furnishing too great a quantity of lime when calcined. Septaria fit for furnishing cement are dredged in large quantities in Chichester harbour, and off the coast of Hampshire, and are also procured from Harwich, Sheppy, and several other places. A stratum of septarian stone, forming the Broad Bench on the coast of Dorsetshire, affords an excellent cement, and is largely quarried.—H. W. B.

SERPENTINE, is a mineral of the magnesian family, being a hydrated silicate of magnesia, composed of silicate 43·64, magnesia 43·35, water 13·01 = 100. Its colour is chiefly green, seldom of a uniform tint, but generally of several shades arranged in dotted, striped, and clouded delineations. For this reason it has received the name of serpentine (or ophiolite, from ophis, *a serpent*, and lithos, *stone*), from the fancied resemblance which it bears to the skin of a serpent, both in colour and in its spotted or mottled arrangement. Specific gravity, 2·5 to 2·6. It is slightly unctuous to the touch, sectile, and tough; and therefore easily cut into ornamental forms. It has been divided into precious or noble serpentine, comprising the purer translucent and massive varieties, with a rich olive-green colour, and common serpentine, or the opaque varieties, forming extensive rock masses, like those of the Lizard in Cornwall, of Anglesea, Portsoy in Banffshire, Unst and Fetlar in Shetland, and Zöblitz in Saxony.

Serpentine, though so soft as to be scratched by calcareous spar, and to be turned in the lathe, takes a good polish, and forms a very beautiful ornamental stone. At Zöblitz it has long been manufactured into a variety of articles, which find their way all over Germany; and within the last few years works have been established in Cornwall, where, by means of powerful machinery, it is made into columns, vases, chimney-pieces, and other ornamental articles. The serpentine of Portsoy is also a very beautiful stone, and was formerly exported for manufacturing into similar objects. The Cornish Serpentine and Steatite were also sent to Bristol in considerable quantities, where they were formerly, but are no longer, used in the manufacture of carbonate of magnesia. Serpentine is used with advantage for the backs of grates, the lining of stoves and furnaces, and the bottoms of bakers' ovens.—H. W. B.

SESAMUM OIL, or TEEL OIL. See Oils.

SEWING MACHINES. The history of these ingenious inventions has been so well told by Professor Willis, in his report on the machinery for woven fabrics of the Paris Exhibition, that we do not hesitate to borrow from it.

At the Paris Exhibition in 1854, fourteen exhibitors came provided with sewing machines. They were of different characters, and have been divided by Mr. Willis into four classes.

Under the first class came the machines in which the needle is passed completely through the stuff, as in hand working: "It is so natural, in the first attempts to make an automatic imitation of handiwork, that the imitation shall be a slavish one, that we need not be surprised to find the earlier machines contrived to grasp a common needle, push it through the stuff, and pull it out on the other side."

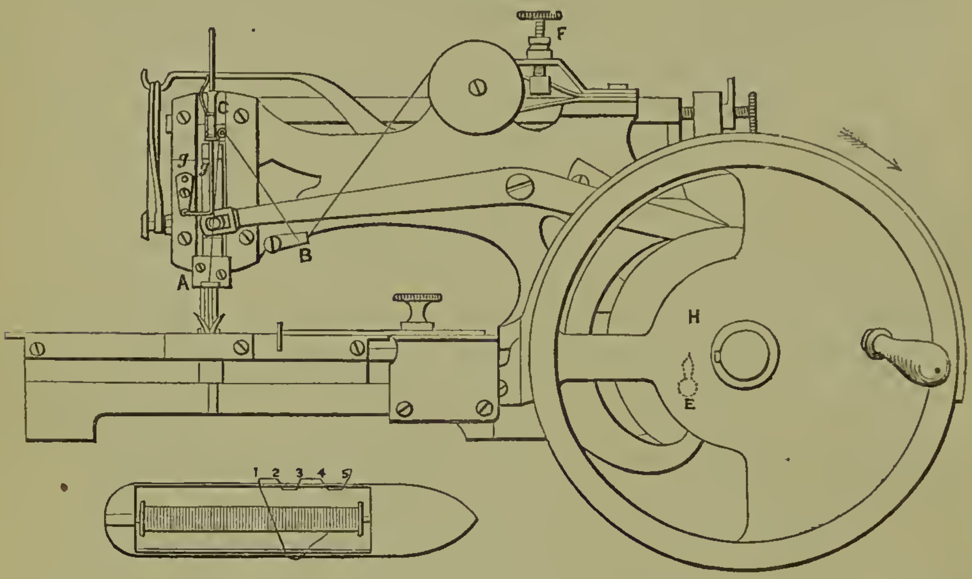
Thomas Stone and James Henderson, and some others, patented machines of this kind, which proved abortive. M. Heilmann exhibited an embroidering machine in 1834, in which "150, more or less, of needles are made to work simultaneously, and embroider each the same flower or device upon a piece of stuff or silk stretched in a frame and guided by a pentagraph." See Embroidering Machine. Several embroidering machines have been from time to time introduced.

The second class of sewing machine was that known as the chain-stitch, or "crochet." This is wrought by a so-called crochet needle, which terminates with a hook; the needle is grasped by the opposite end, and the hook pushed through the stuff, so as to catch hold of a thread below, and, being then withdrawn, brings with it a small loop of the thread; the hook of the needle retaining this loop is then repassed through the stuff at a short distance in advance of the former passage, catches a new loop, and is again withdrawn, bringing with it the second loop, which thus passes through the first. Such a series is called chain-stitch, and may be used either to connect two pieces together, or as an embroidery stitch, for which it is well adapted by its ornamental and braid-like appearance. M. Thimonnier patented in 1830 the first machine of this character. M. Magnin was associated with Thimonnier in 1848 in a patent for improvements, and in 1851 it was exhibited in London.

In 1849 Morey and Johnson patented a sewing machine in this country, in which a needle with an eye near the point, perpendicular to the cloth, was combined with a hooked instrument parallel to the cloth, for effecting the same purpose as the crochet needle. Mr. Singer improved on this, and he introduced a contrivance by which his machine forms a kind of knot at every eighth stitch.

The third class of sewing machines is wrought by two threads, and, as the stitch produced by them is known in America as the *mail-bag stitch*, it may be presumed it was employed by the makers of that article before the introduction of the machine. In the usual mechanical arrangement for its production, a vertical needle, having the eye very near the point, is constantly supplied with thread from a bobbin, and is carried by a bar, which is capable of an up-and-down motion. The cloth being placed below the needle, the latter descends, pierces it, and forms below it a small loop, with the thread carried down by its eye. A small shuttle, which has a horizontal motion beneath the cloth, is now caused to pass through this loop, carrying with it its own thread. The needle rises, but the loop is retained by the shuttle thread. The cloth being next advanced through the space of a stitch, the needle descends again, and a fresh loop is made. This process being repeated along the line of the seam, it results that the upper thread sends down a loop through such needle hole, and that the lower thread passes through all these loops, and thus secures the work. The first machine for producing this stitch was invented by Walter Hind, of New York, in 1834. Several patents for producing this stitch have been obtained. Howe's patent was one of the most practical. Mr. Thomas of London became the possessor of Howe's patent. This was improved; and a new patent obtained in June, 1846, which was modified in December of that year. This machine has been extensively used. This invention, says the patentee, consists in certain novel arrangements of machinery, whereby fabrics of various textures may be sewn together in such a manner as to produce a firm and lasting seam. By this invention a shuttle, when the point of the needle has entered the cloth or other fabric under operation and formed a loop of thread, passes through that loop and leaves a thread on the face of the cloth, by which means the needle when it is withdrawn from the cloth, instead of drawing back the thread with it, leaves a tightened loop on the opposite side of the cloth to that at which it entered. The fabric then passing forward to the distance of the length of the stitch required is again pierced with the needle, and a stitch is in like manner produced. A drawing of this machine is shown in *fig.* 1596, which will be understood from the following description.

1596



1. *The needle.* Place the needle in the slide A, with its flat side towards the shuttle, and the grooved side in front. Turn the wheel of the machine round till the line *g* on the gun-metal slide is level with the line *g* on the iron cheek. Place the *eye* of the needle level with the top of the shuttle box, and screw the needle fast.

2. If the eye is above the box when the marks correspond, the needle is too high; if the eye cannot be seen, the needle is too low.

The needle should pass down the centre of the hole in the shuttle box; but if it does not, it can be made to do so by bending.

4. *The needle thread* runs from the top of the reel, through the rings B, C, and through the eye of the needle.

5. *The shuttle.* It is necessary that the first coil of cotton be wound closely on the bobbin, or it will be difficult to make it lie side by side like that on ordinary reels. The reels should not be filled above the brass, and the cotton or silk should be free from knots, which sometimes pull the wire out of the shuttle.

6. The thread must run from the under side of the bobbin, round the wire and out through holes, Nos. 1, 2, and 3. If the thread is not tight enough, miss No. 3 and let it come out through Nos. 4 or 5, or it may be drawn through five holes. Put the shuttle in the box, turn the wheel round once, then pull the end of the needle thread and draw up the shuttle thread through the hole in the plate. Place the cloth under the mover, and the machine is ready for work. The proper time for turning the work to sew a corner, &c., is when the spring at the top is lifted off.

7. The length of stitch is regulated by the screw E at back of machine.

8. The tightness of the needle thread is regulated by the screw F.

9. The tightness of the shuttle thead is regulated by passing the thread through more or less holes.

11. The quantity of thread pulled off the reel for each stitch is regulated by the

position of the piece of brass B. The lower the hole at its end the greater the quantity pulled off: when the cloth is thick, more thread is used, and the end of the brass B should be lowered; when thin, raised. It should be in such a position that the trumpet C is drawn nearly down to the pin on the slide when the shuttle passes through the loop.

A patent was obtained by John Thomas Jones, of Glasgow, in February, 1859, for a sewing machine presenting many novelties and improvements. Mr. Jones's patent well explains his machine, we therefore transfer his description to our pages.

The machine consists, under one modification, of an open frame, having a platform top upon which the sewing or stitching operations are carried on. Beneath this platform, and near one end of it, is a short transverse horizontal first motion shaft running in bearings in the framing and carrying a long crank, a connecting rod from which is jointed at its opposite end, directly to the shuttle driver or slide piece, working in a horizontal guide recess beneath the opposite or front end of the platform or table. The first motion shaft has also another and shorter crank upon it, the stud pin of which is connected to the pin of the longer crank by an overhanging link piece, provision being made for the adjustment of the relative positions of the two cranks as regards their sequence of revolution. It is this shorter crank which actuates the needle movement, the pin being entered into a differentially slotted or operated cam piece, forming the pendent lower end of a bent lever, working on a stud centre, in the interior of the overhead bracket or pillar arm of the framing. The centre on which this lever works is in the horizontal part of the overhead bracket arm, and its opposite or free working end has a rectangular slot in it to embrace a rectangular block of metal working freely upon a lateral centre stud upon the vertical needle-carrying bar. In this way the needle has imparted to it a differential reciprocatory vertical movement, the peculiar connection of the needle bar with the actuating lever having the effect of marking the needle in the most accurate manner, and preventing jarring and wear. These are the whole of the primary movements for working the stitches, which may be of various kinds, as made up from the combined action of the needle and shuttle, or thread-carrier; the form of the slotted piece or operated cam in the end of the needle lever, being variable to suit any required peculiarity of needle movement, the main elements of which are a direct up-and-down motion without a stop or rest, until at the termination of the down stroke, when a short rise takes place, succeeded by a rest to allow of the due looping and stitching of the thread. The feed of the fabric to be sewed is effected by the operation of a short vertical lever piece with a cranked and slotted lower end, where it is set on a fixed stud in the framing. This feed lever has a roughened or toothed upper end, the teeth or asperities being set or inclined in the direction of the fabric's traverse. After each stitching action, the feed lever being lowered just beneath the operating level, is raised up so as to press firmly against the under side of the fabric, and nip it between the stationary spring pressed above. This elevation of the roughened face is effected by the traverse of the shuttle-carrier, which at its back stroke comes against the inclined tail of a short horizontal lever set on a stud in the framing, and having its opposite bent end bearing against the lower end of the feed lever, at the part where it is carried by its slot upon the holding stud. At the commencement of the return of the shuttle, an inclined piece upon the shuttle carrier bears against a lateral stud upon one end of a short rocking or oscillatory shaft set in bearings in the framing, the other end of the shaft having a lever arm bearing against the side of the feed lever. In this way the feed lever is traversed forward in its elevated position, carrying forward the fabric for the succeeding stitch. The adjustment of the spring presser is effected by an upper screw in the end of the bracket arm of the framing, the lower end of the screw bearing upon a lateral pressing piece which rests or abuts on the top end of a flattened helical spring upon the presser bar. The latter can be set up clear out of work by means of a small cam lever set on a stud in the stationary guide of the presser bar, the cam bearing against a lateral stud in the bar, so that by setting the lever up or down, the cam is correspondingly turned, and the lever set up or down, as required. The actual pressing or resisting foot of the bar is a bent piece of metal screwed on to the bar, and being thus removable to allow of various forms of feet guides, or presser surface pieces, being put on to suit varieties of forms of stitching.

This machine, or a modification of it, is available for working a duplex, or other stitching action without involving further modification of the prime movers. In working a duplex arrangement, two needles and two shuttles are used, each needle and shuttle working independently, so as to allow of sewing in two different and independent lines with one set of actuating parts. To aid the shuttle action there is attached to its side a flat curved blade spring, one end of which is free, but hooked into a hole in the body of the shuttle. Thus, as the shuttle traverses forward, the sewing thread is drawn beneath the hooked end portion of the spring, so as to be nipped against the shuttle. The thread is thus held, and the proper loop is secured at the part immediately outside the nipped portion. With this arrangement the needle can never work on the wrong side of the shuttle thread. Provision is also made for securing an independent shuttle thread controller. This is a nipper or retainer worked from any convenient part of the mechanism, but entirely independent of the shuttle movement. This may be arranged in various ways, the object being the variable and efficient control or retention of the thread, without interfering in any way with the fixed and determined action of the shuttle. Instead of fixing a horizontal shuttle race, or guide track, in the framing, the shuttle driver is itself made the race or carrier, so as to secure both offices in one detail or arrangement. A hook or finger, actuated by any convenient part of the movement, is also used for retaining the needle thread for any desired time after being passed through the fabric; this facilitates the movement or action of the needle bar. The shuttle race, when one is used, is made quite independent of the machine, so that it can be changed at any time to suit various sized shuttles by merely slipping in or taking out the part. The portion of the framing carrying the shuttle race is cast in one piece with the main body of the platform, but the table or plate on which the stitching takes place is a loose piece slotted down the middle for the working movements, and fitted into its position by pins cast upon it, and entered into corresponding recesses in the main base.

There exists a fourth class of sewing machines, which produce more complex stitches than the preceding. These are formed by sewing two threads, which mutually interlace each other in chain stitch, so as to avoid the unravelling to which the simple chain stitch is subject, and also are intended to meet an objection which is urged against the shuttle stitch machines, on the ground that, as the shuttle must be small to enable it to pass through the loop formed by the needle thread, so the bobbin carried by the shuttle can only obtain a moderate length of thread. Thus the operation is stopped at short intervals to supply fresh bobbins to the shuttle. Several patents have been obtained for compound chain stitch machines: two in America, in 1851 and 1852, by Grover and Baker; another in 1852 by Avery; and another by M. Journaux Le Blond.

Mr. Willis, in concluding his report, very justly remarks, "In England, as in France, all the most promising American patents have been repatented, and the use of the machine appears to be slowly and gradually extending itself. The sewing machine is doubtless yet in its infancy; but it has acquired so prominent a position, and shown itself to be so useful, as to deserve the time and attention of able mechanists. Its imperfections will therefore be, if possible, gradually removed, and it may take its place in the series of manufacturing mechanism as a most useful agent."

SHAFT, in *mining*, signifies a perpendicular or slightly inclined pit. See MINING.

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 seed 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 *Chenapodium 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-luna 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 strewed 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 copperas.

Shagreen is also prepared from the skin of the shark.

SHALE, or SLATE-CLAY, is an important stratiform member of the coal-measures. See COAL.

SHAMOY, or CHAMOIS LEATHER. See LEATHER.

SHAWL MANUFACTURE. Shawls were originally, and still continue to be woven in the centre of India, from the fine silky wool of the Thibet goat; and the most precious of them still come from Cashmere. The wool is beautifully rich and soft to the touch, and is superior to the finest continental lamb's wool. It is also divisible into qualities. In the admirable report on this subject, in the *Jurors' Reports of the Great Exhibition*, it is remarked:—"The source from which this article has sprung is well known to be the ancient and beautiful fabric of the valley of Kashmir, where the excellence of the raw material stands to this day unrivalled, although its manufacture has been, and still is, carefully prosecuted in many parts of the world. The great beauty of the eastern tissue, considering the rudeness of the means of machinery employed, as compared with those which are now available to the European manufacturer, is a marvel in the eyes of the most experienced." The manufacture of shawls was first begun in this country, at Norwich, by Mr. Barrow and Alderman Watson, in 1784. They copied the Indian style, but the process was very slow, and the result consequently costly. Mr. John Harvey, of Norwich, followed up the enterprise with Piedmont silk warp and fine worsted shoot; but the designs were darned by hand. It was not until 1805 that a shawl was produced entirely by the loom at Norwich. In Paisley and Edinburgh the manufacture was introduced about the same time. At Paisley the manufacture is still continued, especially the manufacture of shawls of the Indian pattern, from real Kashmir wool. In 1802, a manufacture of shaws was commenced in Paris, and this led Jacquard to the invention of his loom (see JACQUARD LOOM), with which now all kinds of shawls are woven. For the mode of manufacture, the respective articles, SILK, TEXTILE FABRICS, and WEAVING will be sufficiently descriptive.

The varieties of shawls produced may be grouped as follows:—

Woven shawls of India, or of Indian style, made in Europe.

Barége shawls, made of wool, an imitation of shawls made in the Pyrenees, by the peasantry of a place so called.

Crape shawls, made of silk, in imitation of the Chinese fabrics.

Grenadines, made of silk of a peculiar twist.

Levantines and Albanians, made of silk and spun silk, to resemble the scarves worn in the Levant and Albania.

Chenille shawls; a novel application of silk, frequently combined with cotton.

Chiné shawls; a printed warp before weaving.

Woollen shawls; ordinary kinds.

Tartan plaids. The manufacture of these appears to be very ancient. In 1570, an ancient Scottish manuscript gives a list of the colours of the plaids worn by the different clans. In 1747, the weaving of this distinctive dress was prohibited by Act of Parliament, and the grey shepherd's mauds were made instead. In 1782, this Act was repealed; but tartans did not become fashionable until the visit of George IV. to Scotland, in 1822; after which, the Stirling fancy plaids began to be made. In 1828, clan tartan shawls became fashionable, and the Galashiels weavers took up the trade. Paisley commenced to weave these shawls about eighteen years since, and it has since then extended to many other parts, both at home and in other countries.

SHEATHING OF SHIPS. For this purpose many different metals and metallic alloys have been lately proposed. From a train of researches made by Dr. Ure 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. Experiment proved to Sir H. Davy that if a portion of zinc were applied to the copper it would by its electrical relations prevent the process of oxidation in the copper. A vessel sheathed with copper and zinc plates was accordingly sent a voyage to a distant part of the world, from whence it returned with its copper perfectly uninjured by the salt water, 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 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 was 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, twenty 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. 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. 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." See ALLOYS.

Various preparations have been introduced for the purpose of coating the sheating on the bottoms of ships; amongst others that of Mr. Peacock appears to be highly approved of by shipowners. The secret of all of them is the presence of a metallic oxide which is offensive to both the vegetable and animal organisms.

SHELLS. Hollow projectiles filled with combustible materials. See ARTILLERY.

SHERRY WINE. See WINE.

SHIFT. *A miners' term*, used in Alston Moor and the Northern mines. A *shift* is the quantity of lead ore contained in six or eight waggons, and amounts to about 240 kibbles of 14 quarts each; each waggon in a six-waggon "shift" contains 40 such kibbles; while in an eight-waggon "shift" each waggon contains only 30 kibbles.

SHINGLING. Condensing the iron bloom by heavy hammers. See IRON.

SHODDY, properly so called, is the refuse of the willowing and scribbling process in the preparation of mungo and wool, and is sold in large quantities for manure.

SHODEING. *Shodes* (from the Teutonic word *shutten*, to pour forth) are loose stones; applied to such as are of a mineral character. Shodeing, is tracing those loose stones from the valley in which they may be found to the mineral lode from which they have been removed. In this manner many mineral lodes are discovered.

SIENITE, or SYENITE, is a granular aggregated compound rock, consisting of felspar and hornblende, sometimes mixed with a little quartz and mica. 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. Hornblende is the characteristic ingredient, and serves to distinquish sienite from granite, with which it has been sometimes confounded; though the felspar, which is 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. The so called granites of Leicestershire more nearly approach sienites. A careful study of the rocks of the Grooby, Markham, and Bardon Hill quarries, will show a gradual change of the granitic rock through sienite, into a green stone porphyry. This stone is extensively used in the metropolis and other large towns for "pitching" and paving.

SIENNA. Clay coloured by the peroxide of iron and manganese. It is known as raw and burnt Sienna, according to the treatment it has received. It is a good artists' colour.

SILESIAN LINENS. See FLAX and LINEN.

SILEX. Quartz, pure flint.

SILICA. SILICIC ACID. SiO^3. This substance exists nearly pure in rock crystal, chalcedony, opal, agate, and many other minerals; and it is an important constituent of a very large class.

It may be obtained perfectly pure by precipitation from any of its combinations. Silicic acid forms a class of salts termed silicates, which are generally formed by fusing silicic acid with the bases. Those silicates in which the acid predominates are insoluble in water, and constitute the different varieties of glass. See GLASS.

If soluble silica is ignited it is no longer soluble. This and several other peculiarities prove that silica exists in two states.—See *Ure's Dictionary of Chemistry*.

Some curious natural deposits of silica are found in nature. Way has lately discovered at Farnham large deposits of silica, in the condition in which it is readily soluble in hot solutions of caustic potash, or soda. These beds are situated at the base of the chalk formations, between the Upper Green Sand and the Gault Clay. Mr. Way proposes to employ those beds as a convenient source of silicate of lime for agricultural purposes. He found that a mixture of slaked lime with the powdered rock, when made into a thin paste and left for some weeks, is entirely converted into silicate of lime. The action is promoted by the presence of 2 or 3 per cent. of carbonate of soda; the latter appearing to act as the carrier between the silica and the lime. Similar deposits had been previously found by Sauvage in the *Départment des Ardennes*.

Siliceous deposits are often formed from warm springs. In the Island of Terceira a deposit of this kind contains 77·05 of silicic acid. The hot springs of New Zealand deposit a crust containing 75 of silica; and some springs in the Azores leave precipitated a stratum containing 67·6 of silica.

The Dinnas sand, Glamorganshire, is remarkable. Some samples are actually pure silica, and most of it gives 91·95 of silicic acid; the sand of Penderyn, in the same county, giving 94·05 silica. A similar deposit is found near Landudno, in North Wales. See STONE, ARTIFICIAL.

SILICATES. Compounds of silicic acid (*silica*, *oxide of silicon* or *silicium*), with earthy, alkaline, or metallic bases. In mineralogical arrangements these have been divided into *anhydrous silicates*, which include, as Dana classifies them, the *augite* section, the *garnet* section, the *mica* section, the *felspar* section, and some others; and the *hydrous silicates*, which include the *talc* section, the *serpentine* section, the *chlorite* section, the *calamine* section, the *datholite*, and others.

An interesting paper on hydraulic cements has been submitted to the Academy of Sciences by M. F. Kuhlmann, showing the advantage that may be derived from the combination of silicates with mortars and cements in general, and especially with those that are intended to resist the action of sea water. It is well known that the first effect of water on cements is that of forming hydrates; after which a gradual contraction takes place, producing a degree of hardness, which increases in proportion as the contraction is slower, and there is more silex or alumina in the cement. Now, M. Kuhlmann has observed that if alumina or its silicate, or else magnesia, whether caustic or carbonated, be kneaded into a paste with a solution of silicate of potash or soda, the compounds resulting therefrom will bear a perfect resemblance to the natural silicates, such as felspar, talcose slate, magnesite, &c., and will, by repose and slow contraction, become hard and semi-transparent, resisting in a high degree the erosive effects of water. If slaked lime be added to the said compounds they acquire the properties of hydraulic cements. M. Vicat, junr., having shown that calcined magnesia added to a cement would resist the action of sulphate of magnesia, M. Kuhlmann has endeavoured to turn this observation to account, by mixing calcined dolomites (which contain magnesia) with mortar, containing the alkaline silicates. This composition he finds very advantageous, since most of the salts contained in sea water must contribute towards the preservation of such cements. In fact, the chloride of magnesium, as well as the sulphate of magnesia, will be decomposed and form a layer of silicate of magnesia on the surface of the cement; in the same manner, the sulphate of lime must, being in contact with the silicate of potash or soda, form a silicate of lime; and all these silicates strongly resist the action of sea water. As for sea salt, which is a chloride of sodium, M. Kuhlmann proves that, in the proportion in which it exists in sea water, it will slowly decompose the silicate of potash contained in the cement and leave the silex free. The compositions proposed have therefore the singular property, not only of resisting the action of sea water, but of actually becoming more insoluble the longer they are in contact with it. A cement composed of 30 parts of rich lime, 50 of sand, 15 of uncalcined clay, and 5 of powdered silicate of potash, is recommended by M. Kuhlmann as having all the requisite hydraulic properties, especially for cisterns intended for spring water. In marine constructions care should be taken to add an excess of silicate to those portions of cement which are exposed to the immediate contact of the sea.

SILICATISATION. The process of impregnating bodies with silica. See Stone, Artificial; and Stone, Preserving.

SILICON, or SILICIUM. The base of silica or flint. It was first obtained by Berzelius in 1823. Silicon is obtained by heating the double fluoride of potassium and silicon with sufficient potassium to combine with the whole of the fluorine, and afterwards washing the mass with cold water, until no alkaline reaction is observable, then boiling with water to decompose any of the double fluoride which may not have been acted upon, and finally washing the silicon perfectly with hot water.

Silicon is a dark brown powder, heavier than water, infusible before the blowpipe, non-volatile, increasing in density when considerably heated. Silicon, boron, and carbon exhibit great similarity.

SILK MANUFACTURE. (*Fabrique de soie*, 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. 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 $\frac{1}{2000}$ of an inch in average fine silk, and the pair measures of course fully $\frac{1}{1000}$ 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 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, possesses 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 Keysler.

The silkworm, called by entomologists *Phalæna 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 cearments, 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 completly 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 temperature 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 develope 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, according to the variety of the *bombyx*, and when they display the spinning instinct by crawling up among the twigs of heath, &c., they are not long in beginning to construct their cocoons, by throwing the thread in different directions, so as to form the floss, *filoselle*, 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 an 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 sixth 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; 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. 25 centimes per pound, or 125 francs in the 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; tram is made usually from inferior silk, and is very slightly twisted, in order that it may spread more, and cover better in the weft; 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 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, *poids 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 of France requires, that all the silk tried by the *Condition* must be worked up into fabrics in that country.

Switzerland. There are silk-stuff factories in the canton of Bâle: but the 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 mantains an incontestable superiority.

The silk trade in Switzerland 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.

The production of silk is conducted on the most important scale in the Lombardo-Venetian States; next in order of importance comes the Tyrol: the same business is also carried on in the military frontier, Görz and Gradiska, 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.
In Venice	200,000
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 Gradiska, 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 with Austria 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 Austrian 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 (1851) 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.

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 Punjee*. 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 *Kouthuri mooga*, in Assam. 6. Another *Saturnia*, from the neighbourhood of Comereolly. 7. *Saturnia Assamensis*, with a cocoon of 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 ; 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 molasses, 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 surface 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 - - -	20
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.

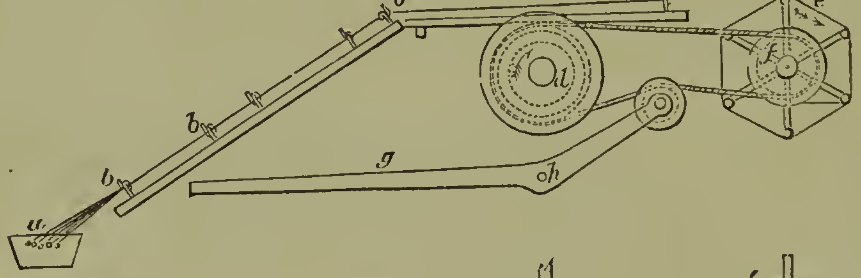
The cocoon of the *Kouthuri mooga* is of the size of a fowl's egg. It is a wild species, and affords filaments much valued for fishing-lines. See SILKWORM GUT.

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 *Palma 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 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 joined together. Upon this injudicious practice I have already animadverted.

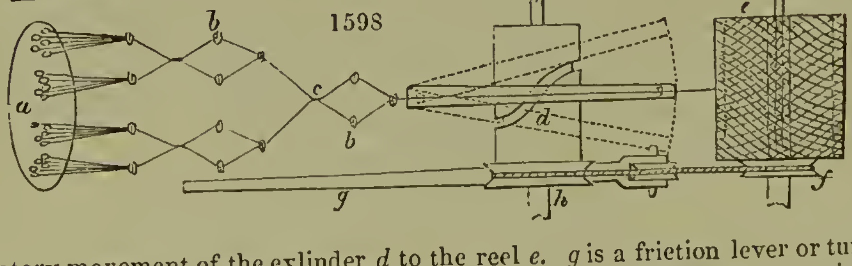
9. The *Saturnia trifenestrata*, has a yellow cocoon of a remarkable silky lustre. It lives on the soom-tree in Assam, but seems not to be much used.

The mechanism of the silk filature, as lately improved in France, is very ingenious. *Figs.* 1597 and 1598 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 five 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

1597



1598



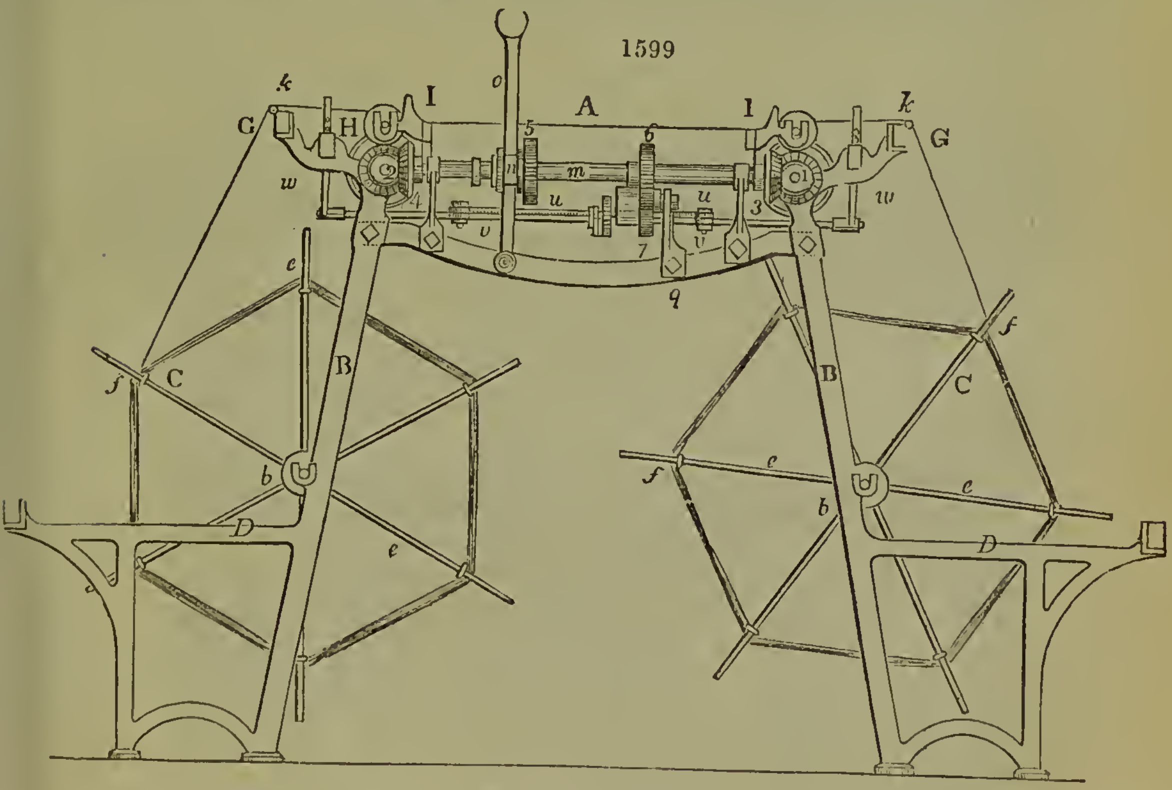
the rotatory movement of the cylinder *d* to the reel *e*. *g* is a friction lever or tumbler, for lightening or slackening the endless cord, in the act of starting or stopping the winding operation. Every apartment of a large filature contains usually a series of such reels as the above, all driven by one prime mover; each of which, however, may, by means of the tumbler 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 7½*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 *rubo* or ten pounds weight of cocoons, which yield from 1-5th to 1-6th of silk, when the quality of good. The whole expenses amount to from 6 to 7 livres upon every ten pounds of cocoons; which is about 2*s.* 8*d.* 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.

It was in Manchester that throwing-mills received the greatest 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 3*s.* 9*d.* 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.

1599



SILK-THROWING MILL.

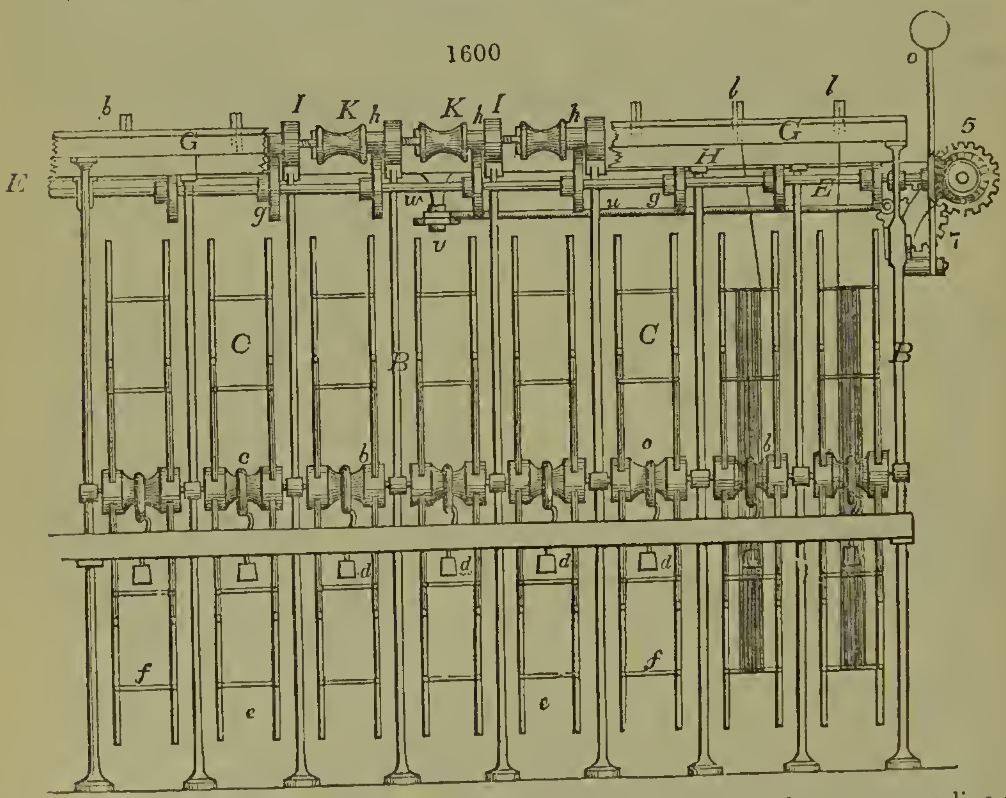
The first process to which the silk is subjected, is winding the skeins, as imported, off upon bobbins. The mechanism which effects this winding off and on, is technieally called the *engine*, or swift. The bobbins to which the silk is transferred, are wooden cylinders, of such thickness as may not injure 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.* 1599 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 a 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 *a*, 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.* 1600 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. 1600 is a front view of the engine. B, B, are the legs, placed at their appropriate distances (scale $1\frac{1}{2}$ inch to the foot); C, C, are the swifts. By comparing *figs.* 1599 and 1600 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;

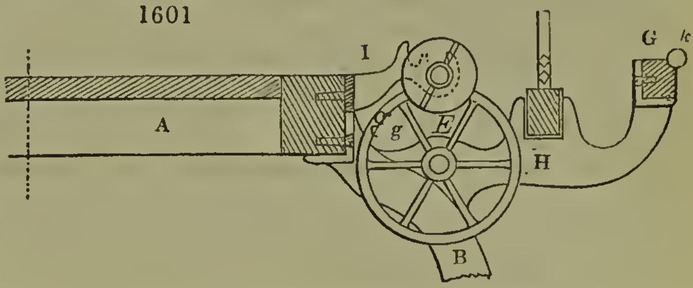
1600



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. Slendor wooden rods are set between each pair of spokes, to stay them, and to keep the cord tight. E 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.* 1601). These serve, by friction, to drive the bobbins which rest upon their peripheries.

To the table A, *fig.* 1599, 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 F, *fig.* 1603) carry upon one end a little wooden pulley *h*, whereby they press and revolve upon the larger driving pulleys *g*, of the shaft E. 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.* 1603), by which the bobbins K, K, are made fast to their respective spindles.

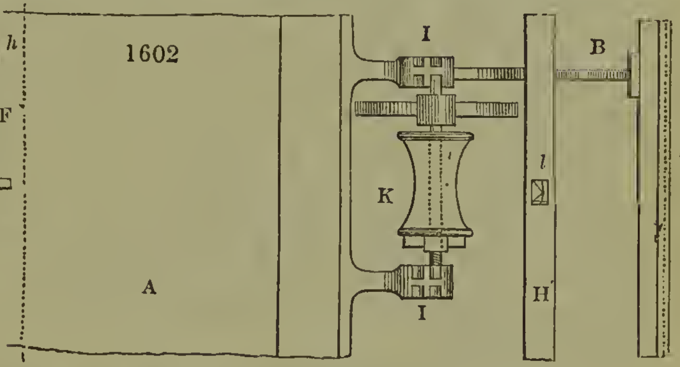
1601



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.

1603

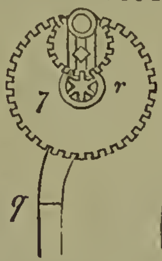
1602



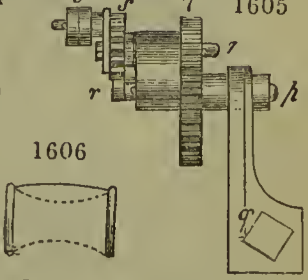
G is a long ruler or bar of wood, which is supported upon every eighth or twelfth leg B, B. (The figure being, for convenience of the page, contracted in length, shows it at every sixth leg.) To the edge of that bar the smooth glass rods *k*, are made fast, over which the threads glide from the swifts, in their way to the bobbins. H is the guide bar, which has a slow traverse or seesaw motion, sliding in slots at the top of the legs B, where they support the bars G. Upon the guide bar H, 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.* 1599, there are attached to the shafts E (*fig.* 1600), 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.* 1599; *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 *n*, through the hand lever or gearing rod *o* (*figs.* 1599 and 1600), 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 H. This wheel is represented, with its appendages, in double size, *figs.* 1604 and 1605, 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

1604



1605



1606

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.* 1599 and 1600), to a cross-piece *v*, which unites the two arms *w*, that are fixed upon the guide bar H, 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.* 1605, having moved the bar H through the whole extent of its traverse. The bobbins, when filled, have the appearance represented in *fig.* 1606; the thread having been laid on them all 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. 1607 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. 1608 is a front view of a considerable portion of the machine.

Fig. 1609 shows part of a cross section, to explain minutely the mode of winding upon a single bobbin.

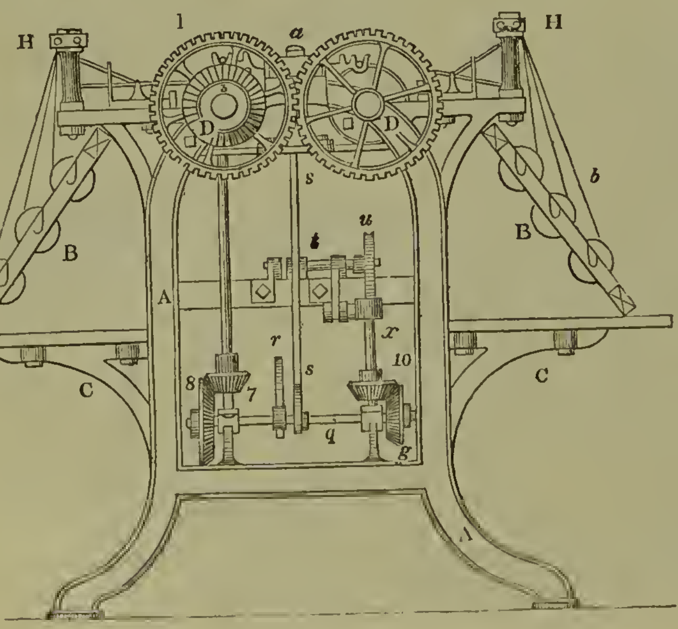
Fig. 1611 is the plan of the parts shown in *fig.* 1609; these two figures being drawn to double the scale of *figs.* 1607 and 1608.

A, A, *figs.* 1607 and 1608 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.* 1609 and 1611.

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.

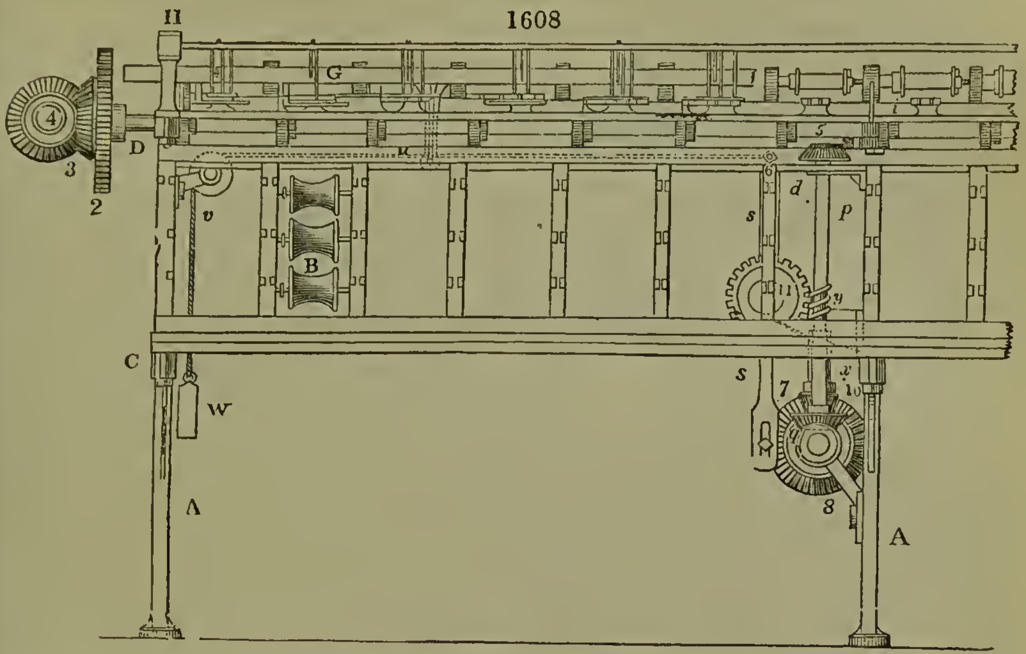
D, D, are two horizontal iron shafts, which pervade the whole machine, and carry a series of light movable pulleys, called *stars*, *c*, *c* (*figs.* 1609, 1611), which serve to drive the bobbins, E, E, whose fixed pulleys rest upon their peripheries, and are therefore turned simply by friction. These 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.* 1611, 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.* 1610.

1607



The spindles with their bobbins revolve in two slot-bearings F. F, *fig.* 1611, screwed to the bar-beam *a*, which is supported by two or three intermediate upright frames, such as A′. The slot-bearings F, 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. G is the guide bar (to which the cleaner slit pieces *g*,

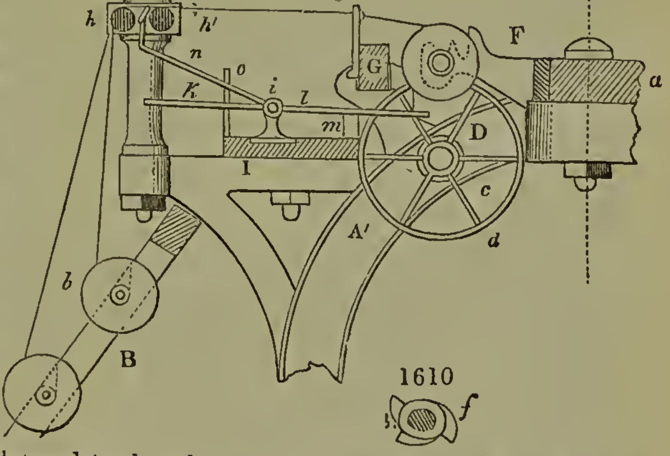
1608



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 E, E.

I, I, 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 creel, 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*′ (1611). The arm *l*, being heavier than the arm *k*, naturally rests upon the ridge bar *m*, of the lever board I. *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 *h*′. These faller wires, or stop fingers, are guided truly in their up-and-down motions 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 E, the wire, *n*, which hung by its eyelet end to that thread, as it passed through between the steel rods in the line of *h*, *h*′, 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.* 1610 and 1611), 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 hangs up the faller wire *n*, and restores the lever *k*, *l*, to its horizontal position. If, meanwhile, she took occasion to remove the winding bobbin out of the sunk slot-bearing,

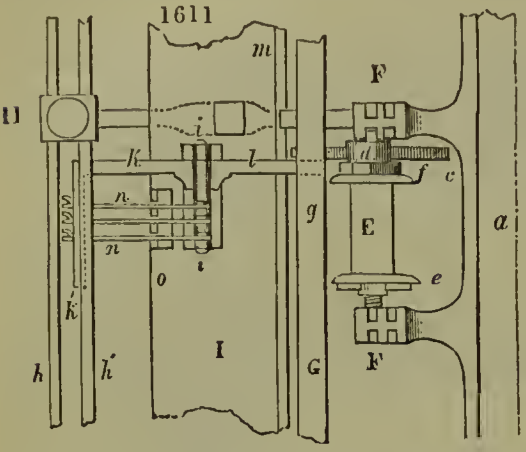
1609



1610

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.

1611

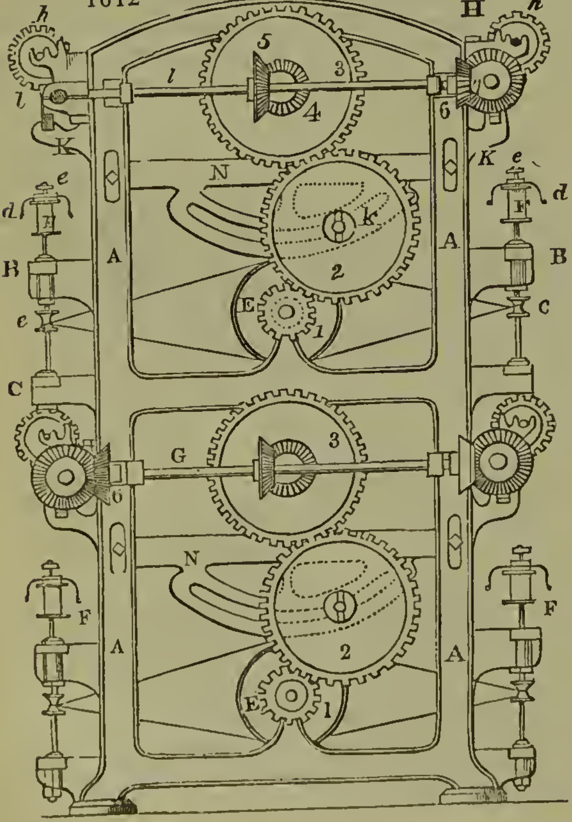


The motions are given to the doubling machine in a very simple way. Upon the end of the frame, represented *fig.* 1607, the shafts D, D, bear two spur wheels 1 and 2, which work into each other. To the wheel 1, is attached the bevel wheel 3, driven by another bevel wheel 4 (*fig.* 1608), fixed to a shaft 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 G, is effected as follows:—Upon one of the shafts D, there is a bevel wheel 5, driving the bevel wheel 6, upon the top of the upright shaft *p* (*fig.* 1608, 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.* 1607. The other end of the lever *s*, is connected by two rods (shown by dotted lines in *fig.* 1608) to a brass piece which joins the arms *u* (*fig.*1608), of the guide bars G. 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.* 1607 and 1608), 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.

1612



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. 1612 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.

Fig. 1613, is a front view, where, as in the former figure, the two working lines are shown.

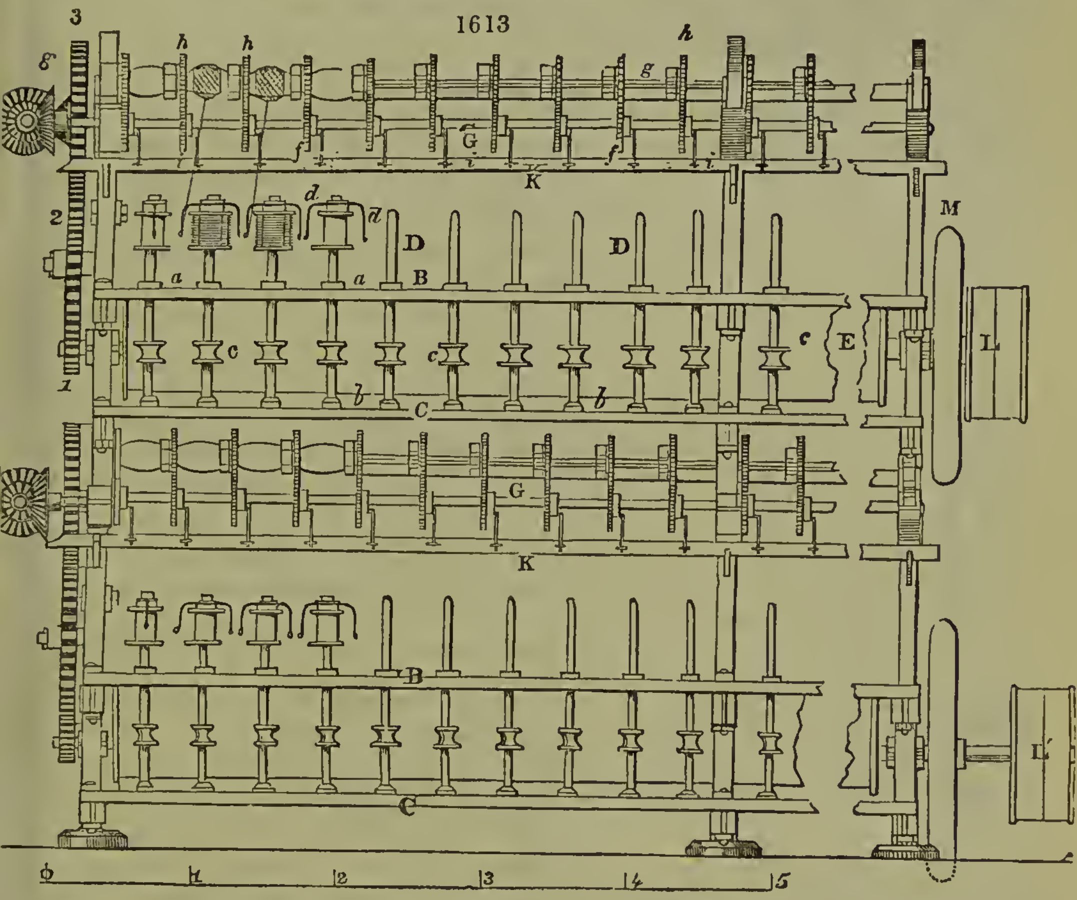
Fig. 1614, is a cross section of a part of the machine, to illustrate the construction and play of the working parts; *figs.* 1620, 1621, are other views of *fig.* 1614.

Fig. 1615, shows a single part of the machine, by which the bobbins are made to revolve.

Figs. 1615, and 1617, show a different mode of giving the traverse to the guide bars, than that represented in *fig.* 1614.

Figs. 1618, and 1619, show the shape of the full bobbins, produced by the action of these two different traverse motions.

1613



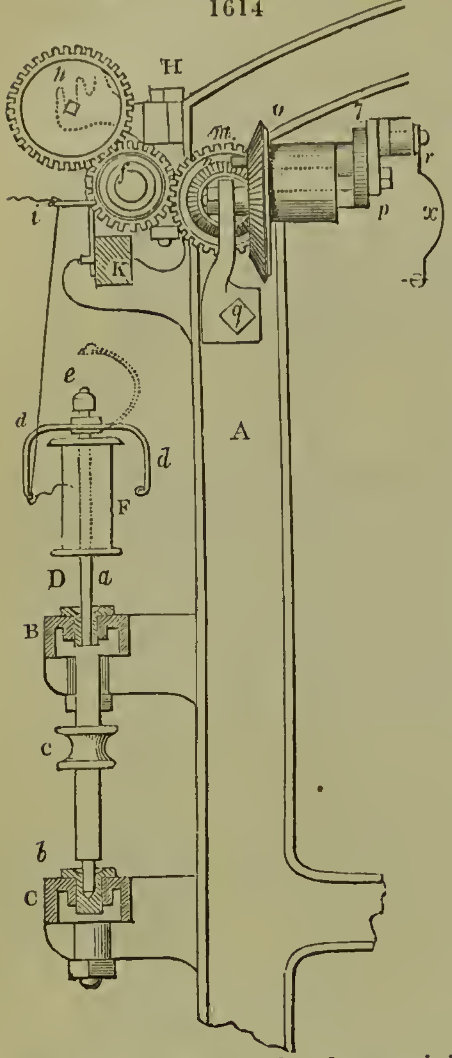
The upper part of the machine being exactly the same as the under part, it will be sufficient to explain the construction and operation of one of them.

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 called by the workmen the spindle box. The standards A, A, are bound with cross bars N, N.

c, *c*, are the wharves or whorls, turned by a band from the horizontal tin cylinder in the lines of E, E, *fig.* 1613, lying in the middle line between the two parallel rows of spindles D, D. F, F are the bobbins containing the untwisted double 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 F, 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.* 1614. *e*, *e*, are pieces of wood pressed upon the tops of the spindles, to prevent the flyers from starting off by the centrifugal force. G are horizontal shafts bearing a number of little spur wheels *f*, *f*. H 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*, *fig.* 1602, 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 G; but when it is laid in the back slot, it is out of gear, and at rest. See F, F, *fig.* 1612.

Upon these little cast-iron shafts or spindles *g*, *fig.* 1616, the bobbins or blocks 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 filled 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. K, K, 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 F. The operation of the machine is therefore simple, and the motions are given to the parts in a manner equally so.

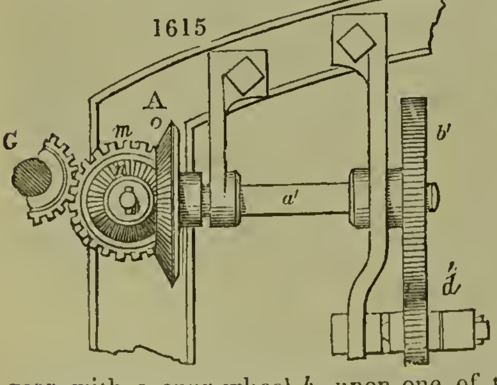
1614



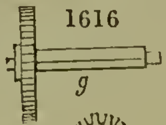
Upon the shaft of the tin cylinder or drum, exterior to the frame, the usual fast and loose pulleys or riggers, L, L′, are mounted, for driving the whole machine. These riggers are often called steam-pulleys by the workmen, from their being connected by bands with the steam-driven shaft of the factory. 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 M, to equalise the motion. Upon the other ends of these shafts, namely, at the end of the spinning-mill, represented in *fig.* 1612, 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 G, G, extending along the upper and under tiers of the machine. At the left-hand side of the top part of *fig.* 1613, the two wheels 6 and 7 are omitted, on purpose to show the bearings of the shaft G, 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.

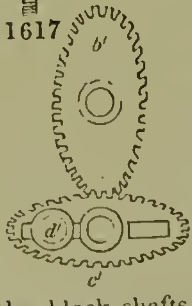
1615



1616



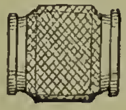
1617



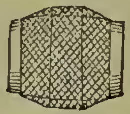
The traverse motion of the guide is given here in a similar way to that of the engine (*fig.* 1599). Near one of the middle or cross-frames of the machine (see *fig.* 1614), the wheel *f*. in gear with a spur wheel *h*, upon one of the block-shafts, drives also a spur wheel *m*, that revolves upon a 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.* 1612, and 1613, and which is here marked with the same letters.

To the crank-knob *r*, *fig.* 1614, a rod *x*, 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.* 1615, and 1617, 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 *a'*, at whose other end the elliptical wheel *b'* is fixed, which drives a second elliptical wheel *c'*, 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 *c'*, 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.

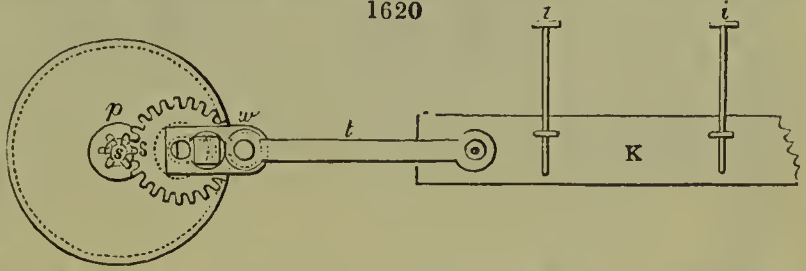
1618



1619

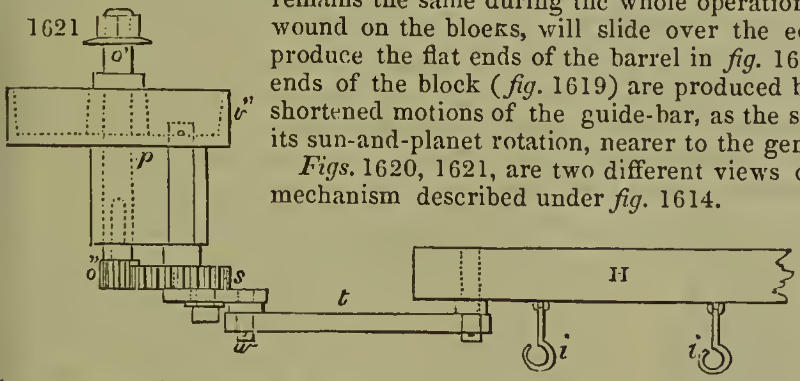


1620



In *fig.* 1620, the elliptical wheels are shown in front, to illustrate their mode of operating upon each other. *Fig.* 1618, is a block filled by the motion of the eccentric, *fig.* 1614; and *fig.* 1619, 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.* 1618. The conical ends of the block (*fig.* 1619) 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.

1621



Figs. 1620, 1621, are two different views of the differential mechanism described under *fig.* 1614.

The bent wire *x*, *fig.* 1614, is called the guide 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.* 1613. 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.* 1618.

The Silk Automatic Reel.

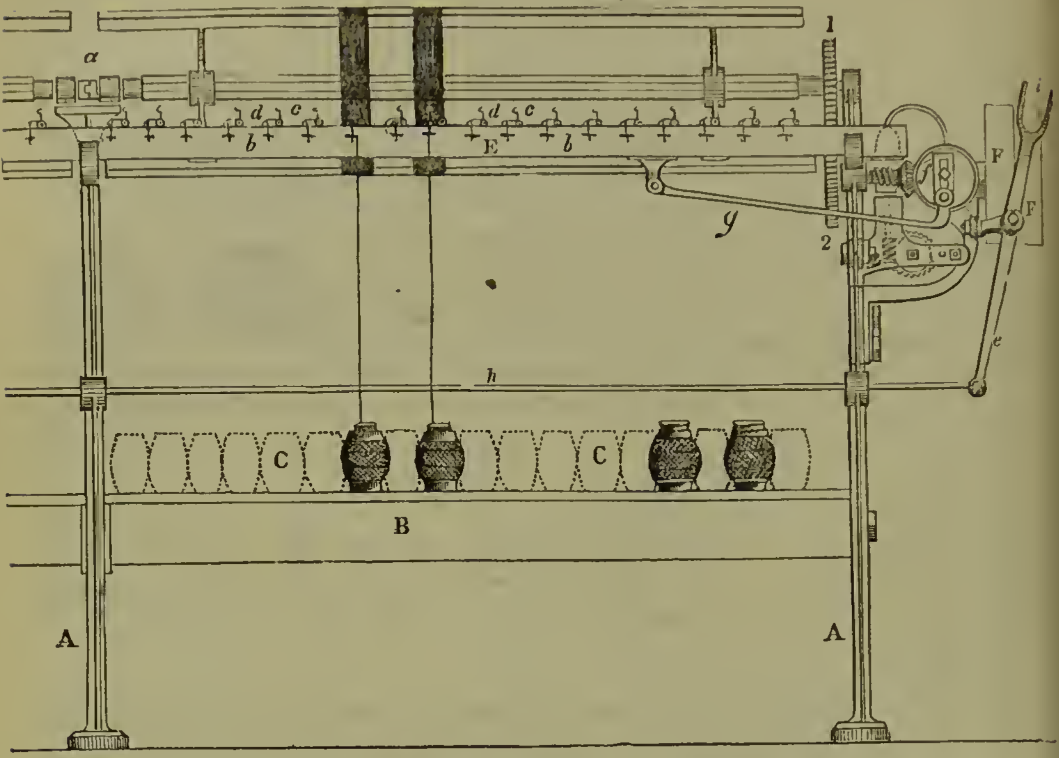
In this machine, the silk is unwound from the blocks of the throwing-mill, and formed into hanks for the market. The blocks being of a large size, would be productive of much friction, if made to revolve upon skewers thrust through them, and would cause frequent breakage of the silk. They are, therefore, set with their axes upright upon a board, and the silk is drawn from their surface, just as the weft 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.* 1618.

Fig. 1622, is a front view of the reel; little more than one half of it being shown.

Fig. 1623, 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 B, 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. E, is the guide bar, which by a traverse motion causes the silk

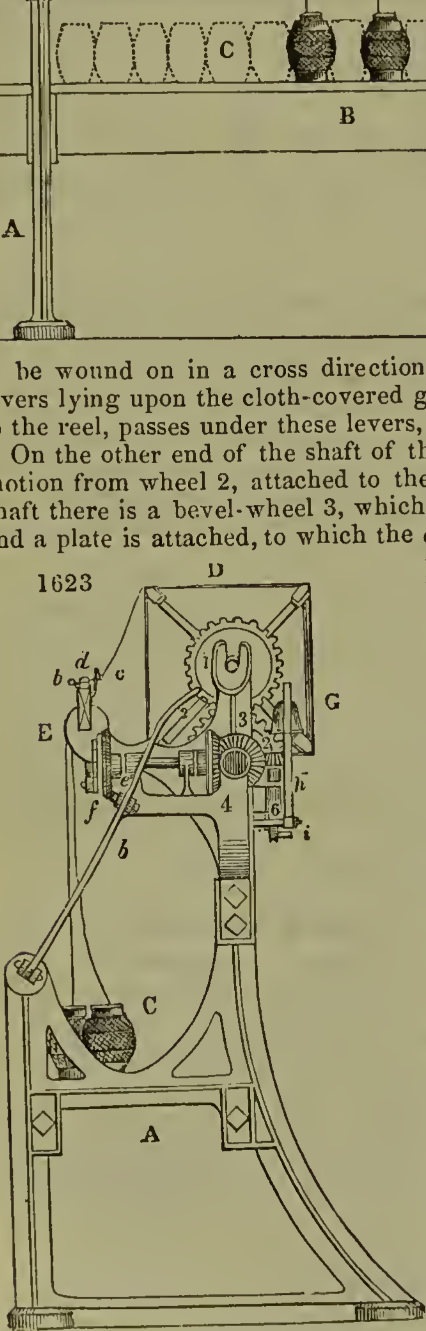
1622



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 E. 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 F. 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 E, connected to that crank or eccentric stud by the jointed rod *g*. Upon the shaft of the steam-pulleys F, there is a worm or endless screw, to the left of *f*, *fig.* 1622, which works in a wheel 5, attached to the short upright shaft *h* (*fig.* 1623). 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, G; 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.

1623



Throwsters submit their silk to scouring and steaming processes. They soak the hanks, 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 hanks, 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 19*s.* 6*d.* a pound; of throwing it into tram, 2*s.* 6*d.*; of dyeing, 2*s.*; of re-winding and re-twisting, after it has been dyed, about 5*s.*; of waste, 2*s.*, or 10 per cent.; the total of which sum is 31*s.*; being the price of one pound of marabout in 1832.

Dr. Ure published in the former editions of this Dictionary a chemical examination of some Indian silks; this inquiry brought out some curious facts, showing that the silks had been impregnated with earthy and other matters in India; but as possibly the conditions leading to this inquiry have entirely passed away, the statement is not preserved.

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.

In 1857, the enormous quantity of 12,077,931 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 above 300 silk factories.

The following represents the condition of our Import and Export trade in silk of five years, commencing with 1854:—

IMPORTS.

	1854.	1855.	1856.	1857.	1858.
	lbs.	lbs.	lbs.	lbs.	lbs.
Silk, Raw - -	7,535,407	6,618,862	7,383,672	12,077,931	6,277,576
— Thrown - -	1,021,832	929,897	853,015	640,936	358,269
— Manufactures of Europe:					
Broad stuffs -	273,830	276,326	270,097	231,895	309,925
Ribbons -	398,719	353,771	463,780	375,890	383,619
— Of India, consisting of bandannas, corahs, choppas, Tussore cloths, romals, and taffeties -	Pieces. 496,459	Pieces. 480,675	Pieces. 601,461	Pieces. 370,225	Pieces. 207,081

Computed Real Value of the above Imports.

	1854.	1855.	1856.	1857.	1858.
	£	£	£	£	£
Silk, Raw - -	5,321,432	4,584,733	7.289,730	13,143,839	5,661,387
— Thrown - -	1,132,925	908,571	1,206,415	1,084,728	449,189
— Manufactures of Europe:					
Broad stuffs -	491,334	509,183	500,577	425,024	553,330
Ribbons -	1,136,140	975,003	1,229,793	963,269	986,531
— Manufactures of India, as above	306,237	313,285	401,645	265,314	132,652

Exports.

Declared Real Value of Silk and British Silk Manufactures Exported.

	1854.	1855.	1856.	1857.	1858.
	£	£	£	£	£
Silk, Thrown - -	185,220	209,936	907,480	769,897	563,002
— Twist or yarn -	280,596	231,815	295,919	316,722	227,399
Silk manufactures: Stuffs and ribbons of silk only - -	635,931	499,810	773,389	803,502	602,578
Other kinds - -	590,633	582,782	985,268	999,708	703,321
Total of silk manufactures - -	1,692,380	1,524,343	2,962,056	2,889,829	2,096,300

Details of Silk Imports in 1858.

				Computed real value. £
Indian,—	Knubs, husks, and waste -	cwts.	16,765	219,115
	Raw - - - - -	lbs.	6,277,576	5,661,387
	Thrown - - - -	„	11,205	11,275
	Trame - - - -	„	15,591	20,895
	Organzine or crape - -	„	310,561	382,156
	Thrown, dyed - - -	„	20,216	33,762
	Millinery - - - -	number	7,307	10,079
	Dresses - - - -	„	576	2,880
	India corahs, &c. - -	pieces	207,081	132,665
	China crape shawls - -	lbs.	23,917	62,328
	China damask - - -	yards	9,926	2,729
	Pongees - - - -	pieces	2,948	3,970
	Pongee handkerchiefs -	„	13,476	12,099
Of Europe,—	Broad stuffs - -	lbs.	277,163	554,157
	Gauze or crape - -	„	8,348	26,220
	Velvet - - -	„	23,765	72,121
	With foundation of cotton	„	650	842
	Sundry articles -	„	4,981	11,084
	Ribbons - - -	„	383,619	986,533
	Fancy silk net - -	„	5,725	15,266
	Tulle - - - -	„	121	323
	Plush - - -	„	1,913	2,940
	Black plush for hats -	„	134,107	93,137
	Parasols and umbrellas	number	2,135	534
	Damask of silk and wool	lbs.	21,024	7,359
	Sundry manufuctures entered at value			189,795

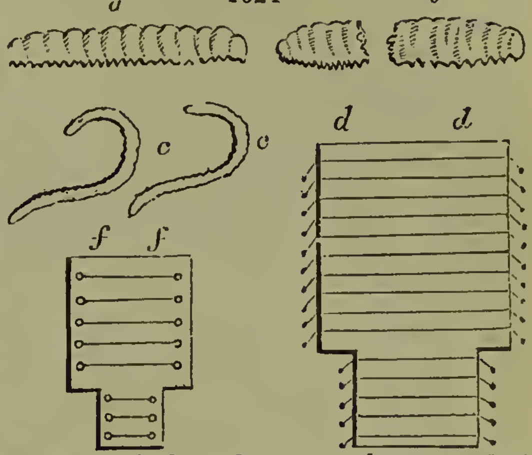
Details of British Silk Manufactures Exported in 1858

			Computed real value. £
Silk only.			
Stuffs and ribbons - - - -	number	490,079	602,578
Lace - - - - - -	yards	620,739	28,606
Stockings - - - - -	doz. pair	4,383	6,315
Hosiery, entered at value - - -	- -	- -	21,264
Fringes, &c. „ - - -	- -	- -	259,449
Sewing silk - - - - -	lbs.	19,674	15,516
Silk and cotton stuffs - - - -	„	249,400	116,436
„ stockings - - -	doz. pair	158	160
„ hosiery at value - -	- -	- -	4,566
„ fringes „ - -	- -	- -	156,882
Silk and worsted stuffs - - - -	lbs.	224,452	90,991
„ stockings - - -	doz. pair	127	180
„ hosiery at value - -	- -	- -	2,956
„ millinery - - -	number	381	634
„ dresses - - -	„	23	115

Indian and European manufactures are not included in these exports.

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.* 1624, *a*, is the silkworm; *b*, the worm torn asunder; *c*, *c*, 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.

1624



SILVER (*Argent*, Fr.; *Silber*, Germ.) was formerly called a *perfect* metal, because heat alone revived its oxide, and because it could pass unchanged through trials by fire, 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, at 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 number 19, 15, and $26\frac{1}{4}$; 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 sulphide. 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 in nature under many forms:—

1. *Native silver* possesses most 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 crystallised 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 those of Kongsberg in Norway, in carbonate and fluate of lime, &c.; at Schlangenberg in Siberia, in a sulphate of barytа; at Allémont, in a ferruginous clay, &c.

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 five 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;

and 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. *Sulphide of silver.*— This is an opaque substance, of a dark-grey 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 crystallised in most silver mines, but especially in those of Freyberg, Joachimsthal in Bohemia, Schemnitz, in Hungary, and Mexico.

5. *Red sulphide of silver; silver glance.*— Its spec. grav. is 5·7. It contains from 84 to 86 of silver.

6. *Sulphide of silver with bismuth.* — Its constituents are, lead 35, bismuth 27, silver 15, sulphur 16, with a little iron and copper. It is rare.

7. *Antimoniated sulphide 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 crystallises 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. It is found in almost all silver mines; but principally in those of Freyberg, Saint Marie aux Mines, and Guadalcanal.

8. *Black sulphide 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 crystallised; but occurs chiefly in irregular forms, sometimes covering the native silver with a thick crust, as in Peru and Mexico. its density is only 4·74. It is found in considerable quantities at North Dolcoath in Cornwall.

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.

10. *Carbonate of silver*, a species little known, has been found hitherto only in the mine of S. Wenceslas near Wolfache.

Large quantities of silver are annually obtained in Europe by the treatment of argentiferous galena, but the New Continent, which produces for the most part ores containing but a small proportion of lead, is estimated to furnish twelve times more silver than the Old.

The following description of the extraction and treatment of silver ores in Mexico is chiefly derived from a paper published by Mr. J. Phillips, in the year 1846:—

The states of Mexico in which silver mines have been worked to the greatest extent are those of Mexico, Guanaxuato, Zacatecas, Guadalajara, San Luis Potosi, Oajaca, Valladolid, and Sonora. The three first, however, have always held, and at present hold, the first rank.

The principal mines nearest to the capital are those of Pachuca, Attotonilco el Chico, and Real del Monte, situated about 60 miles due north; the last named at an elevation of 9,300 feet above the level of the sea.

Farther north, bearing somewhat to the westward, are the mines and city of Guanaxuato, about 240 miles from the capital, 6000 feet above the sea level; and still farther north, about 190 miles frem Guanaxuato, in latitude 23°, are the mines and city of Zacatecas, distant from which about 35 miles are the productive mines of Fresnillo. There are many other mining districts, but those I have mentioned are the only ones producing silver in any great abundance, the others yielding but a comparatively small produce.

In the districts of Real del Monte and Zacatecas the silver veins are very numerous, and cross each other in various places, but generally speaking at the same angle. Thus the principal veins at Real del Monte run in a direction nearly east and west, while the cross veins run north and south: the dip, or inclination of the former, being to the south, and of the latter to the west. The rule however, does not hold good in the neighbouring mines of Pachuca, where the veins cross each other at an acute angle.

At Zacatecas, Fresnillo, and Plateros the surface of the ground may be seen intersected by innumerable veins, most of them producing silver in more or less abundance. There is, however, both in Zacatecas and Real del Monte, one leading vein larger and more productive than the others. That most famous in Zacatecas is called the Veta Grande, and that in Real del Monte is known by the name of the Biscaina.

In the district of Guanaxuato the case is different, for there we do not find a large number of veins, as in the others, but the riches are concentrated in one enormous vein which traverses the country for upwards of eight miles.

This is the largest known vein in Mexico, attaining in some places, a width of 50 varas, or 150 feet. All the principal mines of Guanaxuato are upon this vein, producing eight or nine millions of dollars annually.

The silver veins of Mexico are found in primitive and transition rocks. Thus the Veta Madre of Guanaxuato passes through clay-slate, containing beds of syenite and porphyry. It is thrown out of its course, or dislocated by the conglomerate hill of Sirena, but is again met with on the other side where the mine of El Cedro was opened by the Anglo-Mexican Company.

The veins of Zacatecas occur in greenstone and clay-slate, and are most productive in the former of those rocks. Those of Fresnillo and Plateros are met with in a similar formation.

At Real del Monte, Pachuca, and Attotonilco el Chico, all the veins are found passing through porphyry of various tints, but chiefly grey and green porphyry.

The formerly rich mine of El Doctor occurred in Alpine limestone, of which that district is chiefly composed.

The mines of Bolaños occur in amygdaloid and porphyry, in connection with a channel of steatite or soapstone. There is only one principal vein, as in Guanaxuato.

There are several varieties of silver ores, or ores containing silver, obtained from the Mexican mines; the principal of which are the sulphide of silver, chloride of silver, ruby silver, native silver, argentiferous pyrites and argentiferous galena.

Ruby and native silver, argentiferous pyrites, and galena have been found in Guanaxuato. Zacatecas is rich in the three first of these classes; the mine of Gallega, in this district, yielded a very large quantity of magnificent specimens of ruby silver. The greater proportion of the ore from the mines of San Clemente and San Nicholas is argentiferous pyrites, with native silver; the latter mine especially has recently produced some extraordinary specimens of native silver, weighing 25lbs. each. Zimapan produces a considerable quantity of argentiferous galena. This variety, in fact, occurs, though sparingly, in most of the other mining districts. Chloride of silver has been found at Fresnillo, and is still found at Catorce, where the ores also contain bromide of silver.

The several varieties, however, bear but a small proportion to the great mass of the silver ores of Mexico, which consists of a grey sulphide, generally more or less combined with other metals, and disseminated in minute particles throughout the matrix, in most instances composed of quartz, or in intimate connection with it. By far the largest portion then of the precious metal is obtained in every mining district of Mexico from the sulphide.

In some mines which have been explored to a great depth, and which are much troubled with water, as in Real del Monte, Bolaños, and Fresnillo, steam-engines have been introduced, and so long as an adequate power is applied, maintain the drainage of the mines without difficulty.

We now proceed to state some of the peculiar features observable in the working of the mines of Mexico, confining our attention to the mines of Guanaxuato, Zacatecas (including Fresnillo), and Real del Monte. The mines of Guanaxuato are situated upon one vein of great length and width. It should be understood that this vein, like all mineral veins, is not productive of silver ore throughout its whole extent, but the ore occurs in branches and bunches, leaving intermediate spaces of dead or unproductive ground; and as an ordinary mine level seldom exceeds 6 feet in width, it is clear that a level like this would not explore a vein of such dimensions as that of Guanaxuato, while the expense of cross cutting, as miners term it, would require more capital than the owners of the mine are willing to risk, or able, in many instances, to spare. Hence, there sprung up in Guanaxuato a system of working well adapted to the circumstances noticed, and being based upon the principle that the hope of reward acts as a stimulus to exertion, has been attended with the best effects, and led to the discovery of some of the richest deposits of ore.

This system is called that of the "buscones" or seekers, who are the working miners. These men, at their own risk, work in the mines under certain restrictions, and following up such indications as may appear to them favourable, oftentimes meet with a valuable course of ore, but frequently work for months, earning scarcely enough for bare subsistence. While thus employed the buscon receives half the produce of the ore he breaks; and it may be readily conceived that if he should fall in with a rich deposit, his gains would be very large: thus, instances have been known where a man has obtained, in this way, 1000 or 1500 dollars in a month.

The owners of the mine, however, have the option of taking away such a discovery out of the hands of the miner, after a short notice, and working it on their own account, or, as it is termed, hacienda account, when they pay the miners a dollar per day each, without any share of the ore. To do this, however, the mine must be rich, and as it is, a very large portion of the ore in Guanaxuato is raised by the buscones, who divide the produce equally with the owners.

The ore being broken and separated as much as possible from the rocky parts underground, is tied up in the "botas" of bullocks' hides, which are drawn to the surface by the malacates, in the same manner as the water. In some of the Guanaxuato mines, labourers are employed to take the ore to the surface, and these will carry on their backs from 2 to 3 cwt., and perform several journeys in a day from the bottom of a mine 400 or 500 yards in depth. At the mine of Mellado there is a very excellent double tramroad, on an inclined plane of timber, upon which the ore is drawn up in waggons to a height of 200 varas from the bottom of the mine, where the diagonal joins the perpendicular shaft at about the same depth from surface: each carriage will contain 160 arrobas of 25 lbs. The power applied is that of a malacate working underground; and here at 200 yards from the surface, and shut out from the light of day, one is surprised to behold a storehouse and stabling, with all the necessary appurtenances for thirty-six horses, employed in moving the machine above mentioned, nine horses working at a time.

Having brought the ore to the surface, it is conveyed to the mine yard, and placed in separate heaps, under the eye of the buscon or miner, who prepares it for sale. At a stated time the auctioneer appears, accompanied by a clerk; he walks round to the heaps of ore in succession, and sells them in the following manner:—

Standing before the heap of ore to which he invites attention, those who come to purchase come forward and whisper into his ear the price they severally offer. When all have done, he declares aloud the name of the highest bidder, and the price, which are entered in a book by the clerk; and the same process is followed throughout until all the ore is sold.

In Zacatecas the mines have not been found productive at so great a depth as those of Guanaxuato; and the veins being smaller and the deposits of ore more within reach of an ordinary level, there are not the same reasons for holding out similar inducements to the working miner to seek for ore at his own risk. Hence, most of the works of trial in the Zacatecas mines are carried on by the proprietors, and the miner is paid according to the quantity of ore he raises, this varying from 9 reals to 2½ dollars, or 4*s.* 6*d.* to 10*s.* per carga of 300 lbs., as circumstances may render necessary. Even in this district, however, it has lately been deemed expedient to introduce the system of Guanaxuato into some of the mines. The instances known to me are those of the mines of San Clemente and San Nicolas*, where the effect has been to increase the produce; but there is a peculiarity about these particular veins which renders such a system beneficial; they are very changeable, often separated into narrow branches, or showing mere threads of ore, and frequently again widening and yielding very rich bunches; besides which they are so cut up by cross courses that more than ordinary encouragement is needful to carry on works of research.

The practice in the Real del Monte differs from both the others, but assimilates a little towards the Guanaxuato system, inasmuch as the miner has a share of the ore called *partido*. This partido system has prevailed from a very early period, and has led to many broils and disturbances with the miners.

The method of extracting the silver from the ore, at the establishments maintained for that purpose, called haciendas de beneficio, or haciendas de Plata, of which there are many of great extent in the country, is thus carried forward. The haciendas Nueva in Fresnillo, of Sauceda in Zacatecas, of Barrera in Guanaxuata, and of Regla at Real del Monte, are the principal establishments of this kind at present in use. That in Fresnillo is the largest used for amalgamation only, the outer walls being 492 varas in length, by 412 varas in width. It was erected at a cost of 300,000 dollars, and is very complete in all its arrangements.

The Hacienda de Regla combines very extensive smelting works with those for amalgamation.

The ore being placed in heaps in the yard is broken by hammers into pieces of

* The *partido* or miner's share is at present one third of the ore.

moderate size, and carefully picked; the richer parts being set aside for smelting, and the poorer for amalgamation.

In the smelting process, the ore after being crushed, is mixed with slag or remains from former smeltings, litharge or oxide of lead, and a little iron ore and lime. These are put into the furnace with charcoal, and the silver is brought down with the lead, the two metals being afterwards separated in refining furnaces. The German high furnace is usually employed, although the Castilian furnace described in the article on lead-smelting, would probably be found preferable.

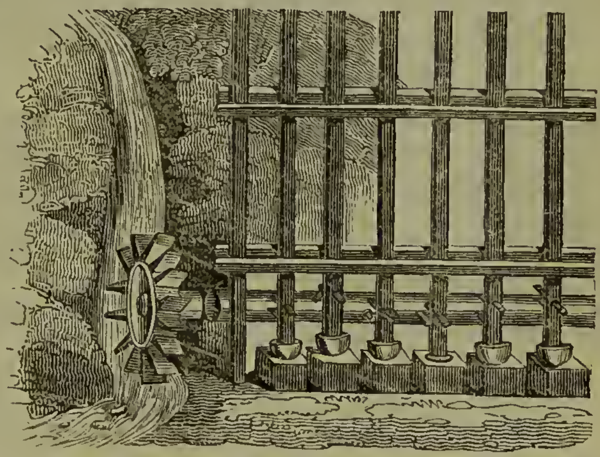
It is estimated that about an eighth part of the silver produced in Mexico is obtained by smelting; but as only the richest ores are subjected to this process, on account of the expense, which is from £15 to £20 per ton, except in a district like Zimapan, where lead ore is abundant, the proportion which the quantity of ore smelted bears when compared with that reduced by amalgamation must be very small indeed.

The process of amalgamation, to which attention is now more particularly directed, depends upon the great affinity of quicksilver for silver. In order, however, to make this known property available, certain operations are requisite, to reduce the silver contained in the ore to such a state that the quicksilver will readily combine with it.

After the breaking and dressing by hand the ore is crushed, either by crushing rollers or more generally by stamps, called in Mexico, *molinos*. The stamps are similar in principle to those used in the tin mines of Cornwall, but not so powerful, and are worked either by water-power or by mules. As the ore is crushed, it falls through small holes of about the size of peas, perforated in strong hides stretched in a slope on either side of the machine placed over a pit which receives the fine ore, from whence it is conveyed to the *arrastres* or grinding mills.

These stamping-mills are sometimes driven by a small breast water-wheel, of five feet diameter, and one foot broad. *Fig.* 1625 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.

1625



The arrastre or tahona, as it is called in the northern districts, is exceedingly simple, but for so rude a machine is very effective. Baron Humboldt, in alluding to it, says that he never saw ore so finely pulverised as he saw it in Mexico. In Guanaxuato, where there is much gold in the ore, this is particularly observable.

The arrastre consists in the first place of a strong wooden post moving on a spindle in a beam above it, and resting on an iron pivot beneath, turning in an iron socket on the top of a small post of hard wood which rises about a foot above the ground in the centre of the arrastre. See Ore Dressing.

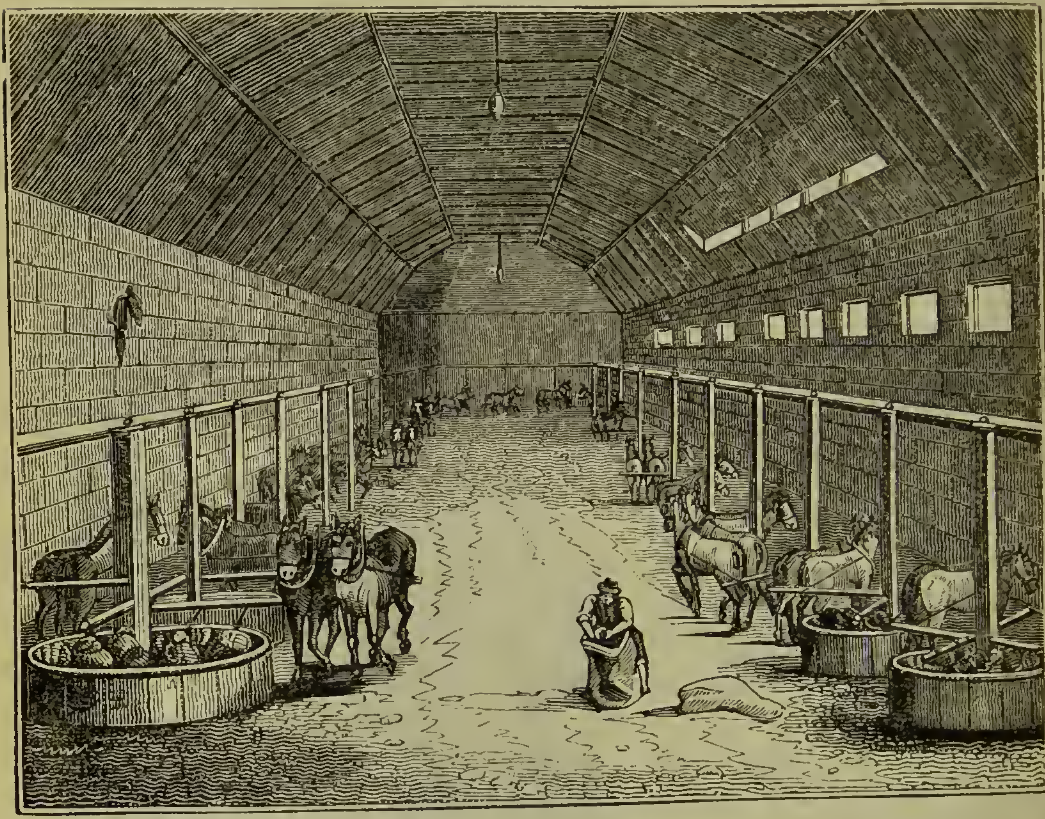
These arrastres are usually arranged in rows in a large gallery or shed, as will be seen by reference to *fig.* 1626, which represents the gallery of the Hacienda of Salgado.

A machine has been introduced at Real del Monte which has superseded the old Mexican arrastres. This machine is similar in principle to some of the grinding mills of this country, and to the trapiche of Peru. It consists of two large circular edge stones faced with iron, and moving over iron bottoms, the ore being crushed and ground with water between the two metal surfaces. The machine is turned by twelve mules in the twenty-four hours, four mules working at a time, and the quantity ground to a fine slime is sixty quintals, or about ten times the quantity ground by a common arrastre; and there is reason to believe that the quantity might be doubled by the use of water or steam-power, as the number of revolutions would be increased.

The ore being brought into a finely-divided state, is allowed to run out of the arrastre into shallow tanks or reservoirs, where it remains exposed to the sun until a larger portion of the water has evaporated, when it has the appearance of thick mud; and in this state the process is proceeded with.

The "lama," as it is called, or slime, is now laid out on the *patio*, or amalgamation floor (which is in some places boarded, and in others paved with flat stones), in large masses called *tortas*, forty to fifty feet in diameter, and about a foot thick, consisting frequently of sixty to seventy tons of ore; and so extensive are the floors that a large number of these tortas are seen in progress at the same time. Thus, at the Hacienda de Regla, the patio, which is boarded and carefully caulked, to render it water-tight, is capable of containing ten of these tortas, of about sixty tons each and fifty feet in diameter. The Hacienda de Barrera, in Guanaxuato, will hold eighteen tortas of seventy to seventy-five tons each. The Hacienda Sauceda at Zacatecas will contain twenty-four tortas of sixty tons each; and the patio floor of the Hacienda Nueva, at Fresnillo, is still larger, being 180 varas in length by as many in width, and capable of containing sixty-four tortas of seventy tons each!

1626



Having laid out the masses of ore in the patio, the operations necessary to produce the chemical changes commence. The first ingredient introduced is salt, which is put into the torta in the proportion of fifty lbs. to every ton of ore (but varying in different districts), and a number of mules are made to tread it, so that it may become dissolved in the water, and intimately blended with the mass. On the following day another ingredient is introduced, called in Mexico *magistral*. It is common copper pyrites or sulphide of copper and iron pulverised and calcined, which converts it into a sulphate. About twenty-five lbs. of this magistral are added for every ton of ore in the *torta*, and the mules are again put in and tread the mass for several hours. Chemical action now commences: the salt, magistral and metallic sulphurets are decomposed, and new combinations are in progress. Quicksilver is then introduced, being spread over the *torta* in very small particles, which is effected by passing it through a coarse cloth. The quantity required is six times the estimated weight of the silver contained in the ore, or three lbs. for every marc of eight oz.

The quicksilver being spread over the surface the mules are once more put in, and tread the whole until it is well mixed. This treading is called the *repaso*, and is repeated every other day, or less often, according to the judgment of the *azoguero* or superintendent, until the operation is completed.

But it is in the progress of the operation that the skill of the *azoguero* is most required, because he must attend to certain signs or appearances which present themselves to him, and upon which depend the success of his work, whether as it regards the produce of silver or the economy of quicksilver and other materials and time. For this purpose he has a small quantity of the *torta* put on one side, upon which he operates before adding materials to the *torta* itself; this is called a *guia*, or guide. In order to ascertain how the chemical action in the *torta* proceeds, he collects a small quantity of the slime and washes it in a small bowl, and by the signs presented by the quicksilver and amalgam he, from his practical knowledge of the subject, is able to judge as to the state of the *torta;* whether it requires more magistral or quicksilver; or whether it has had too much magistral, in which case it is hot, and a little lime must be put in to decompose the excess of bichloride of copper. This simple plan is termed the *tentadura*, by which in fact the *azoguero* is guided throughout the amalgamation process.

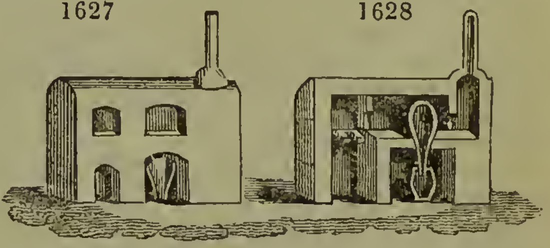
When at length he finds that quicksilver is no longer absorbed, the operation is considered complete, and the *torta rendida*, or ready to be washed, and sometimes lime is added to stop further action. A large quantity of quicksilver is then thrown in, and is called *el bano*, or bath, which combining with the amalgam, causes it to separate the more readily from the slime in the washing. The time required to complete the process varies from ten to thirty days; but in some places is often considerably more, according to climate and the nature of the ore.

The amalgam has now to be separated from the mass, which is done at Real del Monte by washing it in a large square vat, in which several men keep constantly stirring it with their feet, while at the same time a stream of water is made to pass through. By this means the lighter particles of the mud flow out into canals furnished with basins, called *apuros*, to catch all stray amalgam and quicksilver, and the great body of the amalgam remains at the bottom of the vat.

In Guanaxuato, the process of washing is more perfect. They have three circular vats called *tinas*, in which the ore is stirred by means of long wooden teeth fixed in cross bars attached to a vertical shaft, the whole turned by a simple machine, worked by mules. The slime has to pass through the third vat before being carried entirely away, so that a very small portion indeed of the amalgam escapes. The process of washing is somewhat similar in Zacatecas, but there they use but one *tina* or vat."

The amalgam is carried in bowls into the *asogueria*, where it is subjected to straining through the strong canvas bottom of a leathern 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.* 1627), to the number of 11, upon a solid copper stand, called *baso*, having a round hole in its centre. Over this row of wedges several others are built; and the whole pile is called *pina*. 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 *pina*, to give free egress to the mercurial vapours.

1627 1628



Mr. J. C. Bowring, who has had many years' experience in the reduction of the ores of silver, both in Peru and Mexico, and has devoted much time and attention to an examination of the subject, disputes the theory of the amalgamation process hitherto received.

In reference to this subject, he remarks:—

"The theory of the chemical decompositions which take place in the Mexican amalgamation process has hitherto been supposed to be, that the bichloride of copper which is formed by the contact of magistral and common salt, abandons its chlorine to the silver, the sulphur of which combines with the copper, and the chloride of silver is decomposed by the mercury with which the precious metal becomes amalgamated. The following considerations, however, will disprove this theory:—

"1. Ores containing silver combined only with chlorine, are considered by Mexican miners as those most difficult of reduction, and the loss of mercury caused by them is at least treble that experienced in those which contain only sulphurets, and the process is much more tedious. To practical men also the appearance of the amalgams proceeding from these different combinations of silver, when assays are taken out of the tortas, are a convincing proof that the theories of their reduction cannot possibly be similar, for in the chloride the quicksilver is instantly attacked, and its globules are very difficult to be united by friction, on account of their being covered with a thin coating of protochloride (calomel), whereas, when operating upon sulphurets, the mercury is always bright (except at the very beginning of the process), and does not separate into globules, unless, indeed, too large a quantity of magistral has been used, when the appearance becomes similar, though in a slighter degree, to that when chloride of silver has been reduced.

"Various plans have been imagined to diminish or even entirely to do away with the loss of mercury, on the hypothesis that chloride of silver is formed, and in ores containing this native combination, as those of the district of Catorce, great advantages are derived by boiling them in copper vessels, as by the contact of this metal the chloride is decomposed before the mercury is added, thus rendering the loss of this scarcely appreciable. Upon this class of ores many of the plans proposed by European chemists have been successfully tried, but all have invariably failed when sulphides of silver have been attempted to be reduced by them.

"2. Although the experiments of M. Boussingault prove that a *strong* solution of the bichloride of copper mixed with one of salt, placed in contact with sulphide of silver, form, after some lapse of time, chloride of silver and sulphide of copper, still in practice this cannot be the case, for in many instances a solution of less than *one ounce* of sulphate of copper is required in *seventy pounds* of water, and even in the ores most difficult of reduction the quantity is rarely more than *eight ounces.* Numberless experiments have been made in Mexico to bring this principle into practice, but after leaving the ore for two months exposed to the action of a solution of bichloride of copper in one of salt, a trace even of chloride of silver is rarely to be found; and then, on adding the mercury, the process lasts as long as in ordinary cases, when it is put in before the sulphate of copper. From the constant failure of these trials it is evident that the theory on which they are founded must be fallacious.

"The presence of mercury being thus necessary, not merely as the means of collecting the particles of silver disseminated through the ore, but also as a chemical agent, the action of bichloride of copper upon it must be considered. By this action, which takes place instantaneously, a protochloride of both metals is formed, and that of the copper by absorbing oxygen from the atmosphere becomes converted into an oxychloride, which by giving up its oxygen to the sulphur combined with the silver, leaves this in a metallic state, and free to amalgamate with the mercury. This is proved by boiling native sulphuret of silver with oxychloride of copper in a solution of common salt, when metallic silver will be obtained; or as a more practical experiment, by mixing some rich ore with these materials and mercury at the ordinary temperature; in about an hour the whole of the silver will have become amalgamated, when on separating all the soluble salts by filtration, on the addition of chloride of barium, sulphate of barytes will be precipitated, equivalent in quantity to that of the sulphur which has been acidified; it will thus be made evident that the sulphuric acid can only have been formed by the decomposition of the sulphuret of silver, and could not have existed if this metal had become combined with chlorine according to the old theory of the process.

"The action of oxychloride of copper in the reduction of silver ores seems to be continuous, and its theory thus offers some analogy to that of the manufacture of sulphuric acid; by giving up its oxygen to the sulphur previously combined with the silver the oxychloride of copper is converted into a protochloride, and this into a bichloride by the action of the chlorine which is evolved by the decomposition of the salt when attacked by the sulphuric acid that has been formed. This bichloride is again decomposed by the mercury, and first a proto and then an oxychloride of copper is formed; the sulphur of the silver becomes acidified, and the action is continued in the same manner until the whole of the metal is amalgamated.

"The imperfections in the Mexican amalgamation process arise chiefly from the small quantity of oxychloride of copper that can be employed; for by using too large a proportion of the sulphate the mercury becomes sensibly attacked, and when its surface is not perfectly clean it will not take up the particles of silver. The use of salt in the tortas has always been supposed to be to dissolve the chloride of silver formed during the process, but its real object is to assist, first, in the formation of the oxychloride of copper, and to dissolve it afterwards, thus rendering it more fit to act upon the sulphide of silver."

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.

It will be observed that quicksilver performs a very important part in the process of amalgamation, the silver being through its agency collected from the ore: but this is only done at an enormous loss of its own bulk, occasioned in part mechanically from its minute subdivision through such an immense mass of matter, but principally from the chemical action upon it during the reducing process. The consumption of quicksilver varies in different districts, according to the nature of the ores, the climate, and the practical skill attained by the operator.

In some places and on some ore the loss of quicksilver is as low as ten ounces for every marc of silver produced, while in others it exceeds 20 ounces; the average loss may, however, be taken to be a pound of quicksilver for every half pound of silver extracted.

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:

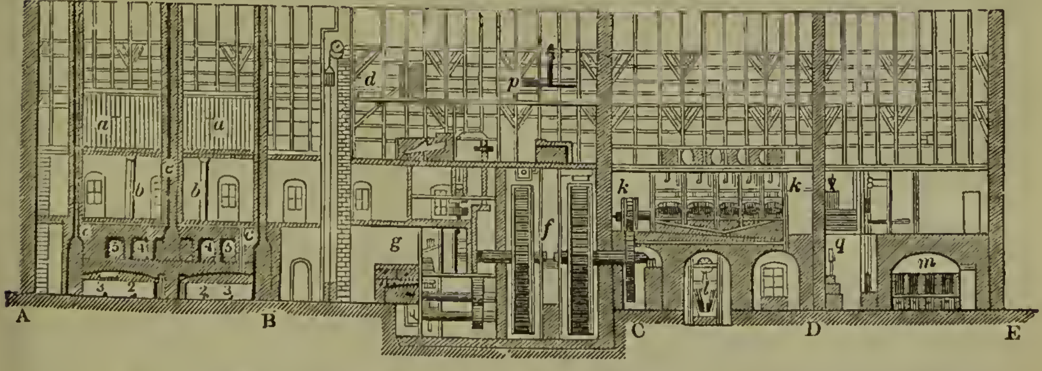
The addition of the *magistral* (powder of the roasted copper pyrites), is not for the purpose of disengaging hydrochloric acid from the sea salt (*saltierra*), as has been supposed, since nothing of the kind actually takes place; but, by reciprocal or compound affinity, it serves to form chloride of 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 partly carry off both, 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, 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 the silver, which is separated by cupellation, &c., 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 convenience and regularity; and we will extend this subject with a sketch of their general distribution.

Fig. 1629 presents a vertical section of this great *usine* or *hüttenwerk,* subdivided

1629



into 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, D, E, is placed the distilling apparatus, 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 economised 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, B; *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 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 any volatile matters which may escape by the opening 7. *c* is the main chimney.

2. In the division B, 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 bolted through sieves. *p*, *f*, is the wheel machinery of the mill.

3. The compartment C, D, is the amalgamation house, properly speaking, where the casks are seen in their places. The washing of the residuums is effected in the shop *l*, below. *k*, *k*, is the compartment of revolving casks.

3. In the division D, E, 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 B, 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 (*anquickverfahren*); because the lead would render the amalgam very impure, and the copper would be wasted. They are sorted for the amalgamation, in such away that the mixture of the poorer and richer ores may contain 7½, or, at most, 8 loths (of ½ oz. each) of silver per 100 lbs. The most usual constituents of the ores are, sulphur, silver, antimonial silver (speissglanzsilber), bismuth, sulphides 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 sea salt in the roasting to disengage as much chlorine as to convert all the silver present into 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 4½ ells broad (13 yards and 3½); and upon that layer the requisite quantity of salt is let down from the floor above, through a wooden funnel; 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 3½ to 4½ cwts. The annual consumption of salt at Halsbrücke is 6000 cwts., and is supplied by the Prussian salt-works.

Roasting of the Amalgamation Ores.—The furnaces appropriated to the roasting of the ore-posts are of a reverberatory class, provided with soot chambers. They are built alongside 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 turnings 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-grey 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 prevent 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, and 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 hydrochloric acid gas. This roasting stage commonly lasts three quarters of an hour, 13 or 14 furnaces are worked at the same time at Halsbrücke; and each turns out in a week upon an average 5 tons. Out of the *nicht* chambers of 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 $115\frac{1}{2}$ cubic feet, and of the latter, $294\frac{1}{4}$, 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 bolter of the mill, must be as impalpable as the finest flour.

The Amalgamation. — This (the *verquicken*) 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.* 1629. The casks are 2 feet 10 inches long, 2 feet 8 inches wide, inside measure, and are provided with iron ends. The staves are $3\frac{1}{2}$ inches thick, and are bound together with iron hoops. They have a double bung-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 bolted ore-flour (*erzmehl*) are introduced after 3 cwts. of water have been poured in. To this mixture, from $\frac{3}{4}$ to $\frac{7}{8}$ of a cwt. of pieces of iron, $1\frac{1}{2}$ inch square, and $\frac{3}{8}$ thick are added. When these pieces get dissolved, they are replaced by others. The casks being two thirds full, are set to revolve for $1\frac{1}{2}$ 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 per 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, 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 chloride 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, in 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.

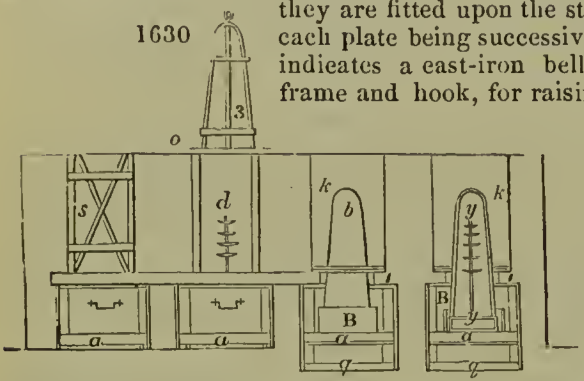
As soon as the revivification is complete, the casks must be filled with water, set to revolve slowly (about 6 or 8 times in the minute), by which in the course of an hour, or an hour and a half at most, a great part of the amalgam will have collected at the bottom; and in consequence of the dilution, 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 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-tun*, while the pieces of iron are kept back. The residuary ore is found to be deprived of its silver to within $\frac{5}{32}$ or $\frac{7}{40}$ 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; $1\frac{1}{2}$ hour for diluting; 1 hour for emptying. In 14 days, 3200 cwts. of ore are amalgamated. For working 100 cwts. of ore, $14\frac{1}{2}$ lbs. of iron are required; and for every pound of silver obtained, 3 ounces 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 desilvering was more complete, the loss of 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 $3\frac{1}{2}$ 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. 1630 represents the apparatus for distilling the amalgam in the Halsbrücke works; marked *m* in *fig.* 1629. *a* is the wooden drawer, sliding in grooves upon the basis *q*; B 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 B; under *d* are five dishes or plates, of wrought iron, with a hole in the centre of each, by which 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.

1630



The box, *a*, and the basin, B, 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 1, 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 B. 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 fused and refined by cupellation.

From 3 cwts. of amalgam, distilled under the bell, from 95 to 100 marcs (½ lbs.) of *teller* silver (dish silver) are procured, containing from 10 to 13½ 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 *löthig* (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 2 per cent.; the loss in silver is inconsiderable.

The dust from the furnace (*tiegelöfen*) 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.

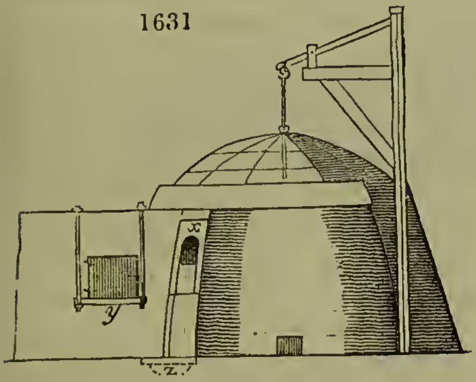
The earthy residuum of the amalgamation casks being submitted to a second amalgamation, affords out of 100 cwts. about 2 lbs. of coarse silver. This is first fused along with three or four per cent. of a mixture of potash and calcined quicksalz (impure sulphate of soda), and then refined. The supernatant 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 fluate of soda. The earthy deposit contains from ¼ to $\frac{9}{32}$ of a *loth* of silver per cwt., but no economical method of extracting this small quantity has yet been contrived.

The most extensive amalgamation works in Europe are probably those of La Bella Raguel, in which are treated the ores obtained from the mines of Hiendelencina, situated in the province of Guadalajura, Spain. In that establishment the ores are chiefly washed in revolving calciners, and are subsequently treated in barrels, of which sixty are employed.

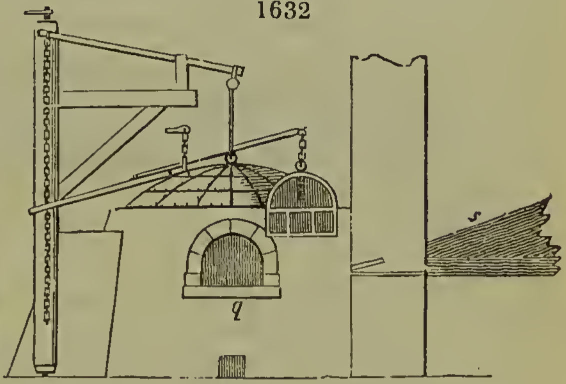
Instead of treating silver ore by the aid of mercury, they are sometimes operated on by a saturated solution of common salt. This process depends on the fact that chloride of silver is soluble in boiling and saturated solutions of this menstruum, and again deposited on cooling and dilution.

Argentiferous or *rich lead* is treated in Germany by the cupellation furnace represented in *figs.* 1631, 1632, 1633, and 1634. These figures exhibit the cupellation furnace of the principal smelting work in the Harz, where the following parts must be distinguished; (*fig.* 1633) 1, masonry of the foundation; 2, flues for the escape of moisture; 3, stone covers of the flues; 4, bed of hard-rammed scoriæ; 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*, *n*, 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

1631

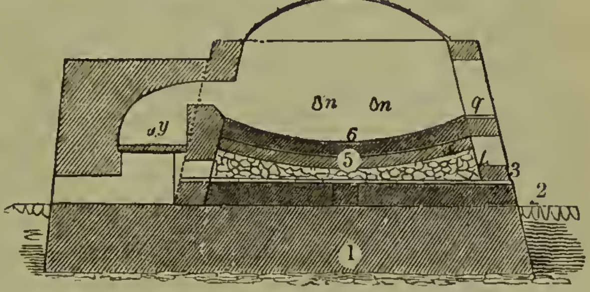


1632



at a time; *s*, *fig.* 1632, two bellows, like those of a smith's forge; *y*, door of the fire-place, through which billets of wood are thrown on the grate; *x*, small aperture or door, for giving issue to the 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*.

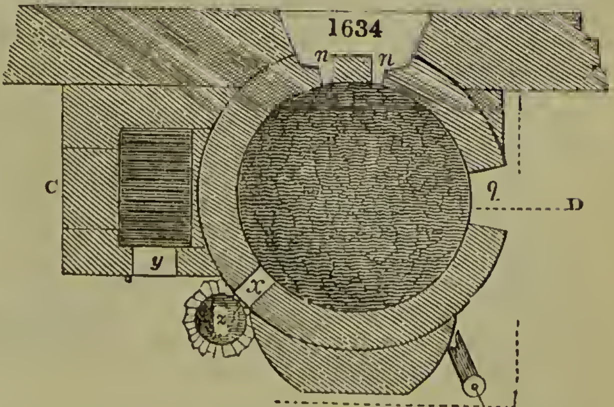
1633



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 *fig.* 1633); and there is left in the centre of 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 6 feet in diameter.

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 two and a half 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, scoriæ containing lead and silver are added, in order to lose nothing. The movable lid is now luted on the furnace, and heat is slowly applied in the fireplace by burning fagots of fir-wood; this is gradually raised. Section *fig.* 1633, is in the line C, D, of *fig.* 1634.

1634



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 four or five strokes per minute, to favour the oxidation.

In five hours, reckoned from the commencement of the process, the fire is smartly raised; when a greyish froth (*abstrich*) is made to issue from the small aperture *x*, of the furnace. This is found to be a brittle mixture of oxidised 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.

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 *n*, *n* (*fig.* 1634), the workman can direct the blast as he wishes 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 metallic bath descends. Litharge is thus obtained during about twelve 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 4 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 against 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 twenty 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 *brightening*. Whenever this occurs, the plate of silver being perfectly clean, there is introduced into the furnace by the door *q*, 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 eighteen or twenty hours. 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 $\frac{8}{10}$ths of wood (Harz 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 follows:—

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 *lbs. Cologne are equal to* 103 *lbs. avoirdupois; and the above quintal contains* 116 *Cologne lbs.*

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 Frankenscharn works of the Harz, 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.

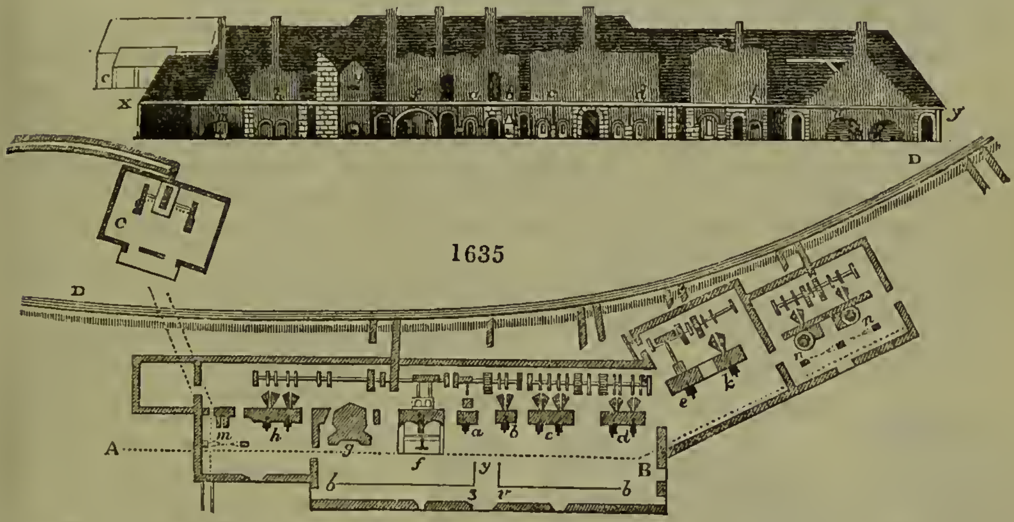
From numerous experiments in the great way, it has been found that not more than 100 quintals of lead can be profitably cupelled at one operation, however large the furnace, and however powerful and multiplied the bellows and tuyères may be; for the loss on either the lead or the silver, or on both, would be increased. In one attempt, no less than 500 quintals were acted on, in a furnace with two fire-places, 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 sometimes executed in a slag-hearth, with the aid of wood charcoal.

The following 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. 1635 exhibits the plan and elevation of these smelting-works, near Clausthal, in the Harz, for lead ores containing copper and silver, where about 84,000 cwts. of

Silver-smelting Works of Frankenscharn, near Clausthal.

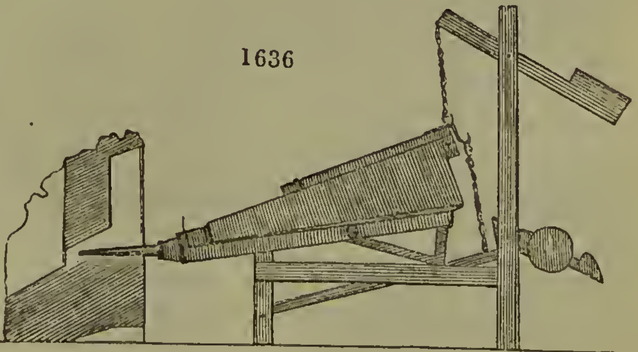


schlich (each of 123 Cologne pounds) are treated every year. This quantity is the produce of 30 distinct mines, as also of nearly as many stamp and preparation works. All these different *schlichs*, which belong to so many different joint-stock companies, are mixed and worked together in the same series 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.

The following is the series of operations:—

1. The fusion of the schlich; 2, the roasting of the matts under a shed, and their treatment by four successive remeltings; 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 Altenau.

1636



The buildings are shown at A, B, C, and the impelling stream of water at D; the upper figure being the elevation; the lower, the plan of the works.

a, is a melting furnace, with a cylinder bellows behind it; *b*, *c*, *d*, furnaces similar to the preceding, with wooden bellows, such as *fig.* 1636; *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 (*krummofen*), employed for working the last *mattes*; *k*, slag-hearths for reducing the litharge; *m*, the area of the liquation; *n*, *n*, cupellation furnaces.

x, *y*, a floor which separates the principal smelting-houses 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.

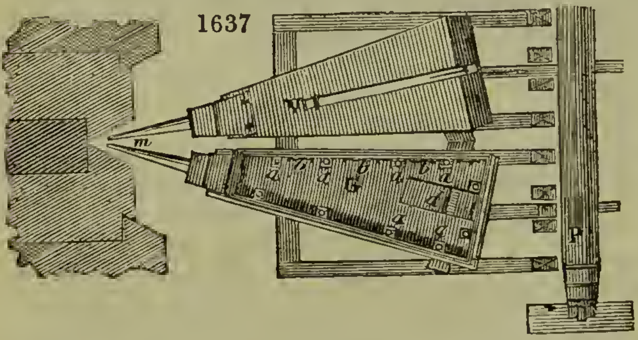
Here 89,600 quintals of schlich are annually smelted, which furnish —

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
Total product - - - -	28,564

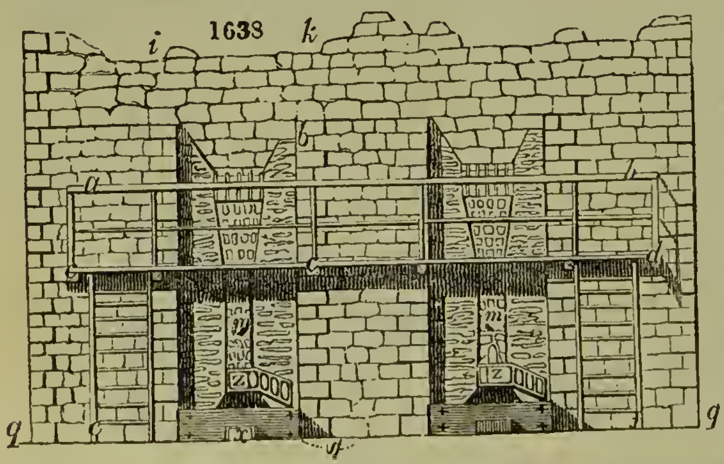
This weight amounts to one twenty-fifth of the weight of ore raised for the service of the establishment. Eight parts of ore furnish, on an average, about one of schlich. The bellows are constructed wholly of wood, without any leather; an improvement made by a bishop of Bamberg, about the year 1620. 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. 1637 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* G. P is the driving-shaft of a water-wheel, which, by means of cams or tappets, depresses the fly, while the counterweight Q, *fig.* 1622, raises it again.

1637



1638



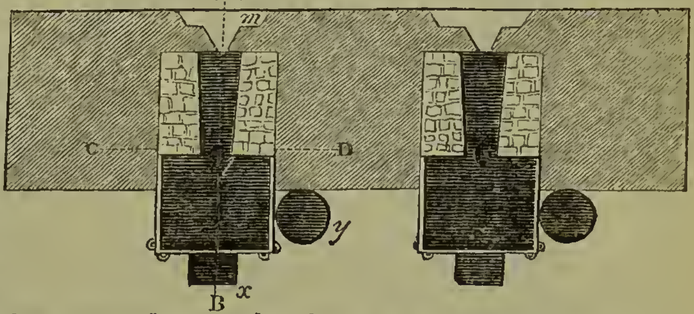
Figs. 1638 to 1641 represent the moderately high (*demihauts*, or *half-blast*) furnaces employed in the works of the Lower Harz, near Goslar, for smelting the silvery lead ore extracted from the mine of Rammelsberg.

Fig. 1638 is the front elevation of the twin furnaces, built in one body of masonry; *fig.* 1639 is a plan taken at the level of the tuyères.

Figs. 1640 and 1641 exhibit two vertical sections; the former in the line A, B, the latter in the line C, D, of *fig.* 1639. 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 *n*; *e, f,* wooden stairs, by which the workmen charging mount from 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 bed of ground charcoal and clay) 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 sloping gutter, seen in *fig.* 1640, formed of slates cemented together with clay.

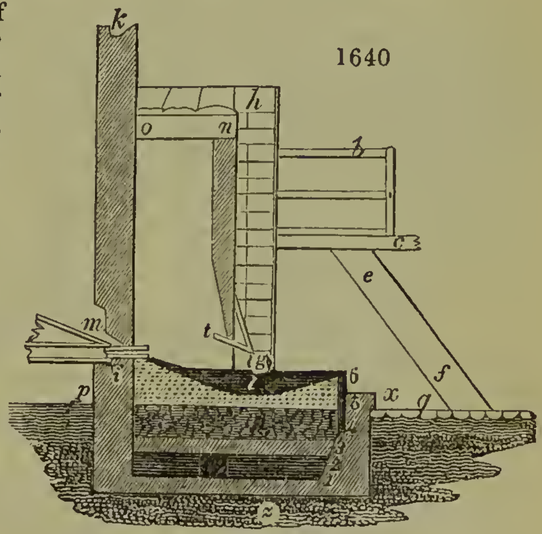
1639



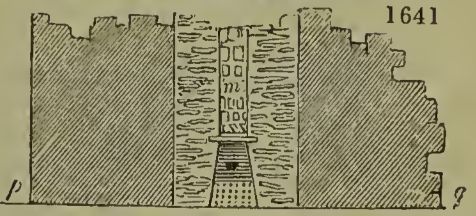
In *figs.* 1640 and 1641, *z,* is the brickwork of the foundations; *m,* conduits for the exhalation of moisture; 4, a layer of slags, rammed above; 5, a bed of clay, rammed above the slags; 6, a brasque, composed of one part of clay, and two parts of ground charcoal, which forms the sole of the furnace.

The refinery furnace, or *treibheerd,* of Fredrickshütte, near Tarnowitz, in Upper Silesia, is represented in *figs.* 1642 and 1643. *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,* outlet for the glassy litharge.

1640



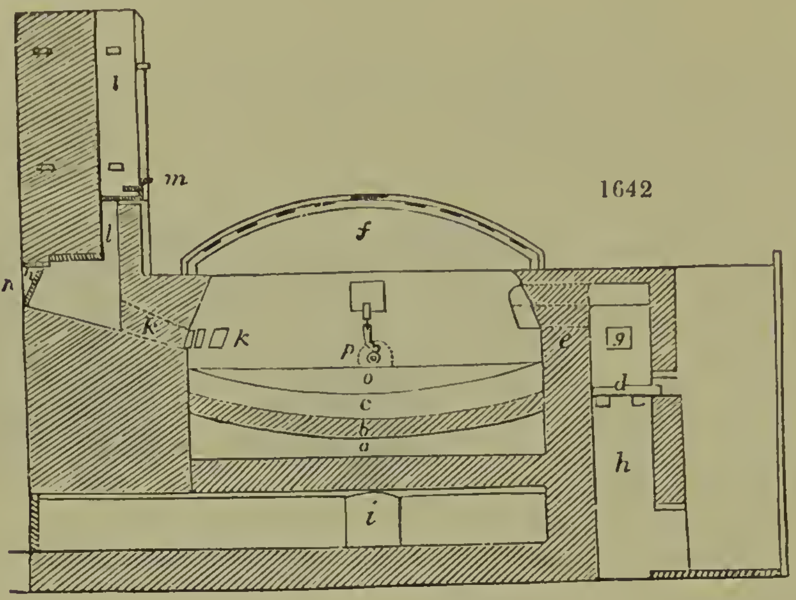
1641



Lime-marl has been found to answer well for making the body of the hearth-sole as it absorbs 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. 1644 to 1646 represent the eliquation hearth of Neustadt. *Fig.* 1644 is a cross section; *fig.* 1645 is a front view; and *fig.* 1646 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 2½ inches wide between them, through which the lead, as it sweats out by the heat, is allowed to fall into 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 liquefied 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.

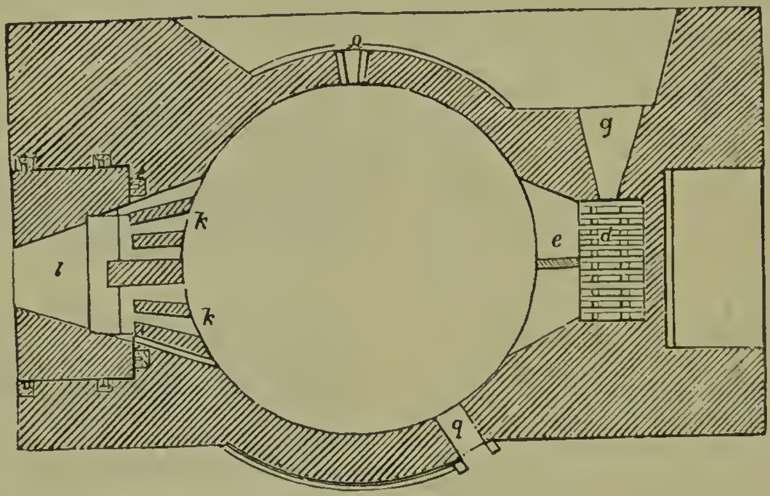
1642



The openings are then shut with a sheet or cast iron plate *e*, which, by means of a chain, pulley, and counter-weight, may be easily raised and lowered. *f* is a passage for increasing the draught of air.

Figs. 1647, and 1648 represent the refining furnaces of Frederickshütte, near 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 marks of *blicksilber*, of the fineness of 15½ loths (half ounces) per cwt., 3 cubic feet of pit-coal are required. The test or cupel must be heated before the impure silver and soft lead are put into it.

1643

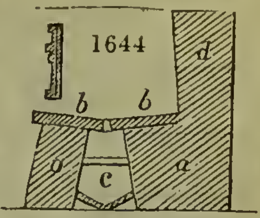


At these smelting-houses from 150 to 160 cwt. of *work-lead* (lead containing silver) are operated on at a time.

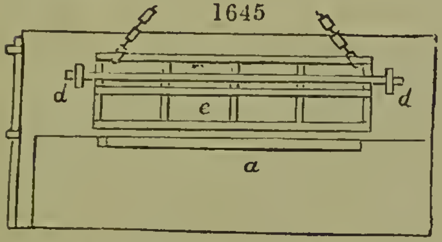
For the English method of refining silver, see article Lead Smelting. It may, however, be here stated that a method of desilverising by the use of metallic zinc has been somewhat recently introduced into some of the metallurgic establishments of the country.

Parkes's process for desilverising lead.—This invention is dependent on the property possessed by metallic zinc of uniting with the silver contained in argentiferous lead, and forming with it an alloy which can be readily skimmed from the surface of the metallic bath. In an establishment where the process is employed, the lead treated does not usually contain more than from 10 to 15 oz. per ton, and is frequently obtained by the reduction of litharge resulting from testing off lead of a higher produce.

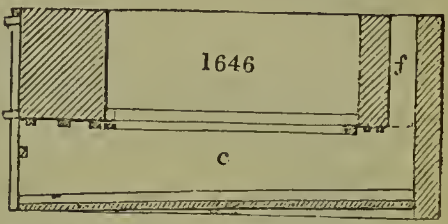
1644



1645

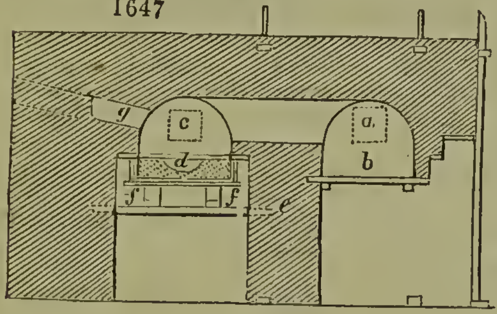


1646

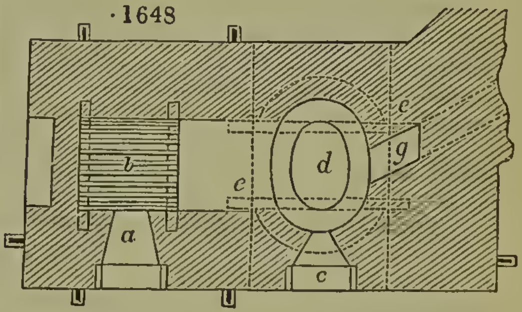


Six or seven tons of the lead to be desilverised are first melted in a large cast-iron pot, close to which is fixed a smaller one for fusing the zinc. The melted lead is then skimmed and a sample taken for assay.

1647



1648



Some zinc is also melted in the smaller pot above referred to, and added to the lead in the proportion of from 1½ to 2 pounds to each ounce of silver contained in the lead operated on, and the alloy is well stirred for from one to two hours. The fire is afterwards withdrawn and the metal allowed to rest until a scum rises on the surface, which is removed by means of a perforated ladle similar to that employed in Pattinson's process.

When this crust no longer forms, the lead is ladled into a gutter, which conducts it into a reverberatory furnace, of which the bottom is composed of a large cast-iron pan, where it is kept for some hours at a low red heat, for the purpose of expelling the last traces of zinc, either by oxidation or volatilisation.

The lead when sufficiently purified is tapped into an iron pot and boiled with green wood, as is usual in tin smelting. The quality of the lead thus purified is said to be exceedingly good, and nearly the whole of the silver is separated.

The scum from the pots contains a considerable amount of lead, which is separated by heating it in an inclined iron retort. As soon as this becomes sufficiently heated, the greater portion of the lead runs out into a mould placed for its reception, and carries with it silver to the amount of about 1000 oz. per ton; this is treated directly in the test furnace. The residues found in the retort are subsequently treated, after being mixed with small coal, in pots made with fire-clay, and the zinc distilled from it in the ordinary way.

The residue, after distillation, contains about 600 oz. of silver per ton, together with lead, copper, arsenic, and nickel, if these metals were originally present in the lead operated on. The quantity of zinc recovered by distillation is said to be about one-half of that originally employed.

The further treatment of the alloy of zinc and silver consists in melting it with lead; and as soon as a sufficient quantity of the mixture has been obtained, it is treated by cupellations in the usual way. The advantage stated to be obtained by the frying process consists in the concentration of the silver in a small quantity of lead with but few operations. The loss of lead by this process is estimated at about one per cent.—

The Produce of Silver from the Lead Ores of the United Kingdom.

Counties.	1854.	1855.	1856.	1857.	1858.
	oz.	oz.	oz.	oz.	oz.
Durham and Northumberland	78,577	75,435	79,924	74,091	78,238
Cumberland - - -	42,020	62,879	51,931	43,460	43,721
Yorkshire - - - -	- -	273	302	445	1,657
Cornwall - - - -	176,675	211,348	248,436	224,277	223,189
Derbyshire - - - -	- -	- -	- -	- -	3,000
Somersetshire - - -	- -	- -	- -	- -	1,295
Devonshire - - - -	119,288	89,908	77,456	50,262	53,366
Total of England - -	416,824	439,983	481,909	417,343	426,974
Caermarthen - - -	- -	- -	- -	- -	3,263
Radnorshire - - -	- -	- -	- -	- -	304
Cardiganshire - - -	32,418	28,079	38,751	35,097	41,100
Flintshire - - - -	28,588	25,823	19,340	13,297	18,797
Denbighshire - - -	1,455	1,180	1,034	2,206	3,176
Montgomeryshire - -	- -	- -	- -	- -	1,341
Caernarvonshire - - -	- -	- -	- -	- -	439
Total of Wales - -	66,051	57,521	62,357	58,097	71,593
Scotland - - - -	5,426	4,947	5,282	4,206	4,882
Ireland - - - -	18,096	7,252	3,700	3,071	14,361
Isle of Man - - -	52,262	51,597	60,382	48,016	46,985
Total United Kingdom -	558,659	561,906	614,180	530,866	569,345
	£	£	£	£	£
Estimated value - - -	140,664	140,476	153,470	132,716	142,336

Silver bullion received and purchased by the Royal Mint in each of the years 1855, 1856, 1857:—

	1855.	1856.	1857.
	oz.	oz.	oz.
Silver bullion purchased -	721,037·198	1,796,002·727	1,442,656·011
Market price per ounce -	59½*d.* to 66*d.*	59¼*d.* to 66*d.*	61¼*d.* to 62⅛*d.*
Value - - -	197,101*l.* 16*s.* 4*d.*	437,291*l.* 7*s.* 7*d.*	397,441*l.* 0*s.* 9*d.*

Silver coined at the Royal Mint in each of the years 1855, 1856, 1857 :—

	1855.	1856.	1857.
	oz.	oz.	oz.
Florins -	302,188·000	800,640·000	607,680·000
Shillings -	248,818·000	576,000·000	465,840·000
Sixpences -	102,644·000	252,720·000	203,040·000
Groats -	39,154·000	5,760·000	——
Threepences	17,425·000	46,080·000	79,920·000
Maundy money	720·000	720·000	720·000
	710,949·000	1,681,920·000	1,357,200·000

Value.

	£ s. d.	£ s. d.	£ s. d.
Florins	83,101 14 0	220,176 0 0	167,112 0 0
Shillings	68,424 19 0	158,400 0 0	128,106 0 0
Sixpences	28,227 2 0	69,498 0 0	55,836 0 0
Groats	10,767 7 0	1,584 0 0	
Threepences	4,791 17 6	12,672 0 0	21,978 0 0
Maundy money	198 0 0	198 0 0	198 0 0
	£195,510 19 6	£462,528 0 0	£373,230 0 0

Silver Ore imported 1858.

	Tons.	Declared value. £
From New Granada	10	5,030
„ Chili	3,106	178,957
„ Peru	329	15,824
„ Australia	369	5,960
„ Honduras	60	2,310
„ British Settlements		
„ Other parts	75	1,073
	3,949	£209,154

Silver Coin and Bullion Imported in 1858:—

Countries from which imported.	Quantities. British Coin.	Quantities. Foreign Coin and Bullion.	Quantities. Total.	Total Value.
	oz.	oz.	oz.	£
Hanse Towns	936	664,542	665,478	180,130
Holland	400	22,138	22,538	6,132
Belgium	7,060	2,095,415	2,102,475	556,347
France	- -	7,619,038	7,619,038	2,079,204
Portugal	3,936	1,340,679	1,344,615	338,295
Spain	120	116,962	117,082	29,568
Gibraltar	4,740	252,590	257,330	64,866
Malta	26,192	- -	26,192	6,700
Turkey	20,155	1,200	21,355	5,486
Egypt	4,136	1,560	5,696	1,470
West Coast of Africa	518	12,931	13,449	3,372
China	- -	319,986	319,986	86,252
Australia	- -	6,033	6,033	1,526
British Columbia				
Mexico, South America and West Indies	33,497	11,368,242	11,401,739	2,986,659
United States	41,046	1,161,274	1,202,320	309,308
Other countries	14,373	156,790	171,163	44,749
Total - Quantities—oz.	157,109	25,139,380	25,296,489	—
Total - Value - £	40,223	6,659,841	- -	6,700,064

Quantities and Total Value of Silver entered for Exportation from 1855 *to* 1858.

Countries to which Exported.	Quantities of Silver.				Total Value of Silver.			
	1855.	1856.	1857.	1858.	1855.*	1856.*	1857.†	1858.†
	oz.	oz.	oz.	oz.	£	£	£	£
Hanse Towns	1,828,034	2,323,490	2,167,743	2,055,197	457,008	580,873	587,352	556.739
Holland	183,125	712,835	138,322	2,518,879	45,781	178,209	34,724	668.025
Belgium	522,046	833,225	31,576	115,853	130,512	208,305	8,005	29,212
France	2,634,524	3,244,596	1,212,129	1,513,362	658.631	811,149	324,511	390,552
Portugal, Azores, and Madeira	59,301	67,130	24,885	- -	14,825	16,782	6,822	- -
Gibraltar	9,000	- -	24,176	10,500	2,250	- -	6,069	2,654
Turkey	- -	39,800	- -	- -	- -	9,950	- -	- -
Egypt	22,523,797	43,716,377	65,680,927	19,067,973	5,630,949	10,929,094	17,295,432	5,088,850
Cuba	- -	- -	- -	2 000	- -	- -	- -	500
St. Thomas	- -	20,000	582,064	284,400	- -	5,000	149,071	72,800
United States	8,921	29,578	63,589	261,704	2,230	7,395	15,980	67,185
Brazil	- -	- -	214,432	485,600	- -	- -	54,901	126.341
British Possessions in South Africa	3,770	- -	- -	9.800	943	- -	- -	2,522
Mauritius	8,500	104,200	- -	100,000	2,125	26,050	- -	25.662
British Possessions in India	78,430	6,419	- -	- -	19,608	1,605	- -	- -
British Settlements in Australia	- -	- -	280	1,560	- -	- -	72	395
Other Countries	64,413	156,344	84,923	119,600	16,103	39,086	22,529	30,439
Total	27,923,861	51,253,994	70,225,046	26,546.428	6,980,965	12,813,498	18,505,468	7,061,836

* Computed at 5*s*. per ounce.

† Computed at the market price at time of entry.

The following table showing the quantities of gold and silver produce, by M Michael Chevalier, is of historic interest.

	1846.		1850.	
	Pure Gold.	Pure Silver.	Pure Gold.	Pure Silver.
	Lbs. Troy.	Lbs. Troy.	Lbs. Troy.	Lbs. Troy.
*California - - - - - -	- -	- -	235,409	18,814
United States - - - - -	4,625	565	2,263	3,165
Mexico:—In 1846, by the gold washings, 980 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 In 1850, by the English Marmato Gold Company, 576 lbs. fine gold, and 350 lbs. fine silver.	4,954	13,009	4,954	13,000
Peru - - - - - -	1,888	303,207	1,888	303,207
Bolivia - - - - - -	1,184	139,452	1,184	139,452
Chili, in 1850, by the English Copiapo Company, about 13 lbs. fine gold and 7,000 lbs. fine silver	2,856	90,009	2,856	90,009
* 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, 314 lbs. gold, containiug about 14 per cent. silver. 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, 120 lbs. gold, containing about 14 per cent. silver.	5,096	607	5,668	675
Total 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.; Public ditto - 5,672 lbs.; Private, Siberia 57,235 lbs.; Public ditto - 2,555 lbs. (9 per cent. alloy.) 73,587 lbs.	66,985	50,858	81,919	52,053
Norway (Konigsberg silver mines) - -	- -	9,802	- -	10,790
North Germany (Hartz Mountains) - -	7	41,825	7	41,825
Saxony - - - - - -	- -	60,606	- -	60,606
Austria, in 1856, 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	86,961
Piedmont - - - - -	350	2,256	350	2,256
Spain - - - - - -	49	68,953	49	133,397
United Kingdom - - - - -	- -	33,330	- -	48,484
*Africa - - - - - -	4,000	320	4,000	320
*Borneo - - - - - -	6,000	480	6,000	480
*Ava - - - - - -	1,961	157	1,961	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 - - - -	2,000	10,000	1,000	10,000
Total of Europe, Africa, and Asia -	89,171	384,653	104,219	463,742
Total of North and South America -	25,503	1,594,431	261,731	2,199,644
Grand Total - - - -	114,674	1,979,081	365,950	2,663,386

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*l.*

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.= 125,108 lbs. British standard gold=5,846,772*l.*

In 1850, the quantity of pure gold produced in America was 261,731 lbs.; in Europe, Africa, and Asia (exclusive of China and Japan), 104,219 lbs.; total produce, 365,950 lbs.=399,247 lbs. British standard gold=18,654,322*l.*

* 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.

SILVER, ASSAY FOR. *Estimation of silver contained in lead ores.* Many varieties of lead ore contain silver, and it is consequently necessary, in order to judge of their commercial value, to ascertain the exact amount of this metal which they afford. This is effected by the process of *Cupellation:* an operation founded on the fact that when an alloy of lead and silver is exposed to a current of air, when in a state of fusion, the silver neither gives off perceptible vapours nor becomes sensibly oxidised, whilst the lead rapidly absorbs oxygen and becomes converted into a fusible oxide.

In order therefore to separate the silver that may be present in buttons resulting from ordinary lead assays, it is only necessary to expose them on some suitable porous medium, to such a temperature as will rapidly oxidise the lead. The litharge produced is absorbed by the porous body on which the assay is supported, and nothing but a small button of silver ultimately remains on the test. These supports or cupels are made of bone-ash, slightly moistened with a little water, and consolidated by being pressed into a mould. The furnace employed for this purpose is described in the article ASSAY; as is also the *muffle* or D-shaped retort in which the cupels are heated.

As soon as the muffle has become red hot, six or eight cupels that have been drying in the mouth of the opening are introduced by means of proper tongs, and the bottom of the muffle is covered with a thin layer of bone-ash, in order to prevent its being attacked in case of any portion of litharge coming in contact with it during the progress of the subsequent operations. The open end of the muffle is now closed by means of a proper door, and the cupels are thus rapidly heated to the temperature of the muffle itself. When this has been effected the door is removed, and into each of the cupels is introduced by the aid of slender steel tongs a button of the lead to be assayed. The mouth of the muffle is again closed during a few minutes to facilitate the fusion of the alloy, and on its removal each of the cupels will be found to contain a bright metallic globule, in which state the assay is said to be uncovered. The lead is now quickly converted into litharge, which is absorbed by the cupel as fast as it is produced, whilst at the same time there arises a white vapour that fills the muffle and is gradually carried off by the door and through the openings in the sides and end. A circular stain is at the same time formed around the globule of metal, which gradually extends and penetrates into the substance of the cupel. When nearly the whole of the lead has thus been removed, the remaining bead of alloy appears to become agitated by a rapid motion, which seems to make it revolve with great rapidity. At this stage the motion will be observed suddenly to cease, and the button, after having for an instant emitted a bright flash of light, becomes immovable. This is called the *brightening* of the assay, and a button of silver now remains on the cupel.

If the cupel were now abruptly removed from the muffle, the metallic globule would be liable to *vegetate*, by which a portion of the metal might be thrown off, and a certain amount of loss be thereby entailed. To prevent this, the cupel in which the assay has brightened should be immediately covered by another, kept red-hot for that purpose. The two are now gradually withdrawn together, and, after having sufficiently cooled, the upper cupel is removed, and the globule of silver detached and weighed.

From the fact that silver becomes sensibly volatile at very elevated temperatures, it becomes necessary to make cupellations of this metal at the lowest possible heat at which they can be effected. The temperature best fitted for this operation is obtained when the muffle is at a full red heat, and the vapours which arise from the assays curl gradually away, and are finally removed by the draught. When the muffle is heated to whiteness, and the vapours rise to the top of the arch, the heat is too great: and when, on the contrary, the fumes lie over the bottom, and the sides of the openings in the muffle begin to darken, either a little more fuel must be added or the draught increased.

If an assay has been properly conducted, the button of silver obtained is round, bright, and smooth on its upper surface, and beneath should be crystalline and of a dead-white colour; it is easily removed from the cupel, and readily freed from litharge. The globule is now laid hold of by a pair of fine pliers and flattened on a small steel anvil, by which the oxide of lead which may have attached itself to it, becomes pulverised, and is removed by rubbing with a small hard brush. The flattened disc is then examined, in order to be sure that it is perfectly clean, and afterwards weighed in a balance capable of turning with one-thousandth of a grain.

The fuel employed consists of hard coke broken into small pieces.

When the ores of lead, in addition to silver, contain gold, the button remaining on the cupel is an alloy of these metals.

For commercial purposes, the silver contained in any given ore or alloy is estimated in ounces, pennyweights, and grains, one ton of ore or alloy being usually taken as the standard of unity.

Table showing the weight of silver to the ton of ore or alloy corresponding to the weight in grains obtained from 400 *grains of the substance operated on.*

If 400 grains give fine metal,	One ton will yield			If 400 grains give fine metal,	One ton will yield		
Grains.	oz.	dwt.	gr.	Grains.	oz.	dwt.	gr.
·001	0	1	15	·600	49	0	0
·002	0	3	6	·700	57	3	8
·003	0	4	21	·800	65	6	16
·004	0	6	12	·900	73	10	0
·005	0	8	4	1·000	81	13	8
·006	0	9	19	1·500	122	10	0
·007	0	11	10	2·000	163	6	16
·008	0	13	1	2·500	204	3	8
·009	0	14	16	3·000	245	0	0
·010	0	16	8	3·500	285	16	16
·020	1	12	16	4·000	326	13	8
·030	2	9	0	4·500	367	10	0
·040	3	5	8	5·000	408	6	16
·050	4	1	16	5·500	449	3	8
·060	4	18	0	6·000	490	0	0
·070	5	14	8	6·500	530	16	16
·080	6	10	16	7·000	571	13	8
·090	7	7	0	7·500	612	10	0
·100	8	3	8	8·000	653	6	16
·200	16	6	16	8·500	694	3	8
·300	24	10	0	9·000	735	0	0
·400	32	13	8	9·500	775	16	6
·500	40	16	16	10·000	816	13	8

Assay of silver ores not containing lead. — In the assay of ores belonging to this class, it is usual to obtain the silver they afford in the form of an alloy with lead; and this is subsequently passed to the cupel in the ordinary way.

Ores of silver in which the metals exist in the form of oxides are commonly fused with a mixture of litharge, red lead, and powdered charcoal, by which an alloy of lead is obtained, which is afterwards treated by cupellation. The amount of litharge employed must be varied according to circumstances, as the resulting button should not be too small, since in that case a portion of the silver might be lost in the slag; nor too large, as the cupellation would then occupy a long time, and a loss through volatilisation be the result.

In most cases, if 400 grains of ore be operated on, a button of 200 grains will be a convenient weight for cupellation; this may be obtained by the addition of 400 grains of litharge, and from 7 to 8 grains of pulverised charcoal. This is to be well mixed with 200 grains of carbonate of soda, and introduced into an earthen crucible, of which it should not fill more than one-half the capacity. This is covered by a layer of borax, and fused in the assay furnace, taking care to remove it from the fire as soon as a perfectly liquid slag has been obtained, since the unreduced litharge might otherwise cut through the crucible and spoil the assay. When cold, the pot is broken, and the button cupelled in the ordinary way.

In this, and all other similar experiments, it is necessary to ascertain the proportion of silver contained in the lead obtained from the litharge used, in order to make the requisite deduction from the results obtained. When fine litharge is employed the resulting lead contains so small an amount of silver, that for many commercial purposes it may be disregarded.

When other minerals than oxides are to be examined, the addition of charcoal becomes in many cases unnecessary, since litharge readily attacks all the sulphides, arsenio-sulphides, &c., and oxidises many of their constituents, whilst a proportionate quantity of metallic lead is set free. The slags thus formed contain the excess of litharge, and the button of alloy obtained is cupelled. The proportion of oxide of lead to be added to ores of this description varies in accordance with the amounts of oxidisable substances present; but it must always be added in excess in order to prevent any chance of loss of silver from the action of sulphides in the slags.

The only objection to this method of assay is the large quantity of lead produced for cupellation,—since iron pyrites afford by the reduction of the litharge 8½ parts of lead, whilst sulphide of antimony and grey copper ore yield from 6 to 7 parts. This inconvenience may be obviated by the previous oxidation of the mineral, either by roasting, or by the aid of nitre, by the judicious employment of which buttons of almost any required weight may be obtained.

Should this reagent be employed in excess, it would cause the oxidation of all the metallic and combustible substances present, not even excepting the silver.

When, however, the mixture contains at the same time a large excess of litharge and the quantity of nitre added is not sufficient to decompose the whole of the sulphides, a reaction takes place between the undecomposed sulphide and the oxide of lead added, which gives rise to the formation of metallic lead, and this combining with the silver, affords a button of alloy, which may be treated by cupellation.

The quantity of nitre to be used for this purpose will depend on the nature and richness of the ores under examination; but it must be remembered that 2½ parts of nitre will decompose and completely oxidise pure iron pyrites, whilst 1½ and ⅔rds of its weight are in the case of sulphide of antimony and galena respectively sufficient.

In cases when the excess of sulphur present is very great, a partial roasting of the ore is preferable to the addition of a large quantity of nitre.

Instead of operating according to any of the processes above described, it is sometimes found advantageous to expel the whole of the arsenic and sulphur, by a careful roasting, and then to fuse the residue with a mixture of litharge, carbonate of soda and borax, taking care to add a sufficient amount of some reducing flux to obtain a button of convenient size.

When in addition to silver the mineral operated on contains gold, the button obtained by cupellation will consist of a mixture of these metals, which may be separated by the aid of nitric acid. See Assay.

Scorification.—Instead of operations as above described, silver ores are sometimes treated by scorification. In that case, they are mixed with granulated lead and exposed in small refractory saucers to a strong heat in an ordinary muffle furnace. After a sufficient amount of the lead has become oxidised, and the resulting litharge has formed a fusible slag with the gangue of the ore, the metallic lead is poured into a suitable mould, and afterwards subjected to cupellation. When the granulated lead employed for this purpose contains silver, due allowance for its presence must be made in the result obtained.

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° Beaumé, 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 to which Dr. Ure gave the name of *grey silver*. This 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.

SILVER, BROMIDE OF (AgBr), is occasionally found native. If a soluble bromide is added to a solution of nitrate of silver, a precipitate of bromide of silver is formed of a very pale yellow colour. This salt changes readily under the action of the solar rays, and for photographic purposes possesses many very important properties, of which photographers have not availed themselves. This is mainly owing to the neglect of scientific investigation amongst the body of photographic artists, which is exceedingly to be regretted.

SILVER, CHLORIDE OF, is obtained by adding hydrochloric acid, or any soluble chloride, 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 grey mass, called, from its appearance, *horn-silver*. Chloride of silver dissolves readily in water of ammonia, and crystallises 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, hydrochloric 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, hydrochloric acid being disengaged.

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.

SILVER, HYPOSULPHITE OF. This salt is formed in the process of fixing photographic pictures with *hyposulphite of soda* (which see). Solutions of the hyposulphite of soda, potash, or lime, which are bitter salts, dissolve chloride of silver into liquids possessing a remarkable sweetness.

SILVER, IODIDE OF. (AgI.) This compound of iodine and silver, which is obtained when a solution of an iodide is added to nitrate of silver, is a pale yellow powder. It is also found native, but not in large quantities. This silver salt 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 iodide of potassium, 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. Iodide of silver, when pure, is very slowly darkened when exposed to sunshine; but if in combination with any organic compound it changes colour with much rapidity. From this property it furnishes one of the most valuable of our photographic agents. (See PHOTOGRAPHY.) It is the active material in the calotype, the collodion, the Daguerreotype, and other processes.

SILVER, NITRATE OF. ($AgNO^6$.) This salt was known to Geber, and was chiefly used in medicine; but since the discovery of photography, this salt has been made on a very large scale. It is found in commerce in two different forms, viz. crystallised, and in sticks, the former being more general; in sticks it is called "lunar caustic," and is used by the surgeon. It is prepared by digesting metallic silver with moderately strong nitric acid; the silver speedily dissolves, especially if heat be applied. Some of the nitric acid is decomposed, yielding oxygen to the silver, and liberating binoxide of nitrogen, which, in contact with the air, abstracts oxygen and forms red vapours of hyponitric acid.

$$\underbrace{3Ag.}_{\text{Silver.}} + \underbrace{4HNO^6}_{\text{Nitric acid.}} = \underbrace{3Ag.NO^6}_{\text{Nitrate of silver.}} + \underbrace{NO^2}_{\text{Binoxide of nitrogen.}} + \underbrace{4HO.}_{\text{Water.}}$$

The clear solution is evaporated, either to the crystallising point or to dryness—if for *caustic*—fused and cast into sticks. If ordinary standard silver be used, the solution will contain some nitrate of copper; in this case it must be evaporated to dryness, and gradually heated till all the nitrate of copper is decomposed, which may be known by taking a little of the salt, dissolving in water, and adding excess of ammonia; when, if copper be still present, the solution will have a blue tint. When all the copper is thus rendered insoluble, the fused mass is dissolved in distilled water, evaporated and crystallised. When pure, nitrate of silver is white; the crystals are transparent, colourless, hexangular tables, or right rhombic prisms, very soluble in water, requiring only their own weight of cold water and half that quantity of boiling water for solution; they are also readily soluble in hot alcohol, but the greater portion is again deposited on cooling. Nitrate of silver possesses a strongly metallic and bitter taste. It is not deliquescent, and when free from organic matter is not decomposed by light (*Scanlan*). The dark colour of the outside of the ordinary sticks of the shops is caused by the decomposition of the nitrate by the paper in which they are wrapped, as the presence of organic matter reduces the silver to the metallic state. Nitrate of silver is frequently adulterated to a considerable extent, principally with nitrate of potash, but sometimes with other nitrates. The price at which it is sometimes sold is proof enough that it is largely adulterated; for instance, it may sometimes be bought for 3*s*. an ounce; at that price it does not pay for the silver alone that *should be* in it: we will prove this. Every ounce (437·5 grains) of pure nitrate of silver contains 278 grains of pure silver, and this itself, without taking notice of nitric acid and time of preparation, is worth 3*s*. 2*d*. This clearly proves there must be considerable adulteration; but although the adulterating substances do not interfere generally with the photographic processes, it is certain that no advantage can be gained by buying it at so low a price. The way to detect the adulteration is to precipitate the silver by hydrochloric acid, and evaporate the filtered liquid to dryness, when, if the salt is pure, there will be no residue.

As many, who use much nitrate of silver in photography, &c., throw away the residues, and hence in course of time waste much silver, it will not be out of place here to show how it may be saved and made again into nitrate of silver fit for use. If the papers, on which there is silver, are preserved, the silver can be obtained by merely burning them, and may be fused in a porcelain crucible into one lump. In the case of the nitrate of silver baths, when too weak for further use, the silver may be precipitated in the form of chloride, by adding hydrochloric acid. The chloride of silver thus obtained may be easily reduced to the metallic state. 1st, by digesting the moist chloride with metallic zinc and dilute sulphuric acid; the hydrogen which is thus liberated reduces the silver to the metallic state, which remains in the form of a black powder, and when well washed with water may be dissolved in nitric acid, evaporated and crystallised. 2nd, by digesting it by the aid of heat with a caustic alkali and tartaric acid, when it will also be reduced to metallic silver, and will remain as a black powder, which may be treated as above. 3rd, by collecting the precipitated chloride of silver on a filter, washing well with water, and drying; the dry chloride is then mixed with four or five times its weight of a mixture of carbonate of potash and carbonate of soda, and subjected to a white heat in a porcelain crucible; the silver will be reduced to the metallic state, and will be found as a metallic button at the bottom of the crucible when cold, and may be easily detached and washed; and is then fit to dissolve in nitric acid, &c.—H. K. B.

SILVER, OXIDE OF. There are two oxides of silver; the *protoxide* (AgO), and the peroxide AgO^2. 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-grey 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 alkalies upon reddened litmus paper, and displacing, from their combinations with the alkalies, 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*. See Fulminating Silver. The second, or peroxide, is formed when a very dilute solution of nitrate of silver is decomposed by the voltaic current; dark grey lustrous needles of the peroxide of silver are formed around the positive pole.

SILVER, SULPHATE OF, 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 crystallises in small needles as the solution cools. It consists of 118 parts of oxide, combined with 40 parts of dry acid.

SILVER, SULPHIDE OF, which exists native, may be readily prepared by fusing its constituents together; and it forms spontaneously upon the surface of silver exposed to the air of inhabited places. The tarnish may be easily removed by rubbing the metal with a solution of *cameleon mineral*, prepared by calcining peroxide of manganese with nitre. Sulphide 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 alkalies are decomposed at that temperature. It consists of 87·04 of silver, and 12·96 of sulphur.

SILVER LEAF is made in precisely the same way as *gold leaf*. See GOLD BEATING.

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 *emorfiler* by the French artists.

2. The *annealing*; or, making the piece to be silvered red hot, and then plunging it in a 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 *blueing*, 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 pearlash, 1 of washed whiting, and one and a half of sea-salt. After cleaning 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 alkalised, then in slightly warm pure water, and finally wiped dry before the fire. See PLATED MANUFACTURE, and ELECTROTYPE.

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. See MIRRORS.

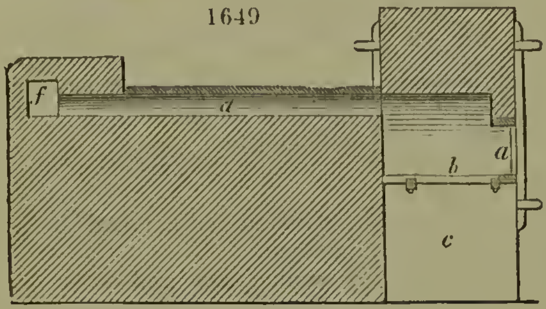
SIMILOR. A name given to a rich-coloured brass, composed of 3 oz. zinc to 1 lb. of copper. See BRASS.

SINAMINE. $C^8H^6N^2$. An alkaloid, produced by the action of the oxides of mercury or lead, on thiosinamine.—C. G. W.

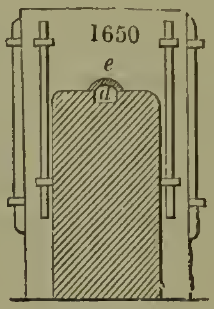
SINAPINE. $C^{32}H^{23}NO^{10}$. A base existing (in the state of hydrosulphocyanate) in white mustard.—C. G. W.

SINGEING. In the article BLEACHING, Vol. I. page 325, the modern and most approved singeing apparatus is described. The old furnace for singeing cotton goods is represented in longitudinal section, *fig.* 1649, and in a transverse one in *fig.* 1650. *a* is

1649



1650

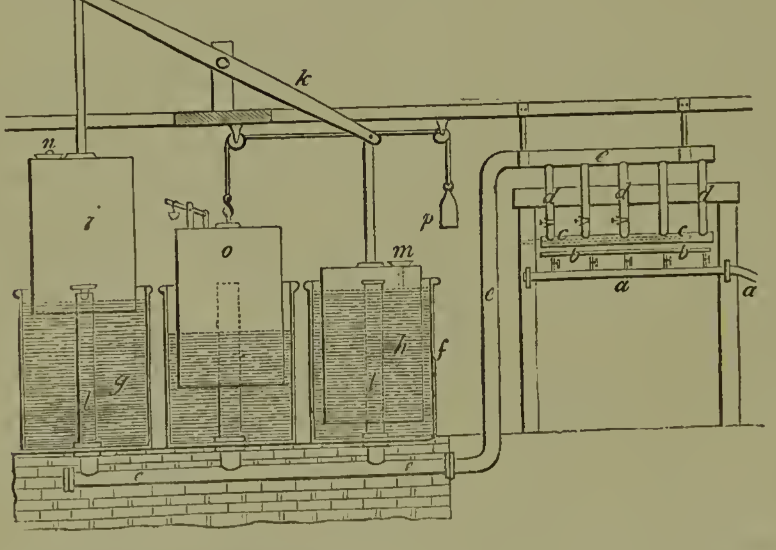


the fire-door ; *b*, the grate ; *c*, the ashpit ; *d*, a flue, 6 inches broad, and 2½ high, over which a hollow semi-cylindrical mass of cast iron *e*, is laid, 1 inch thick at the sides, and 2½ thick at the top curvature. The flame passes along the fire flue *d*, into a side opening *f*, in the chimney. The goods are swept swiftly over this ignited piece of iron, with considerable friction, by mean 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 1,500 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 introduced the plan for removing the downy fibres of the cotton thread from the interstices of bobbinet lace, or muslins, by singeing the lace with the flame of a gas-burner. And in 1823 he modified this process by 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

1651



aperture in a tube placed immediately above the row of gas-jets, which tube communicates with an air-pump or exhauster.

Fig. 1651 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 in 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, is found not to be at all times efficacious. There is now introduced 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 stop-cocks 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.

SIZE. A solution of gelatinous matter, usually made from skin, employed for the purpose of giving adhesiveness to certain substances, which could not be otherwise secured to surfaces. See GELATINE and GLUE.

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, TAN, and FURS. The skins of animals are imported for the preparation of furs, for use, and ornament, and for the manufacture of leather.

The following statement of our importations in 1858 show the importance of this branch of trade:—

SKINS, FURS, PELTS and TAILS, undressed:

	Number.	Computed real value.
Bear	13,885	£15,349
Beaver	108,315	34,336
Coney	218,279	3,638
Deer	98,779	13,016
Ermine	201,334	10,057
Fitch	21,308	2,131
Fox	91,731	57,680
Goat (*undressed*)	568,854	62,146

Skins, Furs, Pelts and Tails, undressed (*continued*):

	Number.	Computed real value.
Goat (*tanned or tawed*) - - -	672,516	£57,065
Kid (*in the hair, undressed*) - -	23,627	900
Do. (*dressed*) - - - -	445,873	60,947
Do. (*dyed*) - - - - -	4,155	605
Lamb (*in the wool, undressed*) - -	1,269,663	73,081
Do. (*tanned or tawed*) - - -	10,949	719
Do. (*dyed*) - - - - -	1,004	81
Do. (*dressed in oil*) - - - -	33,802	2,254
Lynx (*undressed*) - - - -	38,014	16,619
Marten (*do.*) - - - -	163,928	83,580
Martens' tails - - - - -	3,450	86
Minx - - - - - -	123,387	24,793
Musquash - - - - -	971,387	37,347
Nutria - - - - - -	856,130	32,997
Otter - - - - - -	17,791	23,711
Raccoon - - - - - -	437,499	63,219
Sable - - - - - -	869	1,520
Seal (*in the hair*) - - - -	719,926	274,658
Sheep (*in the wool*) - - - -	1,494,562	117,113
Do. (*tanned or tawed*) - - -	899,741	29,268
Do. (*dressed in oil*) - - - -	55,173	4,137
Squirrel or Calabar - - - -	105,750	1,980

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*.

The following, selected from the analyses of Percy and Forbes, show the composition of iron furnace slags:—

Silica - - - - -	28·32	42·06	39·52	29·60
Alumina - - - - -	24·24	12·93	15·11	41·28
Lime - - - - -	40·12	32·53	32·52	0·47
Magnesia - - - - -	2·79	1·06	3.49	0·35
Protoxide of manganese -	0·07	2·26	2·89	1·13
Protoxide of iron - -	0·27	4·94	2·02	48·43
Sesquioxide of iron - -	—	—	—	17·11
Potash with traces of soda -	0·64	2·69	1·06	—
Sulphate of lime - -	0·26	—	—	—
Sulphide of calcium - -	3·38	1·03	2·15	—
Phosphoric acid - -	—	0·31	—	1·34
Sulphide of iron - -	—	—	—	1·61
Loss - -	—	0·19	1·24	—
	100·09	100·00	100·00	101·32

Of the last of these, Dr. Percy remarks:—

"An immense quantity of iron slag, *far richer than many iron ores*, is annually thrown away, and it may be that the presence of phosphoric acid in sensible quantity is one of the causes which prevents the re-smelting of this slag to advantage. The fact has not yet sufficiently attracted the attention of those engaged in the manufacture of iron. The discovery of a method of extracting economically good iron from these rich slags would be of great advantage to the country, and could not fail amply to reward its author."—*Report of the Sixteenth Meeting of the British Association*, 1847.

SLATES. (*Ardoises*, Fr.; *Schiefern*, Germ.) The substances belonging to this class may be distributed into the following species:—

1. Mica-schist, occasionally used for covering houses.
2. Roofing slate.
3. Whet slate.
4. Polishing slate.
5. Drawing slate, or black chalk,
6. Adhesive slate.
7. Bituminous shale.
8. Slate-clay.

1. *Mica-schist*, improperly called *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. *Roofing slate.* — This substance is closely connected with mica; so that uninterrupted transitions may be found between these rocks in many mountain chains. It is a simple schistose mass, of a bluish-grey or greyish-black colour, of various shades, and a shining, somewhat pearly internal lustre on the faces, but of a dead colour in the cross fracture.

This slate is extensively distributed in Great Britain. It skirts the Highlands of Scotland, from Loch Lomond 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. This variety of slate is found in the Cambrian, Silurian, and Devonian formations.

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 immersing 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 Argyleshire, is very durable. The slates of Penrhyn and other quarries in North Wales, are very celebrated; those of Delabole in Cornwall are also well known and much esteemed.

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 slab 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 proportionate to the number of block-hewers. 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. *Whet 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, 1·6; 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 greyish 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. See KIMMERIDGE SHALE.

8. *Slate-clay* has a grey or greyish-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. 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. See CLAY.

SLIDES. A miner's term for a dislocation of the strata, which is evidenced by the sliding of one portion of the rock over the other. These slides are often, but not always, filled with a softer matter than the rock, a clay in a greater or less state of induration.

SLIKENSIDES. The name given to smooth striated surfaces of rocks or of mineral lodes, indicating the grinding action of the movement of heavy masses. Many polished surfaces are called *slikensides* to which the term is evidently inapplicable.

SLOKE. The common name for *laver*. See ALGÆ.

SMALT. See COBALT.

SMELTING. The processes for obtaining the metals from the ores. These are described under the respective heads. See COPPER, IRON, LEAD, METALLURGY, SILVER, TIN, ZINC, &c.

SMOKE, prevention of, or consumption of.

Smoke is the more volatile portions of coal, passing off, charged with finely divided carbon, at a comparatively low temperature.

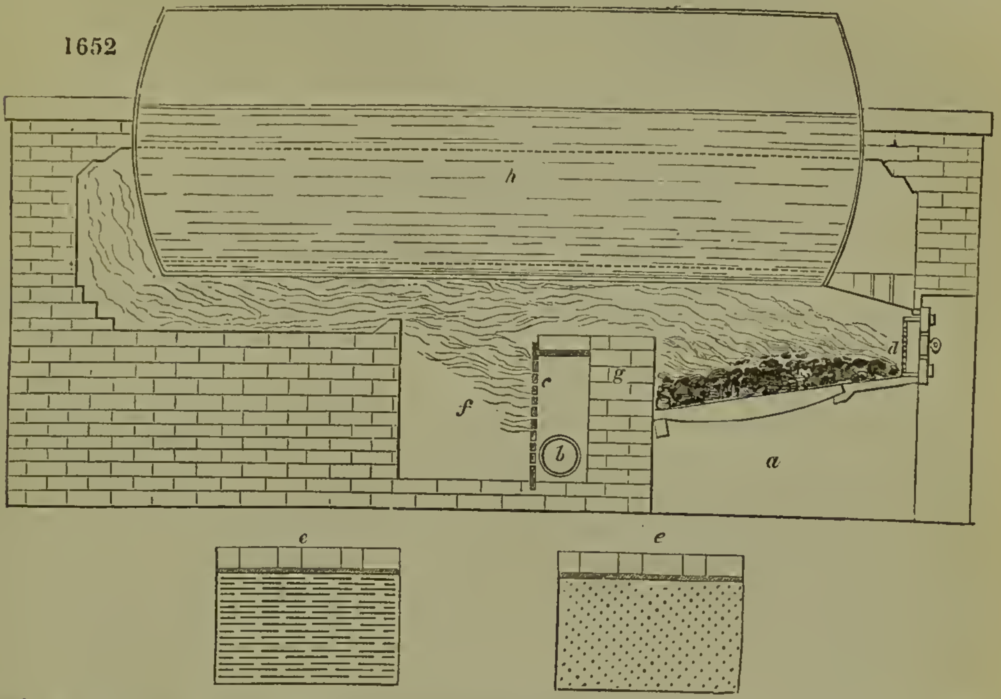
If the black smoke, which escapes from a furnace when a quantity of cold coals is thrown in upon an incandescent mass, can be made to pass over another portion of coal in active combustion, this carbon is *consumed*, *i. e.* combined with atmospheric oxygen, and converted into carbonic oxide, which burns, producing carbonic acid; and eventually escapes as colourless vapour.

One great cause, and perhaps the greatest cause of the annoyance of smoke in large towns is the carelessness of the man supplying fuel to the fire. Where coal is abundant the stoker usually piles an unnecessary quantity of fuel upon his fire, and this has the effect of reducing the heat, and of producing dense volumes of black smoke. Where coal is scarce and dear, as in Cornwall, careful stoking leads to an almost entire absence of smoke. A small quantity of coal is placed in front of the fire at a time, here it undergoes a coking process, the volatile carbon passing over the heated coal is burnt, and no visible smoke escapes. When the coal is thoroughly coked it is shovelled in over the fire, and a fresh portion of coal is placed in front, to undergo the same process.

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 greater 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 the air thus passed in small jets into the half-burned carburetted hydrogen gases over the fires, is their perfect combustion, the development of all the heat which they 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.* 1652, where *a* is the ash-pit of a steam-boiler furnace; *b* is the mouth of a tube which admits the external air into the chamber or iron box of distribution, *c*, 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.* 1652; *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 movable valve in the door. Fire-places of this latter construction perform admirably, without smoke, with an economy of one-seventh of the coals usually consumed in producing a like amount of steam from an ordinary furnace; *h* 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 Houldsworth, 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

1652



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.

SOAP is a chemical compound, manufactured on a very extensive scale, forming, accordingly, a considerable article of commerce. It is a compound resulting from the combination of certain constituents derived from fats, oils, grease of various kinds, both animal and vegetable, with certain salifiable bases, which, in detergent soaps, are potash or soda.

Oils and fats consist chiefly of oleine and stearine, as in tallow, suet, and several vegetable fats; of margarine, which occurs in animal fats, in butter, in olive and other vegetable oils; of palmitine, which is found in palm oil, and so on with various other immediate principles, according to the nature of the fats and oils employed by the soap maker. Natural fatty substances, however, are never exclusively formed of one of these principles, but are, on the contrary, composed of several of them in various pro portions, oleine alone being a constant constituent in all of them.

Natural or neutral fats and oils, chemically considered, are really salts, sometimes called "glycerydes," that is to say, are combinations of acids, oleic, stearic, margaric acid, &c., with the oxide of a hypothetical radical called *glyceryle* (sweet principle of oils).

Stearine being, therefore, a combination of stearic acid with oxide of glyceryle, is a stearate of oxide of glyceryle.

Oleine is a combination of oleic acid with oxide of glyceryle, and is, therefore, an oleate of oxide of glyceryle.

Margarine is a combination of margaric acid and oxide of glyceryle, and is, therefore, a margarate of oxide of glyceryle, and so on with the other constituents of fats and oils.

Glycerine is a combination of oxide of glyceryle with water, which, in that case, plays the part of an acid to form a hydrate of oxide of glyceryle (glycerine).

Now, when neutral fats (namely, oleine, stearine, margarine, &c., or the fats or oils which they constitute) are treated by solutions of caustic alkalies, such as potash or soda, their constituents react upon each other, and combine with the potash or soda; and provided too great an excess of alkali has not been used, the fat or oil dissolves in the alkaline solution into a syrupy liquid, which on cooling forms a gelatinous mass, which is nothing else than an aqueous solution of soap mixed with the glycerine, which the treatment has set free.

The following equation, in which, for the sake of simplicity, one of these principles only, *stearine* and soda dissolved in water, are taken as examples, will clearly illustrate this interesting reaction:—

Stearine.

Stearate of oxide of glyceryle + soda + water
= stearate of soda + hydrate of oxide of glyceryle

hard soap. glycerine.

In the same way:—

Oleine.

Oleate of oxide of glyceryle + soda + water
= oleate of soda + hydrate of oxide of glyceryle

hard soap. glycerine.

and so on all the immediate principles of which the fat or oil employed is composed, splitting, that is to say, separating from this oxide of glyceryle to form a stearate, oleate, margarate, palmitate, &c., of soda or of potash, and glycerine (hydrate of oxide of glyceryle).

Soaps made with soda are hard; those made with potash are soft; the degree of hardness being so much greater as the melting point of the fats employed in their manufacture is higher, hence the more oleine a fatty matter contains, the softer the soap made with it will be, and *vice versâ*. The softest soap, therefore, would be that made altogether with oleine (oleic acid) and potash (oleate of potash); the hardest would be that made with stearine and soda (stearate of soda).

The fats or oils employed for the manufacture of soaps, are tallow, suet, palm oil, cocoa-nut oil, kitchen fat, bone grease, horse oil or fat, lard, butter, train oil, seal oil, and other fish oils, rape oil, poppy oil, linseed and hempseed oil, olive oil, oil of almonds, sesame, and ground nut oil, and *resin*. This last substance, though 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. The employ of caustic alkalies, however, is not necessary with it, since it dissolves readily in aqueous solutions of carbonated alkalies, but even with carbonate of soda it forms only a viscid mass, owing to its great affinity for water, so that even after having been artificially dried in an oven, and thus rendered to a great extent hard, the mass deliquesces again spontaneously by exposure, and returns to the soft state. The drying oils, such as those of linseed and poppy, produce the softest soaps.

We said that by boiling fats or oils with an aqueous solution of potash or of soda a solution of soap was produced. The object of the soap-maker is to obtain the soap thus produced in a solid form, which is done by boiling the soapy mass so as to evaporate the excess of water to such a point that the soap may separate from the concentrated liquor and float on the surface thereof in a melted state, or by an admixture of common salt, soap being insoluble in lyes of a certain strength or degree of concentration, and in solutions of common salts of a certain strength, the glycerine remaining, of course, in solution in the liquor below the separated soap. Such is the theory of soap-making; but the *modus operandi* followed by practical soap-makers will be described presently.

On the Continent olive oil, mixed with about one-fifth of rape oil, is principally used in making hard soap. This addition of rape oil is always resorted to, because olive oil alone yields a soap so hard and so compact that it dissolves only with difficulty and slowly in water, which is not the case with rape oil and other oils of a similar nature, that is to say, with oils which become thick and viscid by exposure, and which on that account are called drying oils, experience having taught that the oils which dry the soonest by exposure, yield with soda a softer soap than that made with oils which, like olive oil, remain limpid for a long period under the influence of the air. The admixture of rape oil has, therefore, the effect of modifying the degree of hardness of the soap, and, therefore, of promoting its solubility. In England tallow is used instead of olive oil, the soap resulting from its treatment with soda is known under the name of *curd soap*, and is remarkable for the extreme difficulty with which it dissolves in water. The small white cubic, waxy, stubborn masses, which until a few years ago were generally met with on the washing-stand of bedrooms in hotels, and which for an indefinite period passed on from traveller to traveller, each in turn unsuccessfully attempting, by various devices and cunning immersions in water, to coax it into a lather, is *curd soap*. Rape or linseed oil, added in certain proportions to tallow, would modify this extreme hardness and difficult solubility, but it is now the general practice to qualify the tallow with cocoa-nut oil, an oil, which, converted into soap, has the property of absorbing incredible quantities of water, so that the soap into the manufacture of which it has entered lathers immediately. Cocoa-nut oil, however, acquires by saponification a most disagreeable odour (due to the formation of caprylic acid), which it imparts to all the soaps in the manufacture of which it enters, an odour which persists in spite of any perfume which may be added to mask it.

The admixture of one-fourth or one-fifth of resin with tallow, in the process of saponification, modifies also the hardness and considerably increases the solubility of curd soap, and this, in fact, constitutes the best *yellow soap*.

I said that soap was more or less hard in proportion as the melting point of the fats employed in its manufacture was higher or lower. There are certain fatty substances, technically called weak goods, such as kitchen fat, bone fat, horse oil, &c., which could hardly be used alone, still less with resin, the soap which they yield being too soft, and melting or dissolving away too rapidly in the washing-tub. This led me to think, that if a means could be devised of artificially hardening soap, a larger class of oleaginous and fatty substances could be rendered available, at any rate to a greater extent than they hitherto had been, and that, by thus extending the resources of the soap boiler, he should be enabled to produce a good and useful soap from the cheapest materials, and thus convert soaps of little commercial value into useful and economical products.

In making experiments with this view, I found that the introduction of a small quantity of melted crystals or sulphate of soda into the soap answered the purpose admirably, and that the salt in recrystallising, imparted to the soap, which otherwise would have been soft, a desirable hardness, and prevented its being wasted in the tub. The use of sulphate of soda acts, therefore, *inversely*, like the addition of rape oil, or linseed oil, or of resin to tallow, in the manufacture of soap. This process, which I patented in 1841, has been, since the removal of the duties on soap, extensively employed by soap makers, and continues to be highly approved of by the public. I shall describe further on the manner of practising this process, and the further improvements which I made to it in 1855.

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 resin. From 12 to 13 cwt. of tallow are estimated to produce one ton of good soap. Several 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 as improved quality of the crude sodas, have led to their general adoption in soap-works.

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 above alluded to, is stratified with a quantity of recently-burnt, or quick-lime, in tanks of wrought-iron, or cylindrical cast-iron vats, from 6 to 7 feet wide and from 4 to 5 feet deep, the lowest layer being, of course, quick-lime. These vats have frequently a false bottom, perforated with holes, or else a coarse piece of matting is placed over the plug-hole, placed at the bottom of the said vats or tanks, which plug-hole is, of course, closed generally by a wooden plug. Water is then poured upon the whole mass until the tanks are full, and the whole is 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 replaced, more water applied, and this operation is repeated five or six times, until, in fact, the soda is almost entirely extracted; the various liquors thus obtained, in a clear and caustic state, after infiltration through the beds of lime, being conveyed to separate and distinct reservoirs, distinguished from each other by the names of *first running*, *second running*, and so on; the last being, of course, the weakest.

Having in this way produced a series of caustic lyes of different degrees of strength, about 200 gallons of the weakest, which has a specific gravity of about 1·040, is pumped into the soap pan or boiler, or *copper*, as it is called, though generally made of cast iron, and about 1 ton of tallow is added, heat is applied, and after a gentle ebullition of about four hours, it will be found that the lye will have lost its causticity, or, in technical language, that it is *killed*, and that the fat is saponified, which is known by taking a portion of the mass on a trowel, when it will be observed that the liquid separates at once from the soapy mass, which it leaves in streaks on the trowel. The lyes thus used at first, if composed of pure soda, would contain about 4 per cent. of alkali, but from the presence of neutro-saline matter they seldom contain as 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 lbs. of real soda. The fire being withdrawn, the whole is now allowed to cool and remain at rest for about one hour, until the lye, now deprived of its alkali. and, therefore, called *spent lye*, settles to the bottom of the copper. This spent lye contains a portion of glycerine derived from the fat or tallow, together with the sulphate of soda and common salt of the soda ash, and is pumped off by means of an iron pump, which is lowered down into the lower pan of the soap copper, a practice which might be advantageously replaced by opening a cock which might be placed at the bottom of the copper, but which is retained as a remnant of that abominable system of excise which did not permit the spent lyes to be otherwise withdrawn, as the excise laws forbade any cock or aperture being placed or made at the bottom of soap coppers. This constitutes what is called an operation. A second similar charge of lye is now introduced into the pan along with a fresh quantity of tallow or of grease, and a similar boiling process is again repeated. Three or four such boilings may be practised in the course of a day by an active soap-boiler, with lyes of gradually increasing strength. Next day the same routine is renewed with stronger lyes, and so progressively until towards the sixth day the lye may have the density of 1·160, when a period arrives at which it will be found that the whole of the tallow or fat is completely saponified, that is to say, has combined with its full equivalent of soda. This point is well known to the workmen by the consistence of the compound; in effect it is sufficient to take a portion of the mass on a trowel, and to squeeze a little of the mass between the forefinger and thumb; if not quite and thoroughly finished it will still have a greasy feeling, but if done it will on cooling readily separate from the skin in hard scales — neither has it the taste peculiar to grease. A more certain mode, however, especially for those who have not acquired sufficient practice, is to decompose a portion of the saponified or partly saponified mass with an acid, and to ascertain whether the grease is *wholly soluble* in boiling spirits of wine, for if it is not thus wholly soluble, the saponification is imperfect. The addition of common salt for the separation of the spent lyes is essential to the proper granulation and separation of the soap, for otherwise the tallow and the lye would unite into a uniform emulsion, from which it would be very difficult afterwards to separate the spent lye; but as soap is quite insoluble in a solution of common salt, the partly saponified mass is thus brought to float on the surface, so that the spent lye precipitates to the bottom, whence, as we said, it is pumped off.

Assuming, however, that a perfect result has been secured, the soap has now to be brought to a marketable condition, and for this purpose it is boiled with a quantity of weak lye or water. As 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 over 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 semifluid 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. 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 "*niger*," 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

Manufacture of mottled soap.—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.

The best and most esteemed soap on the Continent is that known under the name of Marseilles soap, and it differs from the English mottled soap by a different disposition of the mottling, which in that soap is granitic instead of being streaky. It has also an agreeable odour, somewhat resembling that of the violet, whereas the English mottled soap, generally made of very coarse kitchen and bone fat, has an odour which reminds one of the fat employed. The best English mottled soap in which tallow is employed, has no unpleasant smell, and if bleached palm oil has been used it acquires an agreeable odour, analogous to that of the Marseilles soap, which is made of olive oil alone, or mixed with rape or other grain or seed oil, which, however, seldom exceeds 10 per cent., for otherwise it would not have the due proportion of blue to the white which is characteristic of soap made of genuine olive oil, the mottling becoming more closely granular when an undue proportion of grain has been used, a sign of depreciation which the dealers are perfectly well acquainted with, and of which they at once avail themselves, to compel the maker to reduce his price.

Pelouze and Frémy, in their *Traité de chimie générale*, give the following reliable observations:—

"The best olive oil for the use of the soap maker is Provence oil; that of Aix comes next; it is cheaper, but a same weight of it yields less soap than the other, and the latter has then a slight lemon yellow tinge. The oil from Calabre contains less margarine, and yields a softer soap.

"Two kinds of soda ash are used in Marseilles, the soft soda (*soude douce*) and the salted soda (*soude salée*), which contains a large quantity of common salt.

"To prepare the lye, the soft soda previously reduced into small lumps is mixed with 12 per cent. of slaked lime, and shovelled up into tanks of masonry of about 2 cubic yards' capacity, called *barquieux*, and the exhaustion of the mass with water gives lyes of various degrees of strength.

"The lye marking 12° is used for the first treatment, or *empâtage* of the oil, which is then submitted to a second and third treatment with a lye marking 15° or 20°, the object of which is to close the grains of the emulsive mass in process of saponification (*serrer l'empâtage*). The operation requires about twenty-four hours. During all the time of that operation a workman is constantly agitating the boiling mixture of the oil and lye by means of a long rake or crutch, called *râble*. The *empâtage* is generally practised in large conical tanks of masonry terminated at bottom by a copper pan, and capable of containing 12 or 13 tons of made soap, and the operation proceeds so much the more rapidly, as the soda lye employed contains less common salt, wherefore soft soda lye (*soude douce*) must be used at the beginning, as we said.

"The next operation is that called *relargage*, the object of which is to separate the large quantity of water which has been used to facilitate the *empâtage*. This separation of the water, or *relargage*, is effected by means of salted soda (that is to say, of soda ash, containing a good deal of common salt), of which as much is dissolved in water as will make a lye marking 20° or 25°. This salted lye is then gradually poured by a workman on the surface of the saponifying goods in the copper, while another workman is diffusing it in the mass by stirring the whole with a rake or crutch.

"The immediate effect of the salt thus added is to separate from the soapy mass the water in which it was dissolved, and which gave it a homogeneous and syrupy appearance, and to coagulate it, the soap being thereby curded or coagulated, and converted into a multitude of granules floating among the excess of water in which they were dissolved, and which the salt has separated. The whole being then left at rest for two or three hours, in order to give the grains of soap time to rise and agglomerate at the surface, a workman proceeds to the *épinage*, an operation which consists in withdrawing the liquid portion by removing a wooden plug placed at the lower part of the boiler."

In this country the *épinage* is generally performed by means of an iron pump plunging through the soap down to the pan at the bottom of the copper.

This *spent lye*, in well-conducted factories, retains but little alkali, and is generally thrown away; but as it contains a rather large quantity of salt, which, in France, is an expensive article, it might be, and is sometimes, kept and used for preparing fresh lyes.

After the first *épinage*, the soap is treated twice again with salt lye, followed of course by two *épinages;* but as the salt lye used in these two operations is not exhausted, it is always kept for preparing fresh lyes.

The cleansing, that is to say, the removing of the soap into the frames, takes place on the third day, at which time the operation called *madrage* is performed. For that purpose a plank is thrown across the boiler or copper, and two or three men standing on it, and therefore over the soapy mass in the copper, proceed to stir it up for two or three hours, by means of long crutches, which they alternately move up and down through it, the object being to keep the grains of soap well diffused through the liquid, weak lyes marking only 8° or 10°, or ordinary water, as the case may be, being sprinkled from time to time into the mass, until the grains of soap have reabsorbed a sufficient quantity of water and have swollen to such a size as to have a specific gravity very little greater than that of the liquid among which they float about. A skilful workman knows by the appearance of the soap grains whether he should use alkaline lyes or simply water, and this is indeed a most important point in the manufacture of *Marseilles* soap, for upon it the success of the operation depends in a commercial point of view, that is to say, all things being equal in other respects, a profit or loss on the batch of soap made will ensue. In effect, if too much water has been added the soap will lose either the whole, or too great a portion of its *mottling*. that is to say, the result will be either a dingy white curd, or a soap in which the white portions will predominate to too great an extent over the blue streaks, a circumstance which so far deteriorates the market value, the buyer shrewdly suspecting then that he would pay for water the price of soap. If, on the contrary, a sufficient quantity of water has not been added, the soap grains remaining hard and dry, will form more or less friable, thereby causing also a deterioration of price, the buyer knowing that such soap, by crumbling into small pieces every time he has to cut it with his knife in selling it to his customers, will considerably reduce his profit, or perhaps even entail a positive loss to him.

In the best conditions, that is to say, by employing the best Gallipoli oil for the purpose of producing Marseilles soap of first quality, 100 cwt. of olive oil yield 175 cwt. of mottled soap ; by using mixtures of olive and rape or other seed oils, the yield of soap is reduced to 170, or even less ; in either case the yield is reduced by 5 or 6 per cent. when old or fermented is employed instead of new good oil.

The manufacturing expenses are calculated at Marseilles at the rate of 17f. 25c. (nearly 13*s.* and 10*d.*) per 100 kilogrammes of fatty matter employed, which require 72 kilogrammes of soda for their saponification.

Mottled soap has a marbled, or streaky appearance, that is to say, it has veins of a bluish colour, and resembling granite in their disposition or arrangement. The size and number of these veins or speckles, and the proportion which they bear to the white ground of the soap, depend not only on the more or less rapid cooling of the soap after it has been cleansed, that is, transferred from the copper to the frame ; but also on the quality and kind of the fat, grease, or oil employed, and on the manner in which it has been treated in the copper. A soap which has not been sufficiently boiled at the last stage of the manufacture is always tender. The blue or slate-colour of the streaks or veins of mottled soap is due to the presence of an alumino-ferruginous soap interposed in the mass, and frequently also to that of sulphuret of iron, which is produced by the reaction of the alkaline sulphurets contained in the soda lye upon the iron, derived from the soda ash itself, and from the iron pans and other utensils employed in the manufacture, or which is even purposely introduced in the state of solution of protosulphate of iron. This introduction, however, is never resorted to, I believe, in this country. The veins or streaks disappear from the surface to the centre by keeping, because the iron becomes gradually peroxidised. A well-manufactured mottled soap cannot contain more than 33, 34, or at most 36 per cent. of water, whereas genuine curd soap contains 45, and yellow soap at least 52 per cent. of water, and sometimes considerably more than that. It is evident, in effect, that the mottling being due to the presence of sulphuret of iron held in the state partly of demisolution and of suspension, the addition of water would cause the colouring substances to subside, and a white, unicoloured, or fitted soap would be the result. This addition of water, technically called *fitting*, is made when the object of the manufacturer is to obtain a unicoloured soap, whether it be curd or yellow soap. After *fitting*, the soap contains, therefore, an additional quantity of water, which sometimes amounts to 55 per cent.: the interest of the consumer would, therefore, clearly be to buy mottled soap in preference to yellow or white soap; the mottling, when not artificially imitated, being a sure criterion of genuineness; for the addition of water, or of any other substance, would, as was just said, infallibly destroy the mottling. To yellow or curd soap, on the contrary, incredible quantities of water may be added. I have known five pails of water (15 gallons) added to a frame (10 cwt.) of already *fitted* soap, so that the soap, by this treatment, contained upwards of 60 per cent. of water, to which common salt had previously been added. The proportion of water in fitted soap has also been augmented, in some instances, by boiling the soap in high pressure boilers before *cleansing*. As cocoa-nut oil has the property of absorbing one-third more water, when made into soap, than any other material, its consumption by the soap maker has, within the last fifteen or twenty years, augmented to an extraordinary extent; and, moreover, the patent taken in 1857 by Messrs. Blake and Maxwell, of Liverpool, for the invention of Mr. Kottula, which we shall describe presently, has, I believe, increased the demand for that species of oil in a notable degree. We said that the mottling, inasmuch as it was indicative of genuineness, was the more economical soap to buy; unfortunately, mottled soap has the drawback of not being so readily soluble as yellow soap, and the goods washed with it are more difficult to rinse; but the process patented by Messrs. Blake and Maxwell enabling the manufacturer to manufacture with cocoa-nut oil a soap to which the mottling is artificially imparted, by means of ultramarine, black or brown oxide of manganese, in such a perfect manner as almost to defy detection, mottling has thus ceased to be a safe outward sign of genuineness, as far as regards the article which it pretends to represent. That description of soap, however, has specific qualities; it is almost perfectly neutral, and it will not bear more than a definite proportion of water; so that, although it contains more of that liquid than ordinary mottled soap,—more than a certain fixed quantity cannot be forced into it; so that it also forms a standard soap, like the ordinary mottled, although that standard is different from, and inferior to, the latter. The process in question is briefly as follows:—Take 80 cwt. of palm oil, made into soap in the usual way, with two changes of lye, grained with strong lye, or lye in the usual manner, but so that the lye leaves the curd perfectly free; pump the spent lye away, and add 32 cwt. of cocoa-nut oil, 60 cwt. of lye, at 20° of Beaumé's areometer, and then gradually 14 cwt. of lye, at 14° Beaumé. Boil until the whole mass is well saponified. Put now from 6 to 7 lbs. of ultramarine in water, or weak lye, stir the whole well, and pour it into the soap through the rose of a watering-pot; boil the whole for about half an hour, or an hour, and cleanse it in the ordinary wooden frames, or in iron frames surrounded by matting, or other covering, so that the soap may not cool too rapidly: the above proportions will yield 212 cwt. of soap, with a beautiful blue mottle.

Manufacture of yellow or rosin soap.—We have already said that rosin, though not capable of forming a soap with soda, readily dissolves in that alkali, either in the caustic or in the carbonated state, with which it forms a kind of soapy mass of a viscid or treacly nature; 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 neutralised 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. The maker next proceeds to draw off the 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 or *fob* removed for another operation, the soap is laded off by hand-pails into its frame-moulds. A little palm oil is occasionally 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 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. For plain yellow or curd soaps iron frames are now used instead of wooden ones in almost every factory.

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 hemispheral 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.

Dr. Normandy has 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, sp. gr. 0·9669, consists of—

Soda - - - - - -	10·5
Pasty-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

* By my own experiments upon the liquid silicate made at Mr. Gibbs's excellent soap factory.

Glasgow white soap—

Soda	6·4
Tallow	60·0
Water	33·6
	100·0

Glasgow brown rosin soap—

Soda	6·5
Fat and rosin	70·0
Water	23·5
	100·0

A London cocoa-nut oil soap was found to consist of—

Soda	4·5
Cocoa-nut lard	22·0
Water	73·5
	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
	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
	100

M. D'Arcet states the analysis of Marseilles soap at—

Soda	6
Oil	60
Water	34
	100

With respect to the manufacture of sulphated soap, the process is as follows:—

To every ton of soap made in the usual way and ready to be cleansed and crystallised, add sulphate of soda (Glauber salt) in the proportion of about 1 cwt. or more, according to the quality of the goods employed. The Glauber salt should first be dissolved by turning steam into it, or in a steam pan, in its own water of crystallisation; it is then added to the finished soap, and the whole must be crutched until the mass has become so stiff that it cannot be crutched any longer. In the evidence before the Privy Council, in the month of July, 1855, this process was found by their lordships of such public value that the patent right was extended for three years.

This process, however, has been superseded by another which Dr. Normandy patented in the month of August, 1855. In effect it had been found that whereas sulphate of soda is more soluble in lukewarm than in either cold or boiling water, the temperature of the weather in summer time interfered with or altogether prevented the formation of the crystals, and that as the crystals of this salt contain ten equivalents of water, the maker of sulphated soap was put to the trouble and expense of the carriage of this to him useless water of crystallisation.

Soft soap.—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 crystallisation 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; it 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.

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

* Dr. Normandy's experiments. See Fats, Oils, and Stearine.

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 lyes; 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; ou 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 sp. gr. 1·05; and the strongest, 1·20, or even 1·25. Being made from the potashes of commerce, which contain 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 iu 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 upou 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 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 has 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 analysed, 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 cousisted 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 filling woollen cloth, called *savon économique*, 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; and 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 *aimes* (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 operator 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; when, if it gets covered with a skin, he pours fresh oil into the pan, and continues the boil till the soap is perfect. No wonder the Belgian soap is bad, amid such groping in the dark, without one ray of science!

Besides water, soap is often adulterated by gelatine, forming a soap sometimes called "bone soap," which is made by adding to the soap a solution of disintegrated bones, sinews, skins, hoofs, sprats, and other cheap fish in strong caustic soda; also by dextrine, potato starch, pumice stone, silica, plaster, clay, salt, chalk, carbonate of soda, &c., and by fats of another or inferior kind than those from which they are represented to have been made. These impurities or superadded materials and their amount may be ascertained in the following manner:

Estimation of the quantity of water:— Take about 1000 grains of the soap under examination, cut into small and thin slices, not only from the outside, which is always dryer, but from the interior of the sample, so that the whole may represent a fair average; mix the mass well together, and of this weigh accurately 100 grains; place it in an oven heated to a temperature of 212° Fahr., until it is quite dry, weighing it occasionally until no loss or diminution of weight is observed, the difference between the original and the last weight, the loss, indicates, of course, the proportion of water. The loss of water in mottled soap and in soft soap should not be more than 30 to 35 per cent.; in white or yellow soap from 36 to at most 50 per cent.

If the soap is sulphated, the amount of sulphate employed may be determined by taking 200 grains of the sample, dissolving it in a capsule with boiling water, adding to the boiling solution as much hydrochloric acid as is necessary to render the liquid strongly acid, and therefore to decompose the soap entirely, throwing the whole in a filter previously wetted with water, adding to the filtrate an excess of chloride of barium, washing thoroughly the white precipitate so produced, igniting and weighing it; every grain of sulphate of barytes thus obtained represents 1·467 grain of crystallised sulphate of soda.

If the soap contains clay, chalk, silica, dextrine, fecula, pumice stone, ochre, plaster, salt, gelatine, &c., dissolve 100 grains of the suspected soap in alcohol, with the help of a gentle heat; the alcohol will dissolve the soap and leave all these impurities in an insoluble state. Good mottled soap should not leave more than 1 per cent. of insoluble matter, and white or yellow soap still less. All soap to which earthy or siliceous matter has been added is opaque instead of transparent at the edges, as is the case with all genuine or fitted and sulphated soap. The drier the soap, the more transparent it is.

Bone soap, or glue soap, is recognised by its unpleasant odour of glue and its dark colour, its want of transparency at the edges; that made with the fat of the intestines of animals has a disgusting odour of *fæces.*

When uncombined silica has been added to soap, its presence may be readily detected by dissolving the suspected soap in alcohol, as before, when the silica will be left in an insoluble state; but if the silica is in the state of silicate of soda or of potash, it is necessary to proceed as follows:—dissolve a given weight of the suspected soap in boiling water, and decompose it by the gradual addition of moderately dilute hydrochloric acid, until the liquor is strongly acid; boil the whole for one or two minutes longer and allow it to cool in order that the fatty acids having separated and become hard, may be removed. Evaporate the acid liquor to *perfect dryness*, and the perfectly dry mass treated with boiling water will leave an insoluble residue which may be identified as silica by its grittiness, which is recognised by rubbing it in the capsule with a glass rod. This white residue should then be collected on a filter, washed, dried, ignited, and weighed.

The proportion of alkali (potash or soda) may be easily determined by an alkalimetrical assay as follows:—

Take 100 grains of the soap under examination, and dissolve them in about 2000 grains of boiling water; should any insoluble matter be left, decant carefully the superincumbent solution and test it with dilute sulphuric acid of the proper strength, exactly as described in the article on *alkalimetry.*

The proportion of alkali contained in soap may also be ascertained by incinerating a given weight of soap in an iron or platinum spoon, crucible, or capsule, treating the residue with water, filtering and submitting the filtrate to an alkalimetrical assay. This method, however, cannot be resorted to when the soap contains sulphates of alkalies, because the ignition would convert such salts, or a portion thereof, into carbonates of alkali, which by saturating a portion of the test-sulphuric acid would give an inaccurate result.

The proportion of oil or fat in soap is ascertained by adding 100 grains of pure white wax free from water to the soap solution, after supersaturation with an acid, and heating the whole until the wax has become perfectly liquid, and has become perfectly incorporated with the oil or fat which has separated by the treatment with an acid. The whole is then allowed to cool, and the waxy cake obtained is removed, heated in a weighed crucible or capsule to a temperature of about 220° Fahr. in order to expel all the water, after which the whole is weighed; the increase above 100 grains (the original weight of the wax) indicates, of course, the quantity of grease, fat, or oil contained in the soap. This addition of wax is necessary only when the fatty matter of the soap is too liquid to solidify well in cooling. Good soap ordinarily contains from 6 to 8 per cent. of soda; from 60 to 70 per cent. of fatty acids and rosin, and from 30 to 35 per cent. of water.

The nature of the fat of which a given sample of soap has been made is more difficult to detect, yet by saturating the aqueous solution of the mass under examination with an acid, collecting the fatty acids which then float on the surface, and observing their point of fusion, the operator at any rate will be thus enabled to ascertain whether the soap under examination is identical with the sample from which it may have been purchased, and whether it was made from tallow, or from oil, &c.

When the fatty acids which have been isolated and collected by decomposing the soap with an acid, as already described, are heated in a small capsule the odour evolved is often characteristic, or at least generally gives a clue to the nature of the fats or oils from which the soap has been made. This odour is often sufficiently perceptible at the moment when the aqueous solution of the soap is decomposed by the acid poured in. Cocoa-nut oil can always be detected when in proportions at all available to the soap maker by *tasting* the soap, that is to say by leaving the tongue in contact with the soap for a few moments, when a peculiar, very disagreeable and bitter flavour will become more or less perceptible.

Properly made soap should dissolve completely in pure water; if a film or oily matter is seen to float on the surface, it is a proof that all the fat is not saponified. Another test is that the fatty or oily acid separated by decomposing the aqueous solution of the soap by hydrochloric acid, should be *entirely* soluble in alcohol.

Soft soaps, as we said, are combinations of fats or oils with potash, or rather are solutions of a potash soap, in a ley of potash, and they therefore always contain a great excess of alkali, and a more or less considerable proportion of water; they contain also a certain quantity of chlorides, of sulphates, and all the glycerine which the saponifying process has set free. Soft soap in this country is generally used for fulling, and for cleansing and scouring woollen stuffs. In Belgium, Holland, and Germany it is used also for washing linen, which thereby acquires an almost intolerable odour of fish oil, which no amount of perfume can mask, fish oil being generally employed in the manufacture of that description of soap. The most esteemed soft soap, however, is that made from hempseed oil, which imparts to the soap a greenish colour, but this much prized colour is generally or very often artificially given to the soap made of other oil, which soap has a yellow colour, by means of a little indigo finely pulverised and previously boiled for some time in water.—A. N.

SOAP-BARK. Several months ago, a peculiar bark was introduced into the European trade, and recommended to be employed instead of soap for washing and cleaning printed goods, woollens, and silks, and especially for the delicate colours of ladies' dresses, &c.

This soap-bark is externally black coloured, but internally the liber consists of concentric layers of yellowish white. The bark is remarkable for its density, as it sinks in water. The cause of this is the great quantity of mineral substances in its ashes, there being 13·935 per cent. of the internal parts, dried at low temperature and 18·50 per cent. when dried at a 100° C. The ashes consist largely of carbonate of lime, which forms 2·60 per cent. of the 13·935, and appears as small crystalline needles, isolated or in groups, in the cells of the liber, not only between its concentric rings but in every part of it. They glitter in the sun, resembling, under the microscope, the arragonite form of the crystallised carbonate of lime.

The soap-wort (*Lychnis*, our *Saponaria*) is everywhere sold in the shops for scouring and cleaning dresses. Several of the family of the caryophyllaceous plants (*Dianthus*, *Lychnis*, *Gypsophila*, *Silene*) are remarkable for this property in a greater or less degree. By recent chemical means there has been extracted from these roots the *Saponine* (or *Struthiine*), a special substance, and to this, notwithstanding the very small quantity contained in the roots, the singular power is attributed of making emulsions, and of being used for soap in washing. The soap-wort of the Levant (*Gypsophila*) is, to this day, employed in the East for washing and cleaning silks and shawls. It was generally used in the Mediterranean districts of France and Spain; the French called it *herbe aux foulons* (the fuller's plant). The *Saponaire*, or *Savonnière* of the French, is the root of a kind of *Lychnis*.

The vegetable soap principle, or saponine, was found by Henry and Boutron Charland, in the bark of the *Quillaja saponaria*. *Le Quillay* is a tree of the family of Spiræaceous plants, a native of Huanuco, in Peru. Ferdinand Lebeuf made mention of this bark in 1850 (*Comptes rendus de l'Académie des Sciences à Paris*, xxxi. p. 652) for its richness in saponine, and recommended it for pharmaceutical use in preparing emulsions of oils, rosins, balsams, and several other medicaments. He mentions likewise the bark of the *Yallhoy* (*Monina polystachia*).

SOAPSTONE. See STEATITE.

SODA. (NaO.) This is the oxide of the metal sodium, and can only be obtained in the free state by the combustion of the metal itself in dry air or oxygen gas. Another oxide appears to exist, but its composition is uncertain and is of no commercial value. Soda (*oxide of sodium*), thus prepared, is a white solid, very much resembling the oxide of potassium (KO), and like it absorbs moisture rapidly, the whole of which cannot be again removed by heat alone, the hydrate (NaO,HO) remaining, which also greatly resembles the hydrate of potash (KO,HO). This hydrate of soda, which is largely used in the manufacture of soap, is not prepared from the anhydrous oxide, but by removing the carbonic acid from carbonate of soda by the means of hydrate of lime (CaO,HO). When required in the solid state, the carbonate of lime thus formed is allowed to settle, the clear supernatant liquid is poured off and evaporated to dryness, fused in a silver vessel, and cast into sticks, just as hydrate of potash.

The following is a table of the quantities of real soda (NaO) in the solutions of different specific gravities.—*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
1·00	9·43						

H. K. B.

SODA ALUM. See ALUM.

SODA, BIBORATE. See BORACIC ACID, and BORAX.

For the other salts of soda which are not used in the arts, &c., see *Ure's Chemical Dictionary*.

SODA, BISULPHATE. ($NaSO^4,HSO^4$.) This is obtained in the same manner as bisulphate of potash, with which it corresponds.

SODA, CARBONATE OF (*Kohlensaures natron*, Germ.), is the soda of commerce in various states, either crystallised, 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 anciently 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 burnt 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 comparatively compact. The most valuable variety of this article is called *sweet barilla*. It has a greyish-blue colour, and becomes 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.

Another method 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-weeds 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 low, its principal use being now to obtain iodine. See IODINE.

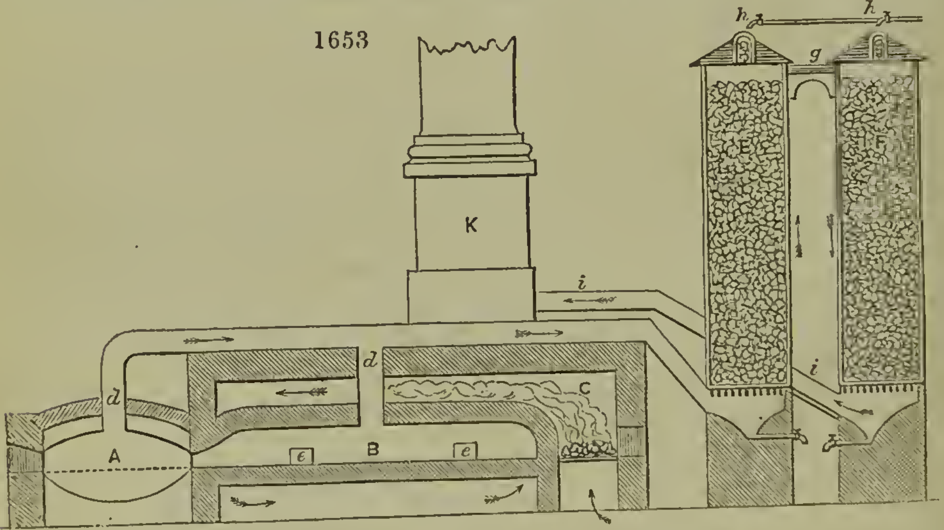
The crystals of soda carbonate, as well as the soda-ash of British commerce are now made altogether by the decomposition of sea salt.

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 workmen. 3. The purification of these balls, either into a dry white soda-ash or into crystals.

1. *Preparation of Sulphate of soda.* The decomposition of the common salt (*chloride of sodium*) by sulphuric acid is effected in furnaces of which fig. 1653 is a drawing,

1653



taken from Dr. Miller's *Elements of Chemistry*. A, the smaller of the two compartments which compose the furnace, is of cast iron; into this (*the decomposer*) from five to six hundred weight of common salt are introduced, and an equal weight of sulphuric acid, of specific gravity 1·6, is gradually mixed with it; a gentle heat being applied to the outside, enormous volumes of hydrochloric acid gas are disengaged, and pass off by the flue, *d*, to the condensing towers, E and F; these towers are filled with fragments of broken coke or stone, over which a continuous stream of water is caused to trickle slowly from *h h*. A steady current of air is drawn through the furnace and condensing towers, by connecting the first tower with the second, as represented at *g*, and the second tower with the main chimney, K, of the works. In the first bed of the furnace, about half of the common salt is decomposed, leaving a mixture of bisulphate of soda and common salt, which requires a greater heat for the expulsion of this latter portion of hydrochloric acid; for this purpose it is pushed through a door into the *roaster*, or second division, B, of the furnace.

The reaction in the first bed of the furnace is represented as follows:—

$$\underbrace{2NaCl}_{\text{Common salt.}} + \underbrace{2HSO^4}_{\text{Sulphuric acid.}} = \underbrace{NaSO^4\ HSO^4}_{\text{Bisulphate of soda.}} + \underbrace{HCl}_{\text{Hydrochloric acid.}} + \underbrace{NaCl.}_{\text{Common salt.}}$$

By the higher temperature obtained in this second part of the furnace, the bisulphate of soda reacts on the undecomposed chloride of sodium, yielding neutral sulphate of soda and a fresh quantity of hydrochloric acid.

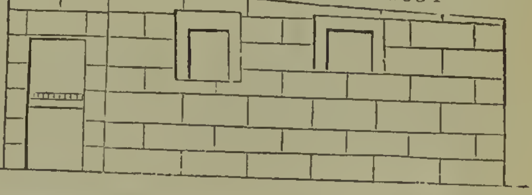
$$\underbrace{NaSO^4,\ HSO^4}_{\text{Bisulphate of soda.}} + \underbrace{NaCl}_{\text{Common salt.}} = \underbrace{2(NaSO^4)}_{\text{Sulphate of soda.}} + \underbrace{HCl.}_{\text{Hydrochloric acid.}}$$

The hydrochloric acid gas, as it is liberated from B, passes off through the flue, *d*, and is carried on to the condensing towers. Heat is applied to the outside of the roaster, B; the smoke, C, circulating in separate flues around the chamber, in the direction indicated by the arrows, but never coming into contact with the salt cake in B.

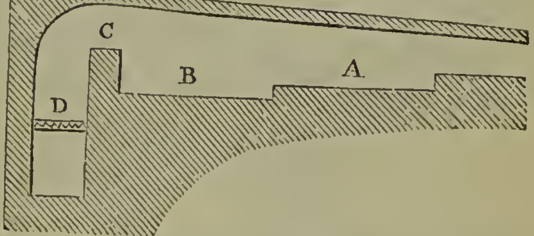
By the kindness of J. L. Bell, Esq., of Newcastle-upon-Tyne, we are enabled to give the process used at present in that district. It differs but little from that above described, with the exception that in the decomposition of the mixture of bisulphate of soda and common salt, in the second portion of the furnace, the smoke and products of combustion from the fire, are allowed to come in contact with the materials, and the hydrochloric acid which is then given off is carried to condensing towers filled with bricks over which water is continually slowly running, and the dilute hydrochloric acid, thus obtained, is used for the liberation of carbonic acid in the manufacture of bicarbonate of soda. The first part of the furnace is a circular metal pan, and the hydrochloric acid from this being unmixed with smoke, &c., is condensed apart from the other.

The next step in the manufacture is the decomposition of the sulphate of soda into sulphide of sodium, and its subsequent conversion into carbonate of soda. This is effected in the following manner. The dry sulphate of soda, obtained by the process above described, is mixed with small coal and chalk, or limestone, in about the following proportions; sulphate of soda 3 parts, chalk 3½ parts, and coal two parts. It is necessary that these materials should be first separately ground, and sifted into a tolerably fine powder, and then carefully mixed, as a great deal depends on the attention to these points. The mixture is then subjected to heat in a reverberatory furnace, *figs.* 1654, 1655, 1656.

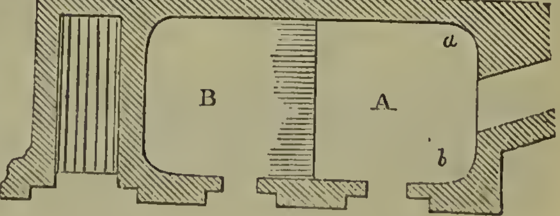
1654



1655



1656



In the section *fig.* 1655, there are two hearths in one furnace, the one elevated above the level of the other by the thickness of a brick, or about three inches. A 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, B, it may not essentially chill it, and throw back the operation. C is the fire bridge, and D is the grate. In the horizontal section, or ground plan, *fig.* 1656, 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.* 1654; 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 COAL, COKING OF. 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, we shall now proceed to describe the mode of making soda with it.

The quantity of this mixture required for a charge depends, of course, on the size of the furnace. This charge must be shovelled in upon the hearth, A, or shelf of preparation (*fig.* 1655); 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 carbonised 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 versâ*. The dexterous management of this transposition characterises 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 product thus obtained is called "black balls," which, of course, vary in their composition. The following is the composition, according to Richardson, of the Newcastle "black balls" from the balling furnaces:—

Carbonate of soda 9·89, *hydrate of soda* 25·64, *sulphide of calcium* 35·57, *carbonate of lime* 15·67, *sulphate of soda* 3·64, *chloride of sodium* 0·60, *sulphide of iron* 1·22, *silicate of magnesia* 0·88, *carbon* 4·28, *sand* 0·44, *and water* 2·17.

The *principal* changes which take place in this process may be represented by the following equations.

$$\underbrace{NaSO^4}_{\text{Sulphate of soda.}} + \underbrace{4C}_{\text{Carbon.}} = \underbrace{NaS}_{\text{Sulphide of sodium.}} + \underbrace{4CO}_{\text{Carbonic oxide.}}$$

then—

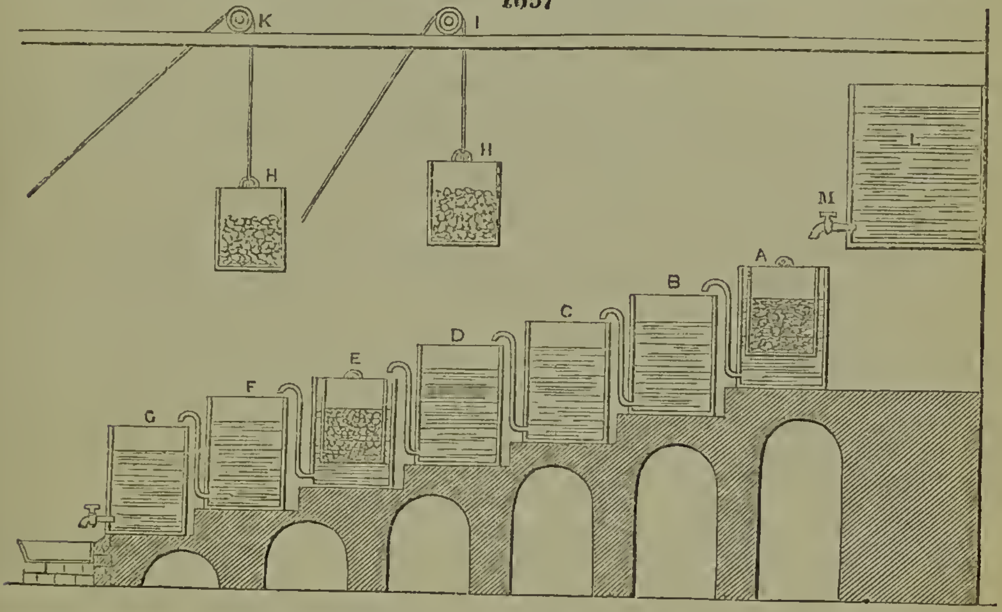
$$\underbrace{NaS}_{\text{Sulphide of sodium.}} + \underbrace{CaCO^3}_{\text{Chalk.}} = \underbrace{NaCO^3}_{\text{Carbonate of soda.}} + \underbrace{CaS}_{\text{Sulphide of calcium.}}$$

In the first place, the sulphate of soda is deoxidised by the coal, with the formation of sulphide of sodium and carbonic oxide, which latter takes fire and forms the candles, above mentioned; in the next place, the sulphide of sodium and carbonate of lime (chalk) decompose each other, forming carbonate of soda and sulphide of calcium; and from the fact of some of the chalk being converted into caustic lime by the heat of the furnace, there is also formed by it some caustic soda; the sulphide of calcium itself is only sparingly soluble in water, but is rendered still less so by the excess of lime which is present, forming with it an oxysulphide, which is much less soluble than the sulphide of calcium alone.

This *black ball* or *ball alkali*, is then treated with warm water to extract the soluble matters. This is effected in the district of Newcastle-on-Tyne in vessels 8 or 10 feet square and 5 or 6 feet deep, furnished with false bottoms; the first waters are strong enough for boiling down, for getting yellow salt, as it is termed; the after washings, which are weaker, are used for fresh quantities of "ball alkali." Care must be taken not to use the water too hot, as the oxysulphide of calcium would be decomposed, and the liquor thus take up much sulphide of calcium.

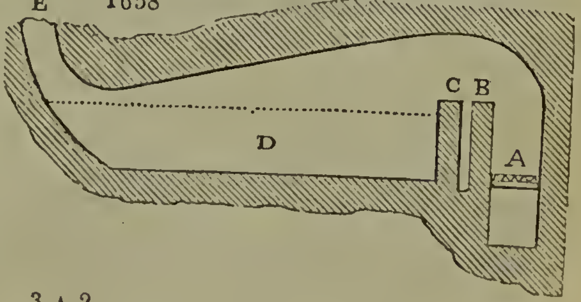
An apparatus used in some places for lixiviating the black ball is shown in the accompanying drawing, *fig.* 1657, taken from Dr. Miller's "Elements of Chemistry." Its object is to extract the largest quantity of soluble matter with the smallest quantity of water. The black ball is placed in perforated sheet-iron vessels, H H, which can be

1657



raised or lowered into outer lixiviating vessels, also made of iron, by means of the cords and pulleys, I, K. When a charge is received from the furnace, it is introduced into the lowest vessels, G, where it is submitted to the dissolving action of a liquid already highly charged with alkali from digestion upon the black ash contained in the tanks above it; after a certain time this charge is raised by the rope from G, into the tank F, where it is submitted to a weaker liquid, and so on, successively. The alkali at each stage becomes more completely exhausted, and the residue is successively submitted to the action of weaker lye, till at length, in A, it is acted on by water only, supplied from the cistern, L. When fresh water is admitted from M, to the top of the vessel, A, as it is specifically lighter than the saline solution, it lies upon its surface, and gradually displaces the solution from A, through the bent tube, whilst the water takes its place; the liquid thus displaced from it, acts in like manner upon that contained in B; and this displacement proceeds simultaneously through each successive tier of the arrangement, until the concentrated lye flows off from G, and is transferred to the evaporating pans. The residue which remains after this treatment contains nearly all the sulphur present in the ball alkali, in the form of oxysulphide of calcium, together with the other insoluble portions, and is of no value; it accumulates to an immense extent in large soda works, and is thus a source of annoyance. Many trials have been made to obtain the sulphur contained in it, and to use it for the reproduction of sulphuric acid, but without much success hitherto.

1658



The solution obtained by thus lixiviating the ball soda, contains principally carbonate of soda and hydrate of soda, as well as some sulphide and chloride of sodium, and a little sulphate of soda. It is allowed to settle; then the clear liquor is drawn off into evaporating vessels. These may be of two kinds. The surface-evaporating furnace, shown in *fig.* 1658, is a very admirable invention for economising vessels, time, and fuel. The grate A, and fire-place, are separated from the evaporating laboratory D, 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 E, 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.* 1640, 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 volatilise 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 calker 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 crystallising cisterns of cast-iron, or lead-lined wooden cisterns. The above dry carbonate is the best article for the glass manufacture.

Instead of this last process of roasting with sawdust, Gossage decomposes the sulphide of sodium present in the lye obtained from the ball soda, by means of the hydrated oxide of some metal, as of lead, thus forming sulphide of lead, and hydrate of soda; this is then converted into carbonate by passing a stream of carbonic acid through it. The precipitated sulphide of lead is decomposed by hydrochloric acid, thus generating sulphuretted hydrogen, which is burnt and converted into sulphuric acid; the lead is then converted again into hydrated oxide by means of lime. This process saves the trouble, time, and fuel used in evaporating to dryness twice as in the ordinary process.

Various attempts have been made to obtain processes which shall supersede the process above described, of manufacturing carbonate of soda from common salt, but none appear to have been successful to any great extent. We shall here mention some of them.

1. Sulphate of iron, being a cheap article, has been heated with common salt instead of using sulphuric acid; sulphate of soda is formed, and the chloride of iron, being volatile, passes away. The latter part of the process was of course similar to that above described. 2. By roasting iron or copper pyrites directly with chloride of sodium, sulphate of soda has been obtained, and it has been found possible by this means also to extract the metal from ores of copper or tin with advantage, which are otherwise too poor to work. Mr. Tilghman effects the decomposition of chloride of sodium by steam at a high temperature, in the presence of alumina. Precipitated alumina is made up into balls with chloride of sodium, and exposed to a current of

steam in a reverberatory furnace strongly heated. Hydrochloric acid is expelled and the alumina unites with the soda.

$$\underbrace{NaCl}_{\text{Chloride of sodium.}} + \underbrace{Al^2O^3}_{\text{Alumina.}} + \underbrace{HO}_{\text{Steam.}} = \underbrace{NaO,Al^2O^3}_{\text{Aluminate of soda.}} + \underbrace{HCl.}_{\text{Hydrochloric acid.}}$$

When cold, this compound of alumina and soda is decomposed by a current of carbonic acid, and the carbonate of soda is dissolved, and thus separated from the alumina, which may be again used. Another process is that patented by MM. Schlœsing and Rolland, which is as follows: they dissolve the chloride of sodium in water, and then pass ammonia into it, and afterwards carbonic acid; bicarbonate of ammonia is first produced, and then double decomposition takes place; chloride of ammonium is formed, and the more sparingly soluble bicarbonate of soda is precipitated in crystalline grains; it is then separated from the liquid and pressed, to free it as much as possible from the chloride.

$$\underbrace{NaCl}_{\text{Chloride of sodium.}} + \underbrace{NH^4CO^3,HCO^5}_{\text{Bicarbonate of ammonia.}} = \underbrace{NaCo^3,HCO^3}_{\text{Bicarbonate of soda.}} + \underbrace{NH^4Cl.}_{\text{Chloride of ammonium.}}$$

This bicarbonate of soda is converted into the monocarbonate by heat, and the carbonic acid thus evolved is used again; the solution, from which the bicarbonate has separated, is boiled to drive off any ammonia that it may contain, as carbonate of ammonia, which is collected; the solution is then boiled with lime, which liberates the ammonia from the chloride of ammonium, and thus little loss is sustained, the same ammonia serving continually, within certain limits, because, of course, some ammonia escapes and is unavoidably lost.

There are three carbonates of soda commonly known, viz., *monocarbonate, sesquicarbonate*, and *bicarbonate.*

Monocarbonate. $NaCO^3+10HO$. This is the salt which is obtained in the ordinary soda manufacture. In the crystalline state, it generally contains ten equivalents of water of crystallisation, sixty-three per cent., but has been obtained with only eight, five, and even one equivalent of water. It effloresces in a dry atmosphere, at the same time absorbing carbonic acid. It is very soluble in water, requiring only twice its weight of water at 60° for solution, and even melts in its own water of crystallisation when heated, and eventually by increase of temperature becomes anhydrous. It is generally found in commerce in large crystals, which belong to the oblique prismatic system. It is strongly alkaline, and acts on the skin, dissolving the outside cuticle. It is largely used in the manufacture of soap, glass, &c., and is generally too well known to require much description.

The soda trade made great progress in 1859, as compared with the two preceding years. In 1857, 1,538,988 cwts. were exported, of the value of 760,741*l.*; and in 1858, 1,618,289 cwts., of the value of 813,727*l.*; whilst last year the quantity was 2,027,609 cwts., and the value 1,024,283*l.*

Sesquicarbonate. $2NaCO^3,HCO^3$. This salt is frequently found native, and is described under NATRON (which see).

Bicarbonate. $NaCO^3,HCO^3$. This salt is found in some mineral waters, as those of Carlsbad and Seltzer; and is obtained from the waters of Vichy in large quantities. It is prepared by saturating the monocarbonate with carbonic acid, for which purpose several methods are employed.

1. *By passing carbonic acid into a solution of the monocarbonate.* A cold saturated solution of the monocarbonate of soda is made, and carbonic acid, obtained by the action of hydrochloric acid on marble or chalk, is passed into it; the bicarbonate forms and precipitates to a great extent, and is then collected, pressed to remove as much of the adhering liquid as possible. A fresh portion of the monocarbonate is dissolved in the mother liquor, and the passage of carbonic acid through it repeated. By this method a pure bicarbonate is obtained, but the process is costly.

2. *By exposing solid monocarbonate of soda to an atmosphere of carbonic acid gas.* This is known as Smith's process. The crystals of the monocarbonate are placed on shelves, slightly inclined to allow the water to run off, in a large box, containing a perforated false bottom; carbonic acid is passed into this box under pressure, which latter is scarcely necessary, since the monocarbonate so rapidly absorbs the carbonic acid. When the gas ceases to be absorbed, the salt is taken out and dried by a *gentle* heat.

The crystals are found to have lost their water of crystallisation, and to have become opaque and porous, and a bicarbonate, still, however, retaining their original shape. These are ground between stones like flour, care being taken to avoid the evolution of much heat.

This is the most economical process, but does not yield a perfectly pure product, yet, nevertheless, quite pure enough for ordinary purposes, the impurities contained in it being a little chloride of sodium and sulphate of soda, found in the original monocarbonate from which it was made, and even these are to a great extent dissolved and carried off by the water of crystallisation as it escapes.

3. Its formation by the action of bicarbonate of ammonia has been already described.

Bicarbonate of soda crystallises in rectangular four-sided prisms, which require about ten parts of cold water to dissolve them, and if the solution be boiled, it loses carbonic acid, becoming first sesquicarbonate, and ultimately monocarbonate. As usually met with in commerce this salt is a white powder. Its taste is slightly alkaline. It is largely used in medicine, for making seidlitz powders, &c., but the salt generally found in the shops is only a sesquicarbonate, or a mixture of bicarbonate and sesquicarbonate.—H. K. B.

SODA FELSPAR. Usually called *albite*; in which soda takes the place of potash. See FELSPAR.

SODA HYPOCHLORITE. (Na,ClO^2.) This is obtained in the same manner as hypochlorite of lime, or by decomposing a solution of this latter by carbonate of soda. Its uses are the same as the hypochlorite of lime.

SODA HYPOSULPHATE. See HYPOSULPHATE OF SODA.

SODA, HYPOSULPHITE. This is now largely prepared for photographic purposes. See HYPOSULPHITE of SODA.

SODA, NITRATE OF. (NaO,NO^5.) Syn. *cubic nitre*; Chile, *saltpetre*. (*Nitrate de soude*, Fr.; *Würfelsalpeter*, Germ.) This important salt is found native in immense quantities in Chili and Peru. It is, in some parts, found in beds of several feet in thickness. As found in nature it is tolerably pure, the principal impurities being chlorine, sulphuric acid, and lime. The following analyses may be quoted as representing the composition of various samples:—

	Wittstein.	Lecanu.	Hofstetter.
Nitrate of soda	99·633	96·698	94·291
Chloride of calcium	—	—	1·990
Chloride of sodium	0·367	1·302	—
Sulphate of potash	—	—	0·239
Nitrate of potash	—	—	0·426
Nitrate of magnesia	—	—	0·858
Water	—	2·000	1·993
Insoluble matters	—	—	0·203
	100·000	100·000	100·000

It is evident that nitrate of soda can be formed artificially by saturating nitric acid with soda or its carbonate, and evaporating the solution until the salt crystallises.

Nitrate of soda is extensively and economically employed as a source of nitric acid. It is also used for the purpose of being converted by double decomposition with chloride of potassium into nitrate of potash. See NITRATE OF POTASH. It is employed in great quantities as a manure.

In analysing a sample of the salt, it should be dissolved in boiling distilled water; any insoluble matters are to be removed by the filter, and after being washed and dried, may be weighed. To the clear filtrate acidulated with pure nitric acid, nitrate of silver is to be added; the precipitate of chloride of silver when weighed with proper precautions will enable the amount of chloride of sodium to be calculated. For this purpose we say; as one equivalent of chloride of silver is to one equivalent of chloride of sodium, so is the quantity of chloride of silver obtained to the quantity of chloride of sodium in the specimen taken. In another portion of the salt, the solution being prepared as before, the sulphuric acid may be determined by precipitation with chloride of barium; and, in a third, the lime and magnesia are to be determined by precipitation, the first with oxalate of ammonia, and the latter in the filtrate from the oxalate of lime, by means of phosphate of soda and ammonia. The water may be determined by drying a known weight of the salt in the water bath until it ceases to diminish in weight.

A good sample of nitrate of soda should not contain more than two per cent. of chloride of sodium. The nitric acid may be determined by the process described under NITRATE OF POTASH.

Nitrate of soda is not applicable for the preparation of gunpowder or fireworks, partly in consequence of its tendency to attract moisture from the air, and partly owing to the fact that mixtures made in imitation of gunpowder, but having nitrate of soda in place of nitrate of potash, explode far less powerfully than gunpowder itself.

Solubility of Nitrate of Soda in Water.

One part of the salt dissolves in—

1·58 at a temperature of 21°2 Fahr.
1·25 „ „ 32·0

1·36 at a temperature of			66°·0
1·12	„	„	82·4
0·77	„	„	116·6
0·46	„	„	246·2

The above table is not perfectly satisfactory, and the solubility of nitrate of soda in water at different temperatures requires reinvestigation.

The term cubic nitre applied to this salt is incorrect; the crystals, it is true, appear cubic at a rough glance, but they are in fact, rhombohedra, of which the angles are not very far removed from those of a cube.—C. G. W.

SODA, NITRITE OF. (NaO,NO^3.) This salt is not unfrequently employed as a source of nitrous acid, especially in researches on the volatile organic bases. Nitrite of soda possesses some advantages over nitrite of potash, owing to the comparative ease with which it is prepared. In the process for preparing nitrite of potash a considerable quantity of the salt is entirely decomposed into the caustic state, the resulting product being strongly alkaline, and therefore deliquescent. But with the soda salt it is easy to produce a very pure nitrite by mere fusion, without any particular dexterity in controlling the temperature. The fused salt, like the corresponding potash compound, gives a rich and brilliant apple-green coloration when dropped into a solution of a salt of copper. Messrs. Perkin and Church have ascertained that nitrite of soda, as prepared by simple fusion of nitrate of soda at a low red heat decomposes acetate of aniline with extreme facility, yielding (probably among other products) a crystalline body to which at present they have not assigned any formula, but which evidently contains an oxide of nitrogen in the place of one of the atoms of hydrogen previously existing in the parent alkaloid. Nitrosonaphthaline may also be prepared by an analogous process from the hydrochlorate of naphthylamine.

These bodies, despite their extreme difference in properties, still belong in the most unmistakable manner to the ammonia type. The product from naphthylamine may therefore be written

$$\left.\begin{matrix} C^{20}H^7 \\ H \\ NO^2 \end{matrix}\right\} N$$

The nitrite of soda is especially adapted for the preparation of nitrite of silver. For this purpose it is only necessary to add to the soda salt dissolved in distilled water, nitrate of silver, when the nitrite of silver is immediately precipitated. In order to obtain the salt chemically pure, it is merely requisite, after slight washing, to recrystallise the salt from boiling distilled water.—C. G. W.

SODA, SULPHATE OF. ($Na,SO^4, + 10HO$.) This salt is obtained as a residue in several chemical processes, as in the manufacture of hydrochloric and nitric acids, &c., but owing to the enormous quantity used in the manufacture of carbonate of soda, it is made purposely as described above. It is generally known as *Glauber's salt*, and has been found native near Madrid, nearly pure, deposited at the bottom of some saline lakes, in anhydrous octohedra, called *Thenardite*, and also combined with sulphate of lime, as glauberite.

It crystallises in oblique rhombic prisms, which belong to the oblique prismatic system (*Pereira*). Its taste is saline, and bitterish. It is very efflorescent, and loses the whole of its ten equivalents of water by mere exposure to the atmosphere, at common temperatures (*Miller*).

There is a peculiarity in the solubility of this salt in water; its solubility gradually increases with rise of temperature, as most other salts, till at 91° F. water takes up about half its weight of the anhydrous salt. Beyond 91° F. by raising the temperature to the boiling point, one-sixth of the salt previously dissolved is deposited in the form of anhydrous acute rhombic prisms, which are again dissolved as the liquid cools to 91° F.

Another peculiarity of this salt is, that a boiling saturated solution of it, if closed hermetically, may be kept for months without crystallising, but the moment air is admitted, the whole becomes a semi-solid mass, and the temperature rises.

Sulphate of soda is used sometimes in medicine and for forming freezing mixtures, which see.—H. K. B.

SODA, SULPHITE. ($Na,SO^3 + 10HO$). This salt is prepared largely for removing the last traces of chlorine from the bleached pulp obtained in the manufacture of paper, and is hence called *antichlore*.

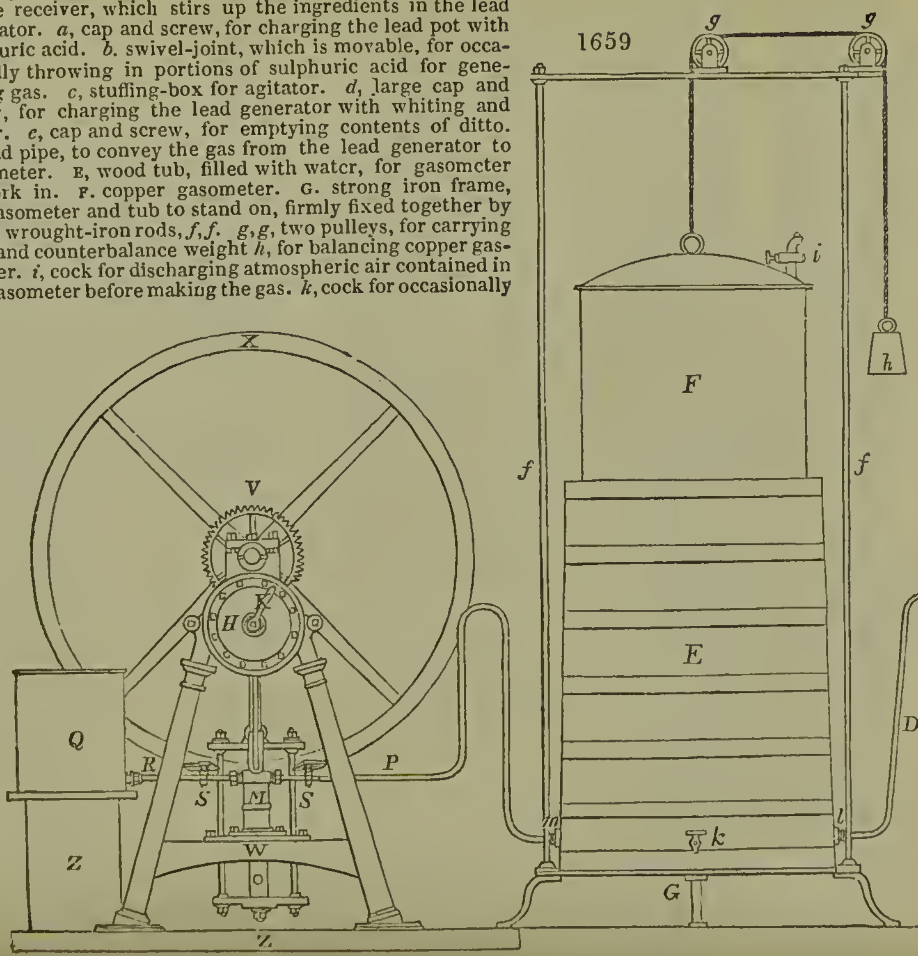
It is prepared by passing sulphurous acid gas through a solution of carbonate of soda, or on the large scale, by passing sulphurous acid gas, obtained by burning sulphur in the air, over crystals of carbonate of soda. It crystallises in oblique prisms, and is efflorescent like the sulphate of soda, which it much resembles. Its taste is sulphurous, and it possesses a slight alkaline reaction.

A bisulphite of soda also exists, which forms irregular opaque crystals.—H. K. B.

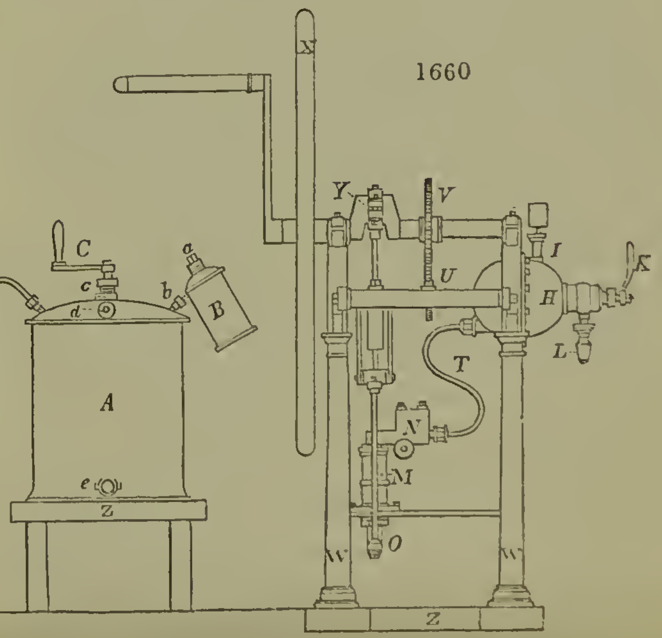
SODA WATER. A solution of soda charged with carbonic acid: for this purpose the following improved apparatus by J. Tyler & Sons, has been introduced. *Fig.* 1659, front view of the soda-water machine. *Fig.* 1660, end view of the same.

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. *a*, cap and screw, for charging the lead pot with sulphuric acid. *b*. swivel-joint, which is movable, for occasionally throwing in portions of sulphuric acid for generating gas. *c*, stuffing-box for agitator. *d*, large cap and screw, for charging the lead generator with whiting and water. *e*, cap and screw, for emptying contents of ditto. D, lead pipe, to convey the gas from the lead generator to gasometer. E, wood tub, filled with water, for gasometer to work in. F. copper gasometer. G. strong iron frame, for gasometer and tub to stand on, firmly fixed together by three wrought-iron rods, *f*, *f*. *g*, *g*, two pulleys, for carrying rope and counterbalance weight *h*, for balancing copper gasometer. *i*, cock for discharging atmospheric air contained in the gasometer before making the gas. *k*, cock for occasionally emptying 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 machine. H, H, condenser for aerating the soda-water. I, safety valve. K, K, bottling valve. L. bottling nipple. M, M, soda-water pump. N, valve-piece. O, O, piston of the pump. P, pipe for conducting gas from the gasometer to 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, pinion 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, wrought-iron crank Z, Z, Z, wood stools and curb, upon which the whole of the machinery is fixed.

1659



1660



SODIUM. (Na.) This metal was discovered by Sir H. Davy, almost immediately after potassium, and by the same means, viz., by exposing a piece of moistened hydrate of soda to the action of a powerful voltaic battery, the alkali being placed between a pair of platinum plates connected with the battery.

By this process only very small quantities could be obtained, and processes have since been devised which provide it in almost any quantity, and since the demand for sodium in the manufacture of aluminium by Wöhler's process, principally by the exertions of M. St. Clair Deville, the cost of it has been considerably diminished. The process now adopted is the same as that for obtaining potassium; an intimate, mixture of carbonate of soda and charcoal is made by igniting in a covered crucible a salt of soda containing an organic acid, as the acetate of soda, &c., or by melting ordinary carbonate of soda in its water of crystallisation and mixing with it, while liquid, finely divided charcoal, and evaporating to dryness; this mixture is mixed with some lumps of charcoal and placed in a retort, which is generally made of malleable iron, but owing to the difficulty of getting these sufficiently large, earthenware or fire-clay retorts have been used with success, and sometimes these are lined with or contain a trough of malleable iron. These retorts are so placed in a furnace that they are uniformly kept at a heat approaching to whiteness.

Mr. Beatson (*Pharmaceutical Journal*, vol. xv. p. 226), made an improvement in the process by which it can be carried on continuously for a week or fortnight. If the proportion of charcoal and soda be well regulated, the retort becomes nearly empty at the end of the process. In Mr. Beatson's process, as soon as one charge is worked off the receiver is removed, and a fresh charge is introduced through the same tube as serves to convey the sodium to the receiver, by means of a semicircular scoop, so that the retort is kept at a constant temperature, and hence little loss of time. The receiver contains rock-naphtha, and is surrounded by cold water. The manufacture of sodium, when properly conducted, is much easier and more certain than that of potassium; one advantage is, that the sodium does not unite with carbonic oxide to form the explosive compound, and the conducting tube is not so likely to be choked. The sodium which comes over is, however, mixed with some impurities, croconates, &c., and in order to separate the metal from these, Mr. Beatson melted the sodium under mineral naphtha, in a cylinder, into which is fitted a piston, worked by a screw or hydraulic press, and when this is forced down the metal forms in a mass above it, while the impurities remain at the bottom of the cylinder.

The principal reaction which takes place in the retort, is the reduction of the soda by the charcoal, which is thus converted into carbonic oxide, which escapes through an aperture in the receiver made on purpose.

$$\underbrace{NaO}_{\text{Soda.}} + \underbrace{C}_{\text{Charcoal.}} = \underbrace{Na}_{\text{Sodium.}} + \underbrace{CO.}_{\text{Carbonic oxide.}}$$

Sodium is a silver-white metal, very much resembling potassium in every respect; it is so soft at ordinary temperatures that it may be easily cut with a knife or pressed between the finger and thumb; it melts at 194° F., and oxidises rapidly in the air, though not so rapidly as potassium. Its sp. gr. is 0·972. When placed upon the surface of cold water it decomposes it with violence, but does not ignite the hydrogen which is liberated, unless the motion of the sodium be restrained, when the cooling effect is much less. When a few drops of water are added to sodium the hydrogen liberated immediately inflames, and such is also the case if it be put on hot water; when burning it produces a yellow flame, and yields a solution of soda. The equivalent of sodium is 23.

When sodium is burnt in oxygen gas or in air, two different oxides are produced, viz. the protoxide (NaO), and another whose composition is uncertain, perhaps binoxide (NaO^2) or teroxide (NaO^3). These oxides also very much resemble the corresponding oxide of potassium. The principal use of sodium is, as before stated, in the manufacture of aluminium, which is now carried on to a considerable extent. See ALUMINIUM. — H. K. B.

SODIUM, CHLORIDE OF. See SALT.

SOLANINE. A poisonous alkaloid of doubtful constitution, contained in various plants of the species *Solanum*, as *S. nigrum*, *S. dulcamara*, and in the potato (*S. tuberosum*). It is remarkable that in the shoots of potatoes which have sprouted in dark cellars the quantity of solanine is greater than in the shoots which have germinated normally. Solanine requires reinvestigation.

SOLAZZI JUICE. A name given to the best kind of Spanish liquorice, Solazzi being the maker's name. See LIQUORICE.

SOLDERING. The process of uniting together pieces of metal, by the interposition of a fusible alloy, which is called either soft or hard solder, accordingly as its fusing point is low or high. One process is called by its inventor, M. de Richemont, *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. See AUTOGENOUS SOLDERING.

SOLDERS. Alloys which are employed for the purpose of joining together metals are so called. They are of various kinds, being generally distinguished into hard and soft. Upon the authority of Holtzappfel, the following receipts for solder are given, and these have been adopted, because, after a long and particular inquiry in the workshops, we learn that these are regarded as very superior to any others recommended.

Pewterers' Solder. (*a*) 2 Bismuth, 4 lead, 3 tin. (*b*) 1 Bismuth, 1 lead, 2 tin.

Soft Spelter Solder. Equal parts of copper and zinc.

Coarse Plumbers' Solder. (*a*) 1 tin, 3 lead, melts at about 500 F. (*b*) 2 tin, 1 lead, melts at about 360 F.

Spelter Solder. 12 oz. of zinc, to 16 oz. of copper.

(For brass work the metals are generally mixed in equal proportions as above. For copper and iron the last given are usually employed).

The following table of solders has been constructed by the late Mr. Holtzappfel, from a table of a much more extended character, published by Mons. H. Gaulthier de Claubry.

	Alloys and their Melting Heats.				Fluxes.
1	1 Tin	25 Lead		558° Fahr.	A Borax
2	1 ,,	10 ,,		541	B Sal ammoniac
3	1 ,,	5 ,,		511	C Chloride of zinc
4	1 ,,	3 ,,		482	D Common resin
5*	1 ,,	2 ,,		441	E Venice turpentine
6	1 ,,	1 ,,		370	F Tallow
7	1½ ,,	1 ,,		334	G Gallipoli oil
8	2 ,,	1 ,,		340	
					MODES OF APPLYING HEAT.
9	3 ,,	1 ,,		356	*a* Naked fire
10	4 ,,	1 ,,		365	*b* Hollow furnace or muffle
11	5 ,,	1 ,,		378	*c* Immersion in melted solder
12	6 ,,	1 ,,		381	*d* Melted solder poured on
13	4 Lead	4 Tin	1 Bismuth	320	*e* Heated iron not tinned
14	3 ,,	3 ,,	1 ,,	310	*f* Heated copper tool tinned
15	2 ,,	2 ,,	1 ,,	292	*g* Blowpipe flame
16	1 ,,	1 ,,	1 ,,	254	*h* Flame alone, generally alcohol
17	2 ,,	1 ,,	2 ,,	236	*i* Stream of heated air
18	3 ,,	5 ,,	3 ,,	202	

SOOT (*Noir de fumée, Suie*, Fr.; *Russ, 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 coal contains some sulphate and carbonate of ammonia, along with bituminous matter.

SORBIC ACID is the same with malic acid. See MALIC ACID.

SOVEREIGN. The sovereign is the standard of value in Great Britain, and its weight is determined by the law that twenty pounds troy weight of standard gold shall be coined into 934½ sovereigns. To obtain the exact weight of one sovereign, reduce the pounds to grains and divide by the number of coins. A sovereign is thus found to weigh 123·274478330658 1059 grains, and as it is usual to deliver the coin to the bank in journey weights of 701 sovereigns, each journey should weigh if it be standard work 180·03210272873194 2215 ounces, and a million sovereigns should weigh 256821·8298555377 troy ounces, in round numbers about 7·8618 tons.—G. F. A.

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,

* No. 5, is the *Plumbers' sealed solder*, which is assayed and then stamped by an officer of the Plumber's Company.

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.

SPANISH BLACK. A black obtained by the charring of cork.

SPAR, HEAVY or PONDEROUS. Sulphate of baryta. See BARYTA.

SPARRY IRON ORE, or SPATHIC IRON. (Syn. *Chalybite*, *Siderite*, *Siderose*, *Brown Spar*, &c.) Spathose iron ore has been largely worked on the Brendon Hills, in Somersetshire, and it is also found on Exmoor, and in small quantities at the iron mines on the north coast of Cornwall. There are numerous other localities in which very fine specimens occur. It is found to be a very valuable ore in the manufacture of iron for steel. See IRON.

SPARTEINE. An organic base discovered by Stenhouse in common broom, *Spartium scoparium*. Its formula is probably $C^{16}H^{13}N$.—C. G. W.

SPECIFIC GRAVITY designates the relative weight 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, = 1·000. See GRAVITY, SPECIFIC.

SPECULUM METAL. The metal employed in the mirrors of reflecting telescopes. The Earl of Rosse, who has been eminently successful in the production and publishing of large specula, says, in his paper published in the *Transactions of the Royal Society*, "Tin and copper, the materials employed by Newton in the first reflecting telescope, are preferable to any other with which I am acquainted, the best proportions being 4 atoms of copper to 1 of tin (Turner's numbers), in fact 126·4 parts of copper to 58·9 of tin."

Mr. Ross remarks that when the alloy for speculum metal is perfect, it should be white, glassy and flaky. Copper in excess imparts a reddish tinge, and when tin is in excess the fracture is granulated and less white. Mr. Ross pours the melted tin into the copper when it is at the lowest temperature at which a mixture by stirring can be effected; then he pours the metal into an ingot, and, to complete the combination, remelts it in the most gradual manner, by putting the metal into the furnace almost as soon as the fire is lighted. Trial is made of a small portion taken from the pot immediately prior to pouring.

SPEISS. A compound of nickel, arsenic, and sulphur, containing small quantities of cobalt, copper, and antimony; it is found at the bottom of crucibles in which smalt is manufactured. See COBALT and SMALT.

SPELTER or SPELTRUM. See ZINC.

SPERMACETI; the *Cetine* of Chevreul. In certain species of the *cachelot* whale, as the *Physeter macrocephalus*, *tursio*, *microps*, and *orthodon*, as also the *Delphinus edentulus*, the fat of some parts of their bodies contains a peculiar substance, called spermaceti. The head is the principal part from whence it is obtained. In the right side of the nose and upper surface of the head of the whale, is a triangular-shaped cavity, called by the whalers, "the case." Into this the whalers make an opening, and take out the liquid contents (oil and spermaceti) by a bucket.

The dense mass of cellular tissue beneath the case and nostril, and which is technically called the "junk," also contains spermaceti, with which and oil its tissue is infiltrated. The spermaceti from the *case* is carefully boiled alone and placed in separate casks, when it is called "head matter." This "head matter," consists of spermaceti and oil. For the purpose of separating the spermaceti from the oil, it is cooled, when the spermaceti congeals, and is separated by being thrown into large filter bags, when the oil filters through, leaving the spermaceti behind; the solid thus obtained is subjected to compression in hair bags, placed in an hydraulic press. It is then melted in water, and the impurities skimmed off. Then it is remelted in a weak solution of potash to remove the last particles of oil, washed in water, and fused in a tub by the agency of steam, laded into tin pans, and allowed slowly to cool, when it forms a white semi-transparent brittle lamellar crystalline mass. Commercial spermaceti usually contains a minute portion of sperm oil, which may be removed by boiling with alcohol; the spermaceti dissolves and again separates on cooling; in order to obtain it perfectly pure, this process must be repeated until the alcohol separates no more oil.

When absolutely pure, spermaceti is a white laminated substance, without taste, and almost odourless, and in this state it is called *cetine.* By the addition of a few drops of alcohol or almond oil, it may be powdered. At 60° its sp. gr. is 0·943. It melts at 120° and at 670°, may be sublimed unchanged. It is insoluble in water, slightly soluble in alcohol, and much more so in ether; it is also soluble in the fatty and volatile oils, and if the solution be saturated when hot, the greater part of the spermaceti separates on cooling.

Spermaceti is only saponified with difficulty, in which process it is separated into two distinct substances, one, $C^{32}H^{34}O^{2}$, belonging to the series of alcohols, is called *cetylic* (*ethalic*) *alcohol*, and the other *cetylic* (*ethalic*) *acid*, $C^{32}H^{32}O^{4}$; the first is a crystallisable fat, whose melting point is nearly the same as that of spermaceti itself, but it is much more soluble in alcohol; it is readily sublimed without decomposition. Cetylic acid stands to cetylic alcohol in the same relation as acetic acid to ordinary alcohol, and may be actually procured from it by oxidation. It resembles in many respects margaric acid. By oxidation by nitric acid spermaceti yields a large quantity of succinic acid.

Spermaceti is composed of $C^{64}H^{64}O^{4} = C^{32}H^{33}O, C^{32}H^{31}O^{3}$. It is cetylate of oxide of cetyl, and represents in the cetyl series the acetic ether of the common alcohol series. —H. K. B.

SPHENE. A compound of titanate and silicate of lime. See TITANIUM.

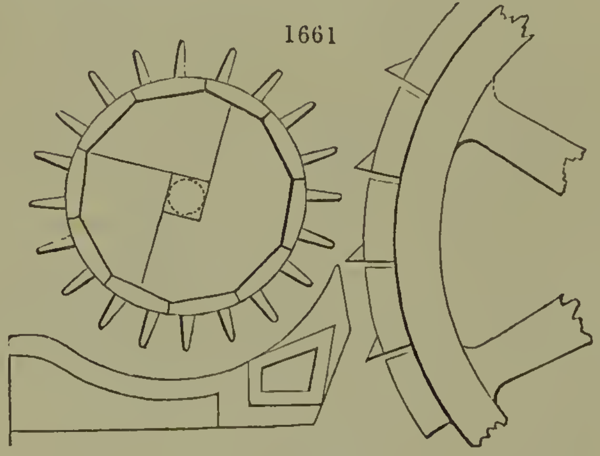
SPHEROIDAL STATE. The name given by Boutigny to the condition assumed by water when projected into red hot vessels. Under this condition the temperature never rises to the boiling point. See *Boutigny's Memoirs* on this curious subject.

SPINDLE-TREE OIL. See OILS.

SPINEL or SPINELLE. See RUBY.

SPINNING. The greatest improvement hitherto made in forming textile fabries, 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 patent of 1824 was the beginning; the result of which was the several patents for improvements in 1835, 1837, 1838, and 1842.

1661



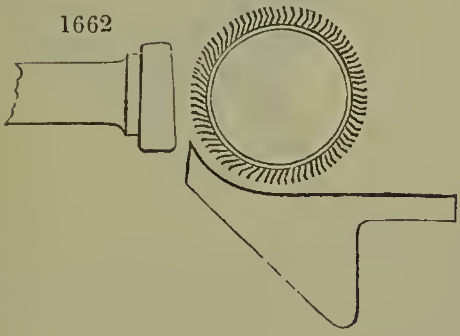
Patent of 1835.

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.*

1661), 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.

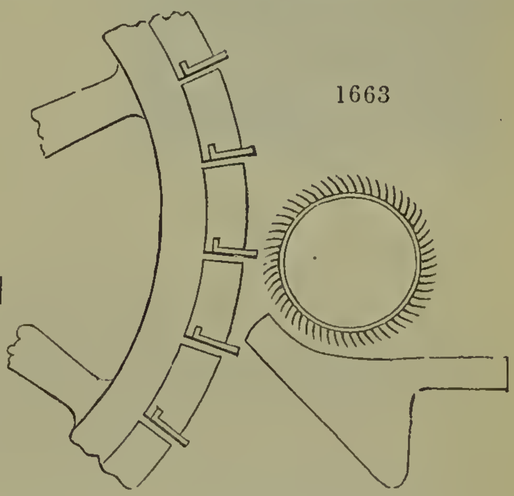
The first blower has a feeding-plate like *fig.* 1662 without teeth, and over this plate the cotton is delivered to the operation of the common beaters, from which it is received into a narrow compartment of 4½ or 5 inches broad, and wound, by means of his lap-machines, upon rollers in beautifully level and well-cleaned laps. Eight of these narrow laps are then placed behind a second blower, of a similar construction to the first. Instead of the common beater, however, a drum with toothed straight edges

1662



Patent of 1835.

1663



Patents of 1824 *and* 1835.

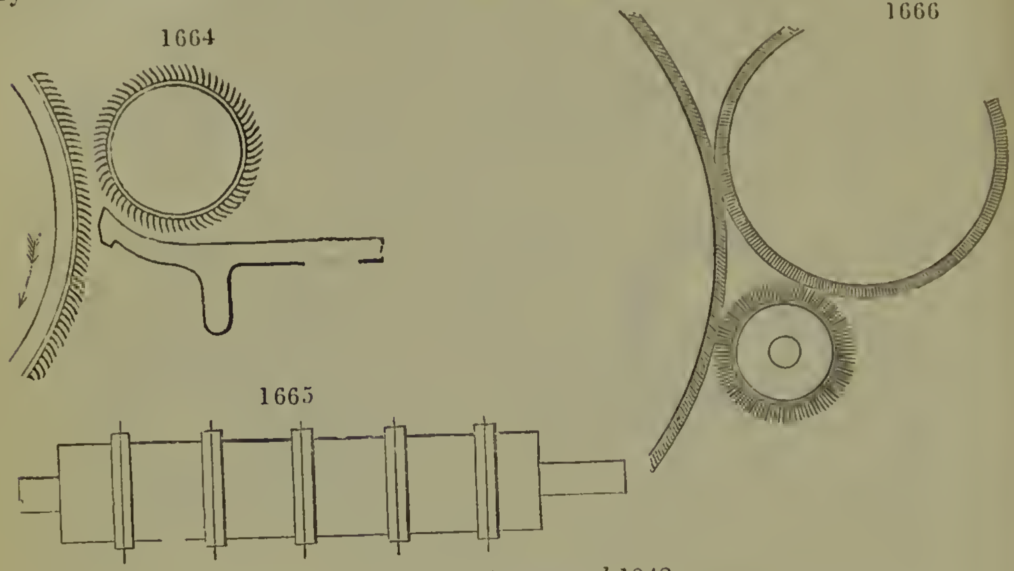
is used (see *fig.* 1663), which opens the cotton still more, and separates the fibres from one another. The cotton is again formed into similar narrow laps, which are still more equal than the preceding ones, and eight of these laps are then placed behind the carding engines. It was only by applying 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.

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.* 1664) 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.* 1665, 1666, give an idea of the clearer: the mechanism within the clearer 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



Patents of 1838 *and* 1842.

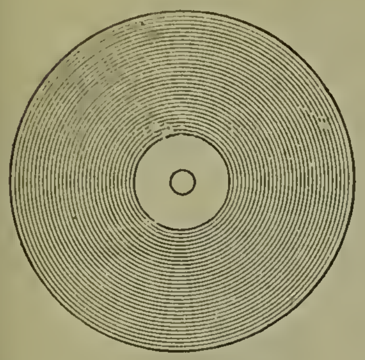
are cast in the same piece; when complete they weigh 50 lbs. less than those made of wood.

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.

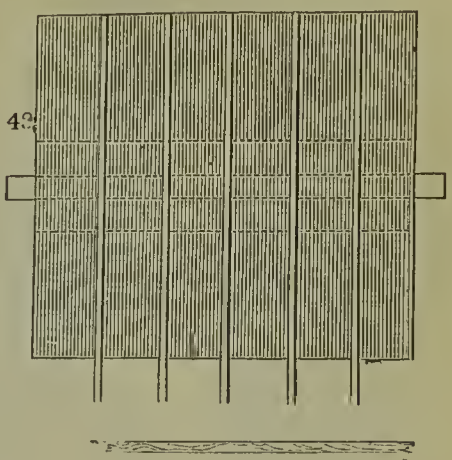
Drawing Frame.—The drawing frame of 1824 was improved, and the improvements patented in 1835, and others again in 1842. That of 1824 is known in Germany and France, and generally in use. The laps from the carding engine lap-machine are put upon delivering rollers, behind a set of drawing rollers, and 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.* 1667, and 1668.) The twist is given by tubes in two directions, so that it remains in it (see *fig.* 1668), 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.

Coil Frame.—The bobbins (*fig.* 1667) 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.* 1669) and calender rollers, A, it is passed through the tube, B, and the finger, C; the spindle with its disc, D, revolves in such a proportion as to take up the cotton which proceeds from the calendar 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, B, must vary accordingly. The coil, E, is stationary, and is pressed by the lid or top, F, which slides up the spindle, G, made of tin plate. The cotton enters through the slot, X, in *fig.* D. It is quite evident that the finger, C, and spindle, G, only perform one and the same varying motion, which is repeated at every fresh layer, and the coil is thus built from below; it is about 8 inches in diameter and 18 inches high when compressed, and contains 4½ 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

1667



1668



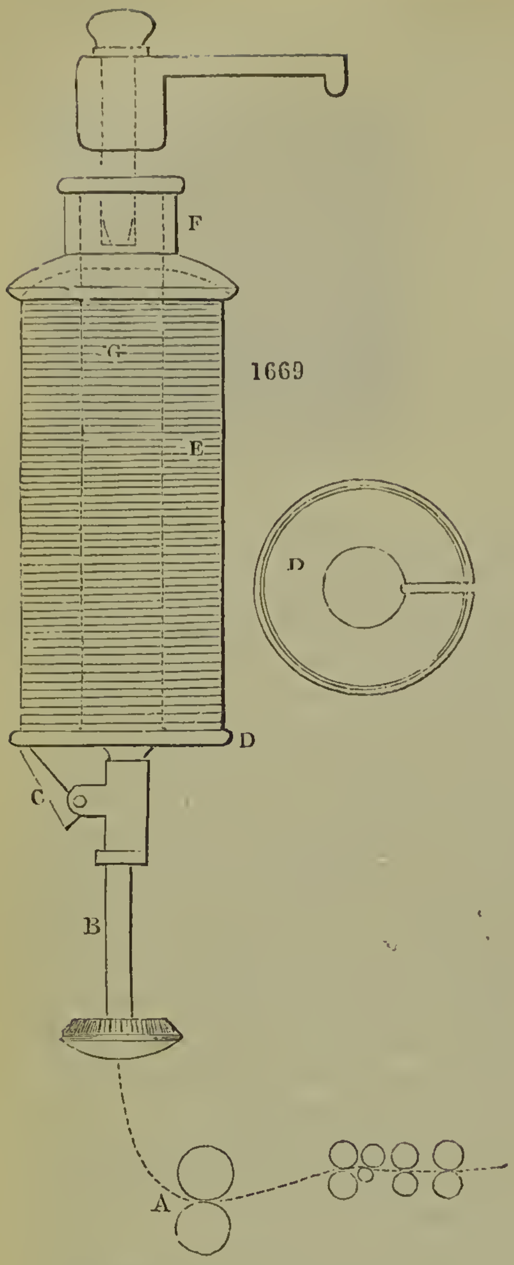
Patents of 1835, 1838, *and* 1842.

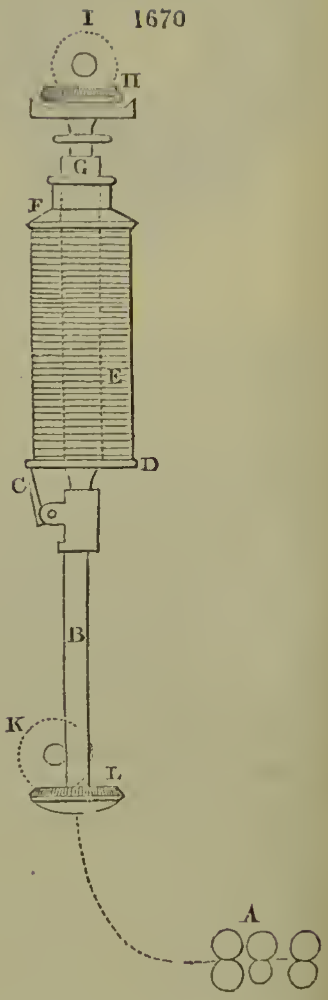
winding machine, where they are wound upon rollers side by side, like the lap or bobbin shown in the drawing frame, and placed behind the twist coil frame in this state.

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 2½ to 5 inches. The same machines produce rovings more or less fine, but the diameter of the coils does not differ. The difference of this machine from that above described consists in the dimensions of their parts, and in its having the spindle, G, and the lid or top, F, revolving, as well as the tube, B. (See *fig.* 1670.) In this machine the motion of the spindle, B, is uniform: the spindle, G, however, is connected by the bevel wheels, H and I, with a differential motion at the end of the frame, with which the motion of the finger, C, corresponds. The skew wheels, K and L, are connected with the drawing rollers, A. The speed of the tube, B, and the spindle, G, are so proportioned, that while the spindle, G, performs one revolution, and therefore puts one twist into the roving, the tube, B, 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 (see *a*, *fig.* 1671) on each machine, for the purpose of doffing without stopping the drawing frame and carding engines. When one coil is 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 adapted 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 may 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.* 1672. 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



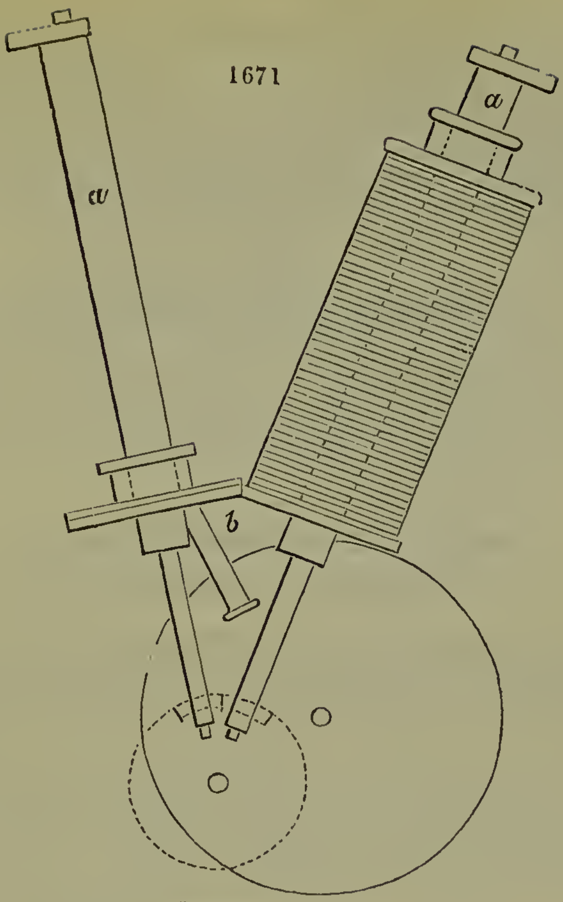


Patents of 1838 *and* 1842. *Patents of* 1838 *and* 1842.

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.* 1673, 1674, and 1675. 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.* 1676, 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.* 1676. 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 certainly 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

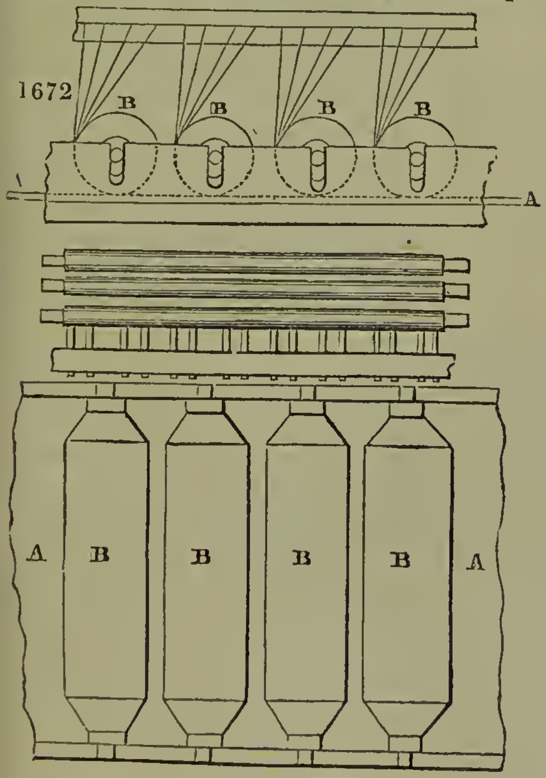
1671



Patents of 1842.

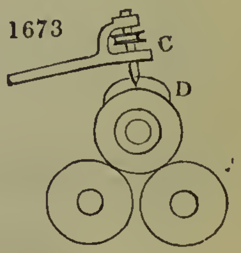
drawing, and thus produce smooth yarn. To remedy the evil above described, when untwisted rovings are used, he causes the spouts or guides, through which the rovings

1672

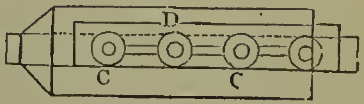


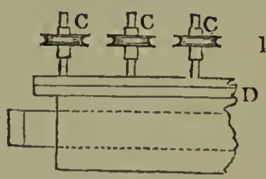
Patent of 1835

1673



1674





1675

1676

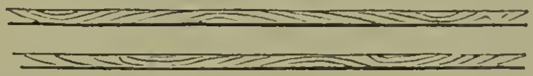
pass into or between the drawing rollers, to revolve slowly first in one, and then in the other direction, and thus puts a certain quantity of twist into the rovings while they are being prepared for spinning. Two modes of performing this operation are clearly described in his patent of 1835.

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.* 1677; in this place the twist is not like that at B, and it would, in some parts

1677

of the 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.* 1678; in this case the reversing place of one roving meets the twisted place of the other, and the fault is completely rectified.

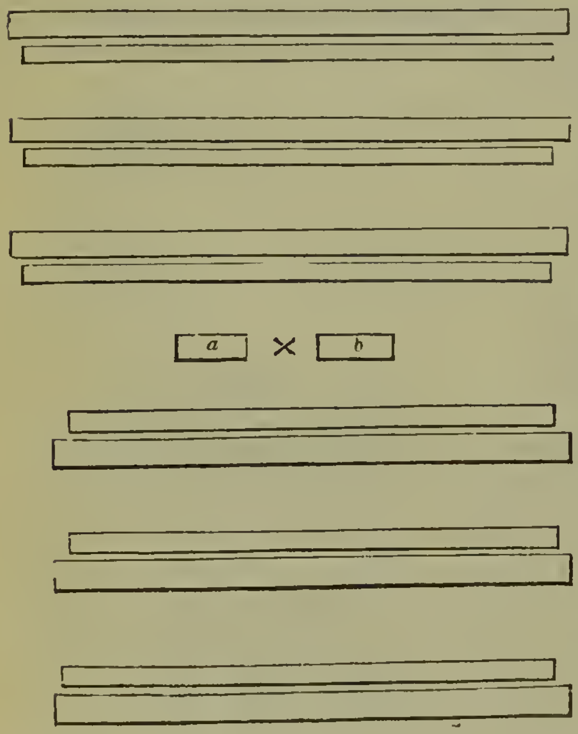
1678



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 combined with the mule are contained in the machine, which is placed between a set of mules, as seen in *fig.* 1679; *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 × 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 piecers 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

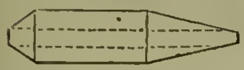
1679



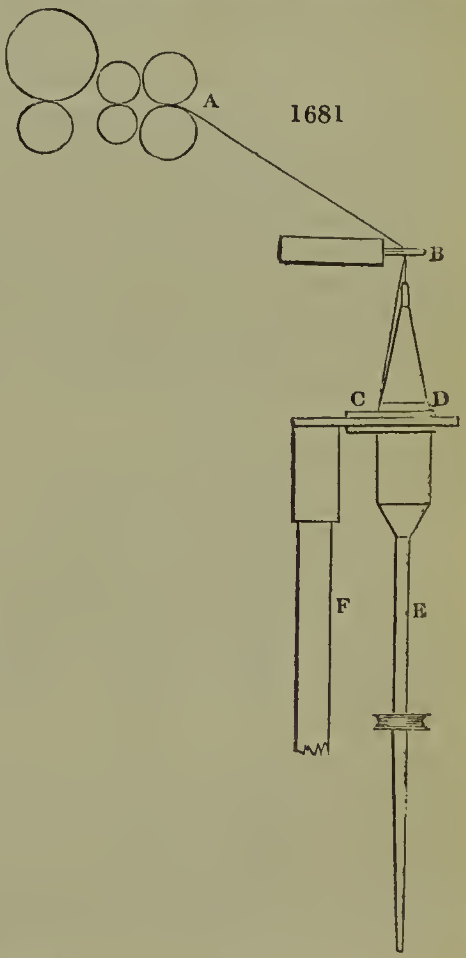
altering, at a trifling expense, the common mules into self-actors; they are equally good for any numbers of yarn.

Bastard Frame.—In his patent of 1838 and 1842, we find the description of a very simple bastard frame, namely, a throstle with mule spindles, forming cops, as seen in *fig.* 1680, 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

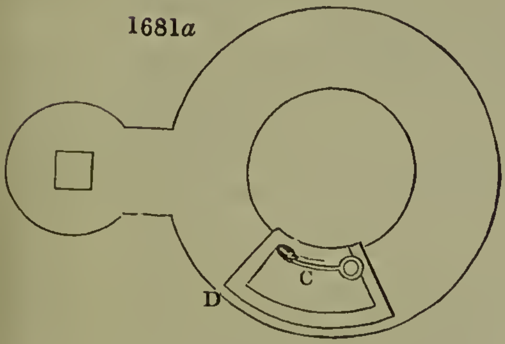
1680



1681



1681*a*



Patents of 1838 *and* 1842.

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.* 1681, and 1681 *a* 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. The name usually given to the solution of ammonia. It should, strictly speaking, be confined to the solution in spirit only.

SPIRIT OF SALTS. Hydrochloric or muriatic acid.

SPIRITS OF WINE. ALCOHOL (which see).

SPIRITS, VINOUS. See ALCOHOL, FERMENTATION, WINE, &c.

SPONGE. (*Eponge*, Fr.; *Schwamm*, Germ.) For a long time it was a disputed point whether the sponge of commerce belonged to the animal or the vegetable kingdom. Of late years the evidence has appeared to be conclusive as to its animal nature.

The sponge consists of a soft gelatinous mass, mostly supported by an internal skeleton composed of reticularly anastomosing horny fibres, in or among which are usually imbedded siliceous or calcareous spicula. Sponges are mostly marine — two or three species only being found in fresh water. They are fixed by a kind of root, by which they hold firmly any surface upon which they once fix themselves. Sponges may be propagated by division, but more usually by gemmules, which detach themselves from the parent body, and float about until they find a fitting resting-place, where they fix themselves and grow. The sponges of commerce are obtained from the Mediterranean—Smyrna being the principal mart. They are collected by divers, many of whom have been trained to the work from their infancy. Sponges are treated with muriatic (hydrochloric) acid to remove the lime.

SPOON MANUFACTURE. See Stamping of Metals.

SPRUCE BEER is prepared as follows:— Essence of spruce, half a pint; pimento and ginger bruised, of each 4 ounces; hops, from 4 to 5 ounces; water, 3 gallons. Boil for ten minutes, then strain and add 11 gallons of warm water, a pint of yeast, and 6 pints of molasses. Mix and allow the mixture to ferment for twenty hours.

SPRUCE, ESSENCE OF, is prepared by boiling the young tops of the *Abies nigra*, or black spruce, in water, and concentrating the decoction by evaporation.

STAINED GLASS. Under Glass, a general account of the processes for colouring glass has been given; for the manufacture, however, of stained glass for windows, some special details have been reserved for this place. 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 canvas 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 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 harmonise 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 fire-place, 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 for three or four 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 slowly, 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 14½ 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 aud 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 fiue 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 sulphide 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 *laminæ* 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 one 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 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.

Coloured transparent glass is applied as enamel in silver and gold *bijouterie* previously *bright-cut* in the metal with the graver or 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 blues of vitrified colours are all obtained from the oxide of cobalt. Cobalt ore (sulphide) 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, 1 of zaffre, 10 parts of white glass pounded, and 1 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.

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 dye, to the stationary block, or bed of the stamping-machine, and the counterpart or intaglio, to the falling hammer or ram.

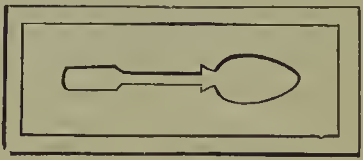
The peculiar feature of improvement in this manufacture consists in producing the opoon, ladle, or fork perfect at one blow in the stamping-machine, and requiring no further manipulation of shaping, by simply trimming off the barb or fin, and polishing the surface to render the article perfect and finished.

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 filling and hammering.

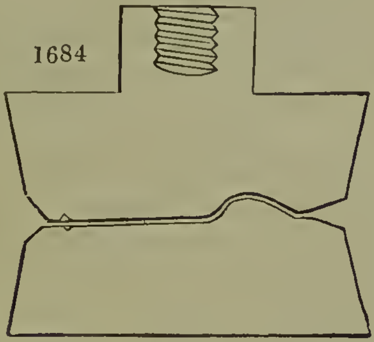
By his improved form of dies, which, having curved surfaces and bevelled edges, allow of no parts of the faces of the die and counter-die to come in contact, he is enabled to produce considerable elevations of pattern and form, and to bring up the article perfect at one blow, with only a slight barb, or fin, upon its edge.

In the accompanying drawings, *fig.* 1682 is the lower or bed die for producing a spoon, seen edgewise; *fig.* 1683 is the face of the upper, or counter-die, corresponding;

1683



1684



1682

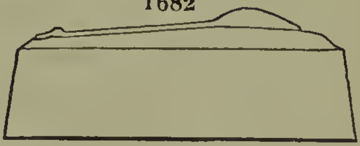
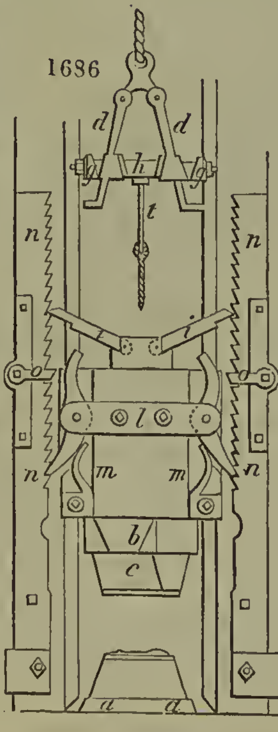


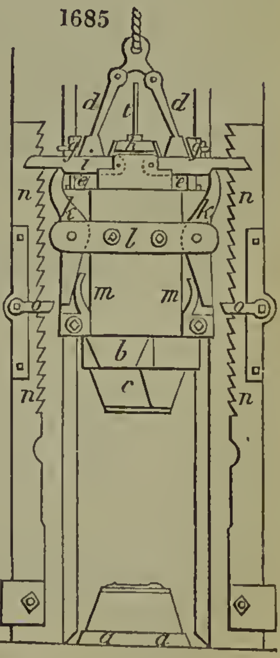
fig. 1684 is a section, taken through the middle of the pair of dies, showing the space in which the metal is pressed to form the spoon.

To manufacture spoons, ladles, or forks, according to his improved process, he first forges out the ingot into flat pieces, of the shape and dimensions 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.

1686



1685



He now fixes the lower die in the bed of the stamping-machine, shown at *a*, *a*, in the elevations *figs.* 1685 and 1686, 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 barb, 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 the figures; 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.* 1686, 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.* 1685, 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*, fixing 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.* 1686, and thereby prevent the hammer from again descending.

STANNATE AND STANNITE OF POTASH AND SODA. Stannates and stannites of alkalies 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 lbs. of caustic soda are first put into an iron crucible, heated to a low red heat, till the hydrate be produced; to which 8 lbs. of nitrate of soda and 4 lbs. of common salt are introduced. When the mixture is at a fluxing heat, 10 lbs. 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 red hot and pasty. This product is stannate of soda. It may be purified by solution and crystallisation.

Stannite of soda is made by putting 4 lbs. of common salt, 13½ lbs. of caustic soda, and 4 lbs. 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 lbs. of stannate of soda are dissolved in 1 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 process of Mr. James Young is much more recent, and presents a very beautiful application of science. Instead of reducing metallic tin from the ore, and oxidating the metal again to form the stannic acid at the expense of nitric acid, Mr. Young takes the native peroxide of tin itself, and fuses it with soda. The iron and other foreign metals present in the ore are insoluble in the alkali, so that by solution of the fused mass in water, a pure stannate of soda is obtained at once. It is crystallised by evaporation, and obtained in efflorescent crystals containing nine equivalents of water.

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 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 $\frac{1}{400}$ of an inch. It occurs — 1. In the seeds of all the acotyledonous plants, among which are the several species of corn, 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 *inuline*, 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 grey with iodine.

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 BREAD.

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.

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 contain much vegetable albumen and gluten, along with the husks; when exposed to fermentation, this 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 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.

With crushed wheat. — 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 *boxing*, 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.

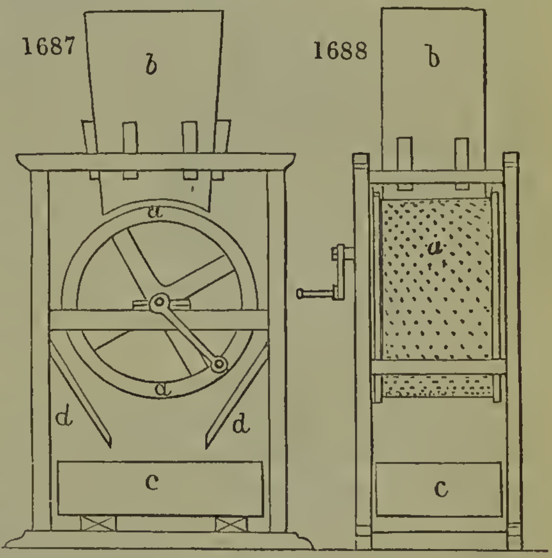
During the drying, starch splits into small prismatic columns, of considerable regularity. When kept dry, it remains unaltered for a very long period. When it is heated to a certain degree in water, the envelopes of its spheroidal particles burst, and the *farina* forms a mucilaginous emulsion, magma, 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 two or three 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 analysis, 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	3·7	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

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.* 1687, 1688, where *a* is a wooden drum covered with sheet-iron, roughened outside with numerous prominences, made from 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 *green 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.



Washing apparatus have been contrived by Lainé, Dailly, Huck, Vernies, Stolz, and St. Etienne. These are contrivances for working very large quantities of potatoes in a short time. Huck's machine is stated to work 30,000 lbs. of potatoes daily, and 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. Völker proposed a process of rotting the potato to separate the starch.

Mr. P. L. Simmons, in a communication to the Society of Arts, has directed attention to a great number of roots from which starch might be possibly obtained, especially the yams, eddoes, cocos (*Arum esculentum*). The same authority has collected from various sources the quantity of starch contained in different tropical roots. *Sweet cassava*, 27 per cent.; *bitter cassava*, 16 to 25 per cent.; *common yam*, 24½ per cent.; *arrow-root*, 17 to 21½ per cent.; *Barbadoes yam*, 18¾ per cent.; *tannia* (*Caladium sagitte folium*), 15½ to 17 per cent.; *the Guinea yam*, 17 per cent.; *buck yam*, 14 to 16 per cent.; *sweet potato*, 16½ per cent.; *Plantain meat*, 17 per cent.

Horse chestnuts have been largely used at Nanterre, near Paris, in the manufacture of starch.

In the manufacture of potato starch a considerable quantity of the product is lost, owing to the strong affinity which the starch has for the fibre of the potato. M. Anthon (*Chemisch Central Blatt*), states that the manufacturer obtains only two thirds of the starch, the remainder being left in the pulp. He suggests that this third may be utilised, by converting it into sugar by means of either malt or dilute sulphuric acid. By employing 10 per cent. of the acid to the dry fibre, the saccharification is complete in about two hours and a half; but if only 3 or 4 per cent. of acid is used the boiling must be continued for at least 5 hours. Ten per cent. of malt effected the conversion in 6 hours. Mr. Calvert has given the following analysis of the potato:—*Water*, 74; *starch*, 20; the remainder being fibrous, earthy, and alkaline matter.

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 roots 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.

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 2,000 gallons of water being introduced, 12½ loads of flour are stirred in. The 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 siphoned 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° Fahr. 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, 43·5 carbon, 6·8 hydrogen, and 49·7 oxygen. See DEXTRINE.

Manufacture of starch from rice, &c. — Mr. Thomas Berger, of Hackney, 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 2,000 gallons of the cold mash, stirs the mixture, filters or strains through fine lawn sieves, settles, neutralises with dilute sulphuric acid, and adding 8 oz. of sulphate of zinc to each cwt. of starch, stirs, boxes, and finishes as usual.

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.

Mr. Orlando Jones 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 is well mixed; after 24 hours he draws off the supernatant 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.

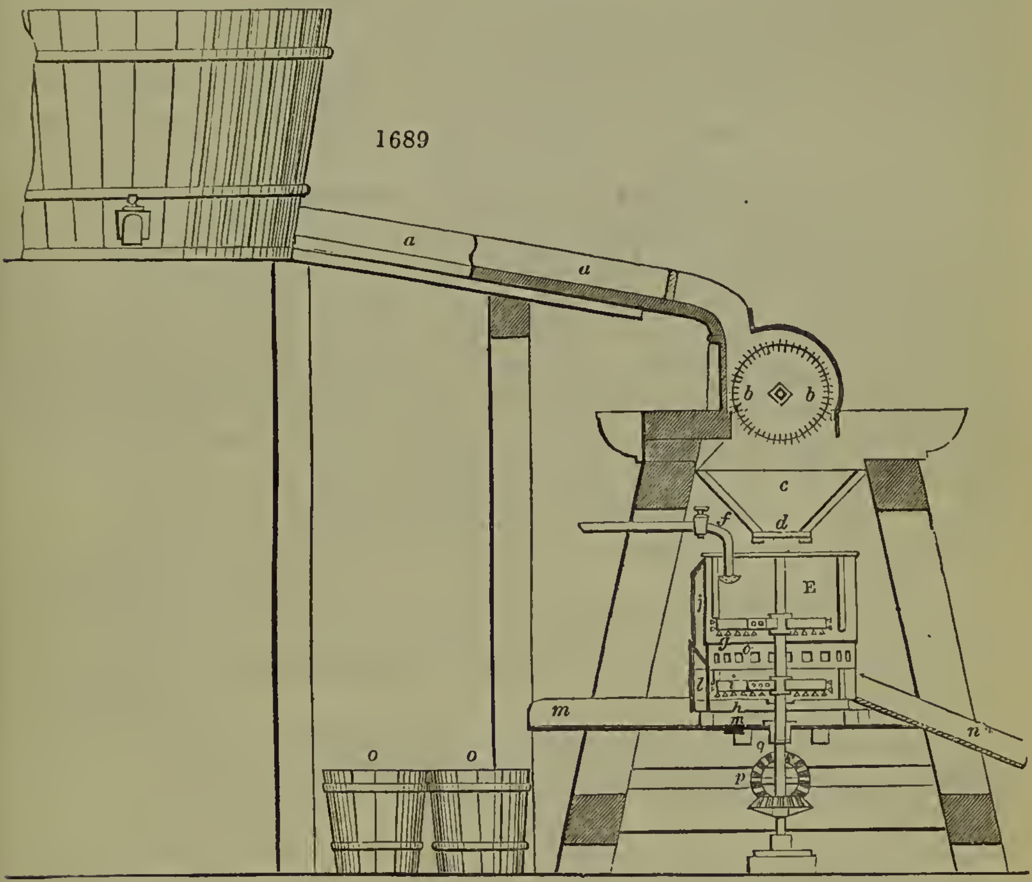
Mr. James Colman, by his patent of December 1841, makes starch from ground maize or Indian corn, by the agency either of the ordinary process of steeping and fermenting, or of caustic or carbonated alkaline lyes. He also proposes to employ dilute muriatic acid to purify the starchy matter from gluten, &c.

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.

Mr. John Hamilton, of Belfast, has a patent for submitting starch, after it has been deposited in the manufacturing process, to the action of a hydraulic press, in suitable boxes, so as to press all the water out of it, instead of evaporating all the moisture in artificially heated rooms, according to the usual practice; a great saving in fuel is thus effected.

Fig. 1689 represents in section the powerful and ingenious mechanical grater, or

1689



rasp (*râpe*), now used in France. *a a* is the canal, or spout, along which the previously well-washed potatoes descend; *b b* 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 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. *c* 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 consists also of wire cloth; it is collected into a wooden spout, *m*, and is thence conducted into the tubs, *o*, *o*, 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 *exported* in 1858: — 17,925 cwts.; declared real value, 33,812*l*.

STARCHING AND STEAM-DRYING APPARATUS. For a full description of these processes, and of the machinery for accomplishing them, see BLEACHING and CALICO PRINTING.

STATUARY PORCELAIN. See POTTERY.

STEAM is water in its vaporiform state. The varied and important applications of steam as a mechanical power, would appear to render a consideration of its laws of the utmost importance. The circumstance that our spinning and weaving machinery, our pumping engines, our ships, our carriages, our hammers, our lathes, and our presses, are all moved by this power, seems to demand a full consideration of steam in a work devoted to *Arts, Manufactures, and Mines*, into each division of which it enters as an important element. But the limits assigned to the entire work renders it impossible to treat in any way commensurate with its importance this great mechanical power. It is, therefore, thought advisable to confine attention to a few general and well-established principles only. For especial information on the subject the reader is referred to W. J. Macquorn Rankine's *Manual of the Steam Engine;* Tredgold *on the Steam Engine;* De Pambour *on the Theory of the Steam Engine*, and *on the Locomotive Engine;* Arago *sur les Machines à Vapeur;* Regnault's papers in the *Memoires* and *Comptes Rendus* of the Academy of Sciences, &c.

Steam is a chemical compound of oxygen and hydrogen, in the proportion of 8 parts by weight of oxygen, to 1 of hydrogen. Its composition by volume is such, that the quantity of steam which, if it were a perfect gas, would occupy 1 cubic foot at a given pressure and temperature, contains as much oxygen as would, if uncombined, occupy half a cubic foot, and as much hydrogen as would, if uncombined, occupy 1 cubic foot, at the same pressure and temperature; so that steam, if it were a perfect gas, would occupy two thirds the space which its constituents occupy when uncombined. Hence is deduced the following composition of the weight of 1 cubic foot of steam would have at the temperature of 32° Fahr., and pressure of one atmosphere (or 14·7 lbs. on the square inch), if steam were a perfect gas, and if it could exist at the pressure and temperature stated.

Data from the Experiments of Regnault.

	lb.
Half a cubic foot of oxygen at the pressure of one atmosphere and temperature, 32° - - - - - - - -	0·044628
1 cubic foot of hydrogen - - - - - - -	0·005592
1 cubic foot of steam in the ideal state of perfect gas, at one atmosphere and 32° - - - - - - - -	0·050220

If steam were a perfect gas, the weight of a cubic foot could be calculated for any given pressure and temperature by the following formula.

Weight of a cubic foot = 0·05022 lbs. × pressure in atmosphere—

$$\times \frac{493\cdot{}^{\circ}2}{\text{Temp.} + 4\cdot 61\cdot{}^{\circ}2}$$

For example, at one atmosphere of pressure, and 212°, the weight of a cubic foot of steam would be:—

$$0\cdot 05022 \times \frac{493\cdot{}^{\circ}2}{673\cdot{}^{\circ}6} = 0\cdot 03679 \text{ lb.}$$

But steam is known not to be a perfect gas; and its actual density is greater than that which is given by the preceding formula, though to what extent is not yet known by direct experiment. The most probable method of indirectly determining the density of steam, is by computation from the latent heat of evaporation, from which it appears that at one atmosphere and 212°, the weight of a cubic foot of steam is probably 0·0379 lb. The greatest pressure under which steam can exist at a given temperature, is called the *pressure of saturation* for steam of a given temperature. The temperature is called the *boiling point* of water under the given temperature. The pressure of saturation is the only pressure at which steam and liquid water can exist together in the same vessel at a given temperature.

It becomes necessary to understand correctly the method of determiniug fixed temperatures by certain phenomena taking place at them. Thus ice begins to melt at a point, which we call the FREEZING POINT, marked 32° upon the scale devised by Fahrenheit (see THERMOMETER), and we determine the BOILING POINT of water to be 212° on the same scale, under the average atmospheric pressure of 14·7 lbs. on the square inch; 2116·4 lbs. on the square foot; 29·992 inches of the column of mercury. At this latter point water ceases to be *liquid*, and becomes vaporiform. From 32° to 212°, all the heat which has been poured into the water, has effected no change of physical condition, but the higher temperature being reached, a new condition is established, and steam is produced — this steam then beginning to act according to certain fixed laws.

A cubic inch of water evaporated under the ordinary atmospheric pressure is converted into a cubic foot of steam.

A cubic inch of water evaporated under the atmospheric pressure gives a mechanical force equal to what would raise a ton weight 1 foot high.

These are the effects produced at 212° under the above-named pressure.

Careful experiments have determined, within very small limits of error, the following facts: — Steam under pressure of 35 lbs. per square inch, and at the temperature of 261°, exerts a force equal to a ton weight raised one foot; under the pressure of 15 lbs. and at the temperature of 213°, it is 2,086 lbs., or about seven per cent. less; and under 70 lbs. and at 306° it is 2,382 lbs., or nearly six and a half per cent. more than a ton raised a foot. It is sufficient for all practical purposes to assume that each cubic inch evaporated, whatever be the pressure, develops a gross mechanical effort equivalent to a ton weight raised 1 foot.

As a given power is produced by a given rate of evaporation, to determine this the following rules are applicable: —

To produce the force expressed by one-horse power, the evaporation per minute must develop a mechanical force equal to 33,000 lbs., or about 15 tons raised 1 foot high. Fifteen cubic inches of water would accordingly produce this effect, which, without evaporation, would be equivalent to 900 cubic inches per hour. To find, therefore, the gross power developed by a boiler, it would be only necessary to divide the number of cubic inches of water evaporated per hour by 900. If, therefore, to 900 cubic inches be added the quantity of water per hour necessary to move the engine itself, independently of its load, we shall obtain the quantity of water per hour which must be supplied by the boiler to the engine for each horse power, and this will be the same whatever may be the magnitude or proportions of the cylinder.

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 *Prechtl's Technological Encyclopædia*, article *Dämpfe.*

The connection 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, 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.

Three formulæ are 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 Mr. Pole 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 Woulf's double, cylinder engine. The equation is,

$$P = \frac{24250}{V - 65}$$

$$\text{or reciprocally, } V = \frac{24250}{P} \times 65$$

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.

In the application of steam power, the most economical means have been attained in the pumping engines of Cornwall, where the steam is employed expansively. The following tables will show the value of the Cornish engines.

General Table of the Action of the Cornish Steam-Engines.

		Month ending 20 July.	August.	Sept.	Oct.	Nov.	Dec.
Pumping-engines.	Number reported - - - -	23	24	24	24	24	24
	Average load per square inch on piston, in lbs. - - - -	11·9	11.4	11·5	11·8	12·5	12·7
	Average number of strokes per minute	4·8	4 8	5·3	5·2	5·3	5·6
	Gallons of water drawn per minute -	3,773	3,980	3,772	4,031	4,373	4,000
	Average duty — being million lbs. lifted 1 foot high by the consumption of 1 cwt. of coals - - -	61·1	59·5	67·2	63·4	64·9	63·9
	Actual horse-power employed - -	710·8	740·1	725·8	787·8	845·8	814 6
	Average consumption of coals per horse-power per horse, in lbs. -	4·0	4·1	3·5	4·3	4 1	4·1
Whim-engines.	Number reported - - - -	18	18	18	18	19	19
	Number of kibbles drawn - -	62,608	66,163	65,645	68,895	71,135	74,705
	Average depth of drawing, in fathoms	130·4	135·6	131·5	129·2	131·7	130·3
	Average number of horse whim-kibbles, of 3 cwts. drawn the average depth, by consuming 1 cwt. of coals	49·0	49·7	47·8	51·7	51·6	66·6
	Average duty, as above - - -	11·8	12·1	18·2	16·3	16·0	16·5
Stamping-engines.	Number reported - - - -	6	6	6	6	6	6
	Average number of strokes per minute	13·9	14·0	14·8	14·9	14·1	13·8
	Average duty, as above - - -	30·6	30·3	28·6	30·0	32·3	31·9
	Horse-pnwer employed - - -	88·5	90·1	54·9	58·2	104 9	111·1
Pumping-engines doing highest duty.	Great Polgooth - 80-inch single -	90·5	90·3	86·2	93·8	90·7	86·0
	Par Consols - 72 and 36-inch Sims' combined	89·9	94·1	88·3	92·0	94·5	—
	Fowey Consols - 80-inch single -	87·8	93·0	102·8	100·5	96·4	92·1
	Par Consols - - 80-inch single -	84·2	44·1	87·5	98·3	90·0	89·6
	Callington Mines - 50-inch single -	82·1	78·1	70·4	62·5	67·0	72·0
	Trelawny - - 50-inch single -	77·4	70·3	—	73·9	67·0	74·7
Whim-engines ditto.	Par Consols - - 24 and 13-inch Sims' combined	31·0	29·3	28·5	38·8	27·0	27·1
	Fowey Consols - 22-inch double -	25·1	26·2	25·2	21·9	24·7	24·6
	Fowey Consols - 22-inch double -	20·3	19·5	18·3	20·8	24·2	23·9
	Callington Mines - 22-inch double -	17·2	18·9	16·3	—	—	—
	Par Consols - - 24-inch single -	16·0	16·3	—	—	—	15·4
	Fowey Consols - 18-inch double -	15·4	—	—	—	—	—
Stamping engines ditto.	Tamar Mines - 30-inch single -	43·3	44·4	41·4	45·8	44·1	39·2
	Great Polgooth - 26-inch double -	33 4	40·8	24·8	29·4	—	—
	South Caradon - 26-inch single -	30·3	—	32·0	30·3	31·7	35·5
	Tincroft - - 36-inch double -	29·8	35·0	—	—	38·5	44·0

Abstract of the Duty of Pumping-Engines in Cornwall.

Year.	Number of engines reported.	Average duty.	Best Engine.			
			Name of mine.	Description.	Engineers.	Highest duty.
1822	52	28,900,000	Wheal Abraham.	Double cylinder.	Woolf.	47,200,000
1823	52	28,200,000	Do.	Do.	Do.	51,000,000
1824	49	28,300,000	Polgooth.	80-in. cylinder.	Sims.	46,900,000
1825	56	32,000,000	Do.	Do.	Do.	54,000,000
1826	51	30,500,000	Wheal Vor.	Do.	Sims & Richards.	50,000,000
1827	51	32,100,000	Wheal Towan.	Do.	Grose.	62,200,000
1828	57	37,000,000	Do.	Do.	Do.	87,000,000
1829	53	41,700,000	Do.	Do.	Do.	82,000,000
1830	56	43,300,000	Do.	Do.	Do.	77,900,000
1831	58	43,400,000	Do.	Do.	Do.	77,700,000
1832	59	45,000,000	Wheal Vor.	Do.	Richards.	91,400,000
1833	56	46,600,000	Do.	Do.	Do.	88,500,000
1834	52	47,800,000	Fowey Consols.	Do.	West.	97,900,000
1835	51	47,800,000	Do.	Do.	Do.	95,800,000
1836	61	46,600,000	Wheal Darlington.	Do.	Eustis.	95,400,000
1837	58	47,000,000	Fowey Consols.	Do.	West.	85,000,000
1838	61	50,000,000	Wheal Darlington.	Do.	Eustis.	78,100,000
1839	52	55,000,000	Fowey Consols.	Do.	West.	77,800,000
1840	54	54,000,000	Wheal Darlington.	Do.	Eustice.	81,700,000
1841	56	54,700,000	United Mines.	85-in. cylinder.	Hocking & Loam	101,900,000
1842	49	53,800,000	Do.	Do.	Do.	107,500,000
1843	36	60,000,000	Do.	Do.	Do.	96,100,000

Average Duty of Cornish Steam-Engines.

1848.	No. of pumping engines.	Quantity of coal consumed.	Water lifted 10 fathoms high.	Average duty.*
		Tons.	Tons.	lbs.
January - - -	27	2,285	22,000,000	54,000,000
February - - -	31	2,540	25,000,000	57,000,000
March - - -	28	3,523	33,000,000	54,000,000
April - - -	27	2,668	25,000,000	53,000,000
May - - - -	27	2,253	22,000,000	54,000,000
June - - - -	27	2,544	24,000,000	54,000.000
July - - - -	26	1,917	18,000,000	54,000,000
August - - -	26	1,780	16,000,000	53,000,000
September - - -	25	2,038	18,000,000	52,000,000
October - - -	25	1,618	14,000,000	53,000,000
November - - -	26	2,168	19,000,000	50,000,000
December - - -	25	1,923	17,000,000	50,000,000

In an inquiry upon the incrustations of the boilers of steam vessels, by M. Couste, it is stated that 8 or 10 per cent. of the heat of fuel is lost after the first few days' work, at Bourdeax 15 per cent., and at Havre, after some days constant work and observation, 40 per cent.; in general practice it has been estimated that 40 per cent. of the heat of the fuel has been lost by the internal incrustations and deposits in the boilers of steam vessels.

The following results were obtained from French ocean steamers: —

Stations.	Sulphate of Lime.	Carbonate of Magnesia.	Free Magnesia.	Iron and Alumina.	Water.
Hamburg, deposit from the surface of boiler (partly crystallised) - -	85·20	2·25	5·95	—	6·5
Mediterranean, tubular boiler (amorphous) -	84·94	2·34	7·66	0·41	4·65
Mediterranean (amorphous deposit) - - -	80·90	3·19	10·35	6·50	4·56

* The average duty in fifth column gives the number of lbs. lifted one foot high by the consumption of a bushel of coal.

An essential character of the sea-water incrustations is that they are free from the deposit of calcareous carbonates.

STEAM BOILERS. Space does not allow of our entering on a consideration of this important subject. We desire however to refer our readers to Mr. W. Fairbairn's papers in the *Transactions of the Royal Society*.

STEARIC ACID. (*Talgsaure*, Germ.) What we have said on stearine explains the production of stearic acid. Chevreul's discovery of the constitution of fats, led to the present processes for the manufacture of stearic acid. The original experiments were published in 1823. And Gay-Lussac with Chevreul in 1825, took patents for the manufacture of fatty acids. 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, dissolve one part of that soap in six parts of hot water, then add to the solution 40 or 50 parts of cold water, and set the whole in 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 a 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 repeatedly dissolving in alcohol, and crystallising, 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°, crystallises 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 crystallised in large white brilliant scales. It dissolves in its own weight of boiling ether of 0·727, and crystallises 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. By analysis it is found to contain in 100 parts, carbon 75·6, hydrogen 12·6, and oxygen 11·8, which agrees with the formula $C^{36}H^{36}O^4$, and makes the atomic weight of it 284, the formula of its neutral salts being $C^{36}H^{35}NO^4$. 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. The 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 neutralisation. 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.

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. Lime was first successfully used by De Milley in 1831. 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 admit 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 neutralise three parts of slaked lime. The saponified fat now liberated from the lime, which is thrown down to the bottom of the tub in a 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 pulverised arsenious acid, after which it is ready to be cast into candles in appropriate moulds. See Candle.

Moinier and Boutigny introduced a process by which the production of stearic acid has been considerably increased. Their process is thus described in *Chemical Technology*, by Ronalds and Richardson: — Two tons of tallow and 900 gallons of water are introduced into a large rectangular vat of about 270 feet capacity. The tallow is melted by means of steam admitted through a pipe coiled round the bottom, and the whole kept at the boiling point for an hour, during which a current of sulphurous acid is forced in. At the end of this period 6 cwt. of lime, made into milk with 350 gallons of water, are added. The mixture soon acquires consistence, and becomes frothy and viscid. The whole is now agitated, in order to regulate the ebullitions and prevent the sudden swelling up of the soapy materials. The pasty appearance of the lime soap succeeds, and it then agglomerates into small nodular masses. The admission of sulphurous acid is now stopped; but the injection of the steam is continued until the small masses become hard and homogeneous. The whole period occupies eight hours, but the admission of sulphurous acid is discontinued at the end of about three hours. The water containing the glycerine is run off through a tube into cisterns prepared to receive it. The arrangements for producing sulphurous acid, are retorts, into which are put sulphuric acid and pieces of wood; upon the application of heat the sulphurous acid passes off, and is conveyed by leaden pipes into the vessel containing the tallow. The lime soap formed is then moistened with 12 cwt. of sulphuric acid, at 152° Fahr., diluted with 50 gallons of water. The whole is thoroughly agitated, and the steam cautiously admitted, so as not to dilute the acid too much until the decomposition is general at all points. This occupies about three hours, and in two or three hours more the sulphate of lime has collected at the bottom, while the fatty acids are floating on the surface of the solution of the bisulphate of lime. Several processes of washing with steam and water are necessary to ensure the removal of the sulphate of lime, &c., and after settling for four hours, the fatty acids are forced through a fixed siphon into a vat, wherethey are again washed with water; they are then siphoned at last into a trough lined with lead, on the bottom of which are placed leaden gutters, pierced below by long pegs of wood. The fatty acids are then placed in cloths, and subjected to pressure in the stearine cold press as described below.

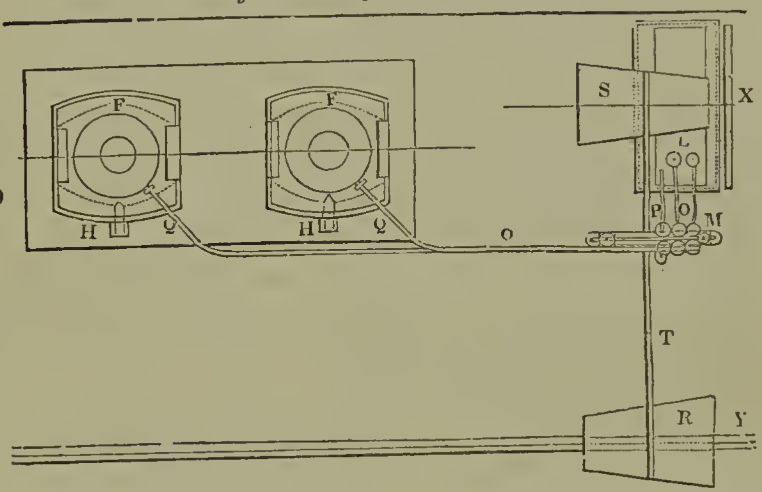
It is important for the fatty acids to cool slowly, as thus the confused crystallisation is prevented, and the expulsion of the oleic acid facilitated. When the cakes are solid they are placed between sacks of horsehair, and submitted to a second pressure at high temperature. The whole is covered with oilskin, and the temperature raised to 158°·5 Fahr., when pressure is applied. The heat slowly falls to 113° Fahr., and ultimately reaches 95° to 80° Fahr. This operation lasts about an hour. The cakes of stearic acid are sorted according to colour and transparency, and about 20 cwt. are then introduced into a vat constructed of wood lined with sheet iron. This is boiled by means of steam admitted through a leaden pipe, which is afterwards employed in heating a stove. Water acidulated is first employed, and afterwards pure water. When the materials are boiling, the whites of twenty-two eggs are introduced, and the albumen is intimately mixed by the violent ebullition. As soon as the albumen is coagulated, the whole is allowed to cool, and the stearic acid is removed to another apartment, where it is kept in a state of agitation to prevent the formation of crystals, and allow the cooling to be as gradual as possible. It is now fit for candles.

The cold hydraulic press, as mounted by Messrs. Maudslay and Field, for squeezing out the oleic acid from saponified fat, or the oleine from cocoa-nut lard, is represented in plan in *fig.* 1690, in side view of pump in *fig.* 1691, and in elevation, *fig.* 1692, where the same letters refer to like objects.

A, A, are two hydraulic presses; B, the frame; C, the cylinder; D, the piston or ram; E, the follower; F, the recess in the bottom to receive the oil; G, twilled woollen

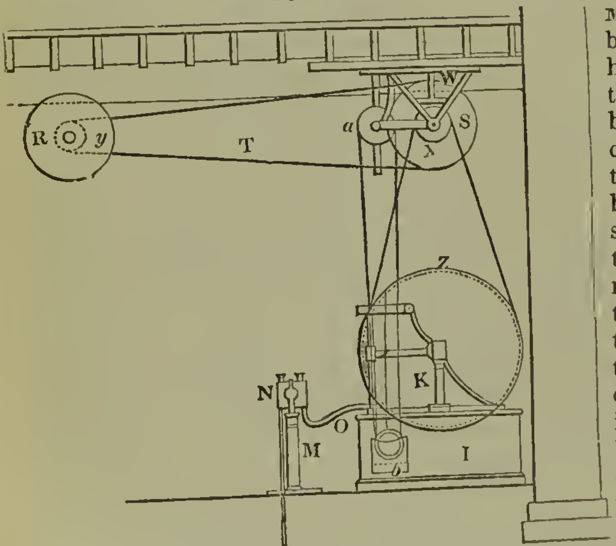
Scale of 3-20*ths of an inch to the foot.*

1690



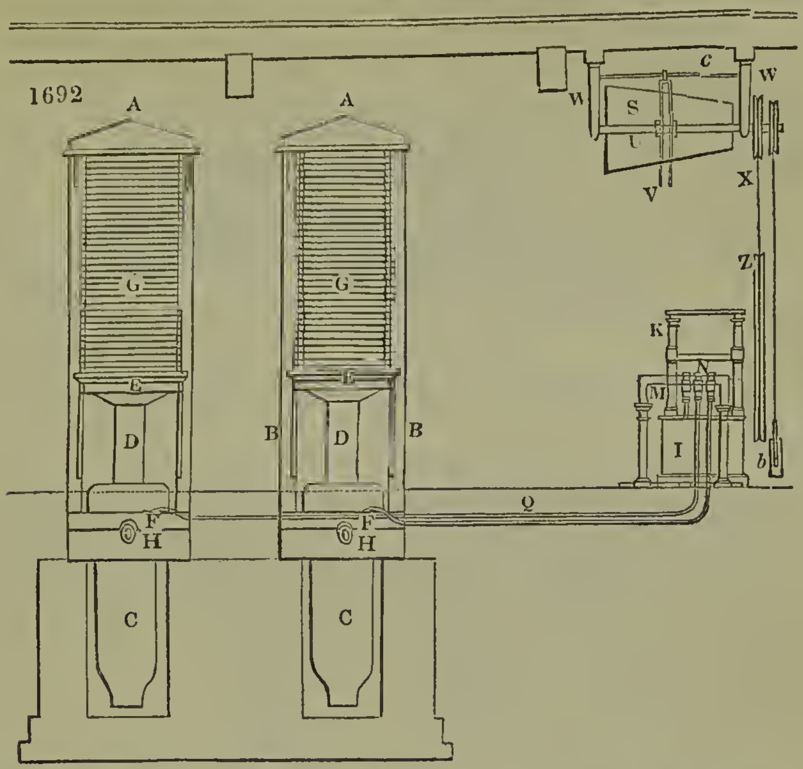
bags, with the material to be pressed, having a thin plate of wrought iron between each; H, apertures for the discharge of the oil; I, cistern in which the pumps are fixed; K, framing for machinery to work in; L, two pumps, large and small, to inject the water into the cylinders; M, a frame containing 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; P, pipe to return the water from the cylinders to the cisterns; Q, pipes leading from the pumps through the branches to the cylinders; R, conical drum, fixed upon the main shaft Y, driven by the steam-engine of the factory; S, a like conical drum to work the pumps; T, 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;

1691



V, the fork or guide for moving the strap T; W, W, two hanging bearings to carry the drum S; X, a pulley on the spindle of the drum S; Y, the main shaft; Z, fly-wheel

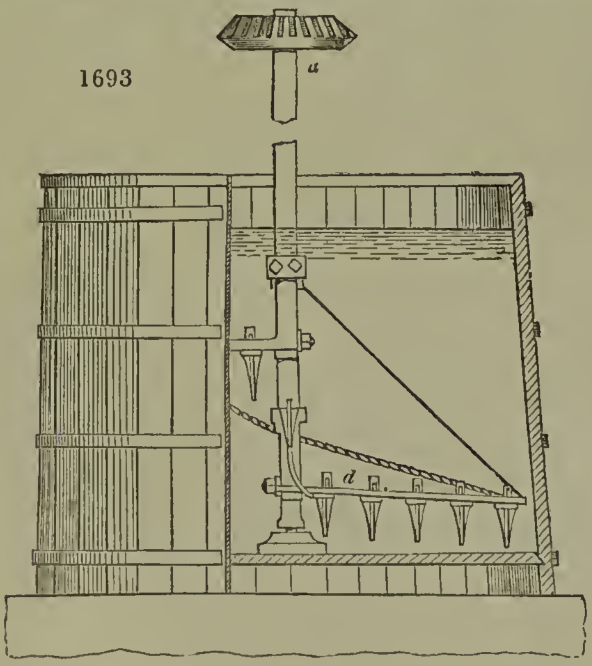
1692



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 this cord, and raising or lowering it, the forked guide V, and the leather strap T, 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.

The accompanying *fig.* 1693, is a view both of the exterior and the interior

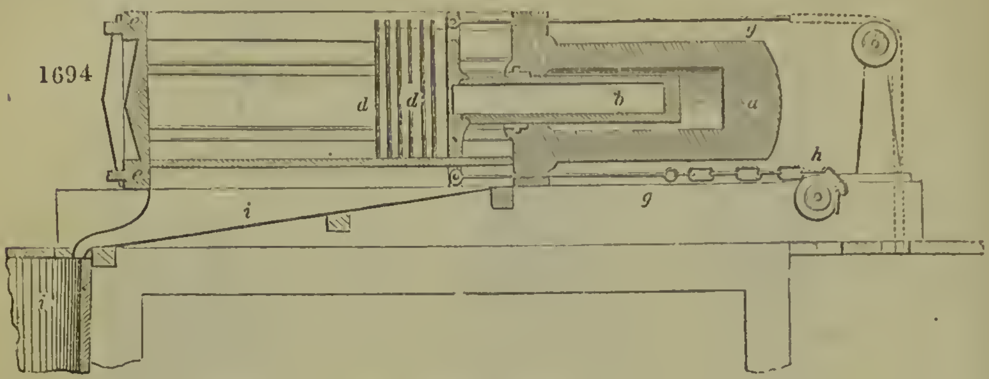
1693



of the saponifying 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. 1694 represents a longitudinal section of the horizontal hydraulic press for

1694



depriving stearic acid, as also spermaceti, of all their fluid oily impurities. *a* is the cylinder of the press; *b*, the ramor piston; *d d*, iron plates previously heated, inclosing hair and flannel bags 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*, on 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.

STEARINE (from στεαρ, tallow). The solid portions of fats are known by this term, the fluid portions being called *oleine* (from ἐλαιον, oleum, oil . If melted tallow be dissolved in about eight times its weight of ether, on cooling the oleine alone remains dissolved, the stearine crystallises, and can be rendered absolutely pure by washing with ether. Stearine is a solid transparent substance, easily reduced to powder. At one time stearine was an object of manufacture; but the production of stearic acid has superseded it. The process employed for the production of stearine was very simple. Tallow was melted, and by being kept quiet in the melted state all impurities subsided and were removed. Then the fluid and transparent tallow was allowed to cool as gradually as possible to the temperature of 100° Fahr. During the process of cooling the fluid mass is kept constantly agitated. At the above temperature, the stearine only becomes solid, separating from the oleine in a crystalline form, thickening the whole into a pasty mass. This is then placed in cloths and subjected to pressure in the hydraulic press. The oleine is absorbed by the cloths or drains off, and the stearine is eventually obtained in a solid cake, in many respects resembling spermaceti. Liebig and Pelouze consider stearine a salt of two bases. Water plays the part of one, while the other is the oxide of the radical *glyceryle* (C^6H^7) with 5 atoms of oxygen, which is contained in most fats, and is known in the form of a hydrate, $C^6H^7O^5 + HO$. See GLYCERINE.

STEATITE, or *Soapstone* (*Craie de Briancon*, Fr.; *Speckstein*, Germ.), is a mineral of the magnesian family, which has been grouped by Dana under the "Talc Section." It has a greyish-white or greenish-white colour, often marked with dendritic delineations, and occurs massive, as also in various supposititious 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 is found frequently in small contemporaneous veins that traverse Serpentine in all directions, as at Portsoy, in Shetland, in the limestone of Icolmkiln, 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, sold under the name of FRENCH CHALK; the chemical composition is silica 62·14, magnesia 32·92, water 4·94, being sometimes contaminated with and coloured by a litttle iron, manganese, or chrome; 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. See Talc.

STEEL (*Acier*, Fr.; *Stahl*, Germ.) is a carburet of iron, more or less freed from foreign matter, and may be produced by two processes opposed to each other. First, by working pig iron, which contains 4 or 5 per cent. of carbon, in a suitable furnace, until such carbon is reduced to that quantity required for constituting steel, which is about 1 per cent; the second method is to heat iron bars in contact with charcoal, until they have absorbed that quantity of carbon which may be required.

Steel may be classed into three kinds.

1st. Natural steel which is manufactured from pig iron direct.

2nd. Cemented or converted steel, which is produced by the carbonisation of wrought iron.

3rd. Cast steel which is produced by the fusion of either natural or cemented steel, but principally from the latter.

The various kinds of iron which are used for the manufacture of steel are imported principally from Sweden, Norway, and Russia; but the high price of Swedish and other steel iron, has for the past few years compelled the consumers to look elsewhere for a supply of foreign made iron, whilst at the same time every encouragement has been offered to English manufacturers so to improve their steel irons as to render them at least suitable for the production of steel good enough for the manufacture of coach springs and such other purposes.

The following shows the importation of Swedish iron from 1845 to 1854:—

	Tons.		Tons.
1845 - - -	18,407	1850 - - -	28,096
1846 - - -	30,840	1851 - - -	35,467
1847 - - -	28,264	1852 - - -	23,817
1848 - - -	20,438	1853 - - -	23,540
1849 - - -	26,605	1854 - - -	24,436

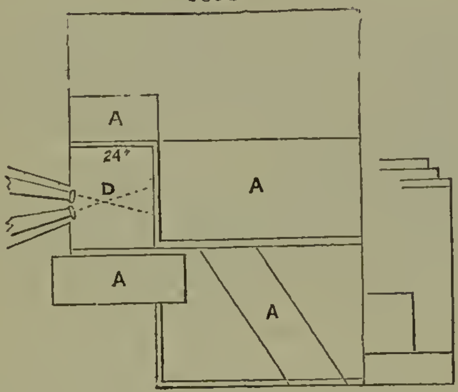
The above forms an average for ten years of 26,011 tons to which must be added 8 to 10,000 tons which comes from Russia and Norway, or 35,000 tons per annum.

England now furnishes a large quantity of iron suitable for steel purposes, which may be estimated at 20,000 tons per annum; this iron is manufactured with great care often with an admixture of charcoal pig iron, and various chemical reactives, which are added at the caprice of each manufacturer, but the object of which is to discharge the deleterious matters and to reduce the semi-metals.

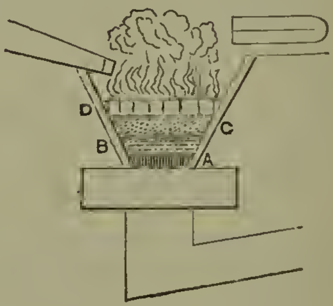
It is of the highest importance that the iron used for steel purposes should be as pure and free from foreign matters as possible; those irons which at present enjoy the highest reputation are those manufactured from the Dannemora ores in Sweden; the whole of the steel irons produced in that country are smelted from the black oxides, containing usually 60 per cent. of metal. The present price of the first marks of iron produced in Sweden are for ⓘ 33*l.*, G_L 32*l.*, GO 30*l.*; of the second marks, G_F 28*l.*, $\overset{3}{W}$ 26*l.*, B 26*l.*; there are others selling from 22*l.* to 16*l.* per ton, whilst the common Swedish steel iron may be estimated at 14*l.* per ton. The Russian iron marked K Ь and IOP3 is largely imported, and sells at 18*l.* per ton; it is produced in the Ural district of Russia. The price of English made steel iron is on an average 11*l.* per ton.

Natural or German steel is so called because it is produced direct from pig iron, the result of the fusion of the spathose iron ores alone, or in a small degree mixed with the brown oxide; these ores produce a highly crystalline metal called spiegle-eisen on account of the large crystals the metal presents. This crude iron contains 4 to 5 per cent. of carbon, and 4 to 5 per cent. of manganese. Karsten, Hassengratz, Marcher, and Reaumur, all advocate the use of grey pig iron for the production of steel; indeed they distinctly state that the best qualities cannot be produced without it; they state correctly that the object of working it in the furnace is to clear away all foreign matters, but there can be no advantage gained by retaining the carbon, and combining it with the iron. This theory is incorrect, although it is supported by such high authorities; grey iron contains the maximum quantity of carbon, and consequently remains for a longer time in a state of fluidity than iron containing less carbon; the metal is not only mixed up with the foreign matter it may itself contain, but also that with which it may become mixed in the furnace in which it is worked. This prolonged working, which is necessary in order to bring highly carbonised metal into a malleable state, increases the tendency to produce silicated oxides of iron; these mixing with the steel produced renders it red short, and destroys many good qualities which the pig iron may have originally possessed. The semi-metals produced tend also to prevent malleability; the use of highly carbonised *white pig iron* is equally inapplicable, and causes a large consumption of charcoal, as well as waste of metal. In Austria, where a large quantity of natural steel is produced, the fluid metal is tapped from the blast furnace into a round hole; water is sprinkled on the surface which chills it, and thus forms a cake about half an inch thick. This is taken from the surface, and the operation is again performed until the whole is formed into cakes, they are then piled edgewise in a furnace, and covered with charcoal, and heated a full red heat for about 48 hours; by this process much of the carbon is discharged. These cakes are then used for producing steel in the refinery. A much superior quality is thus obtained with greater economy. It appears that the most perfect plan for manufacturing the steel is to free the crude metal as much as possible from its impurities whilst in a fluid state. There is a process patented by Mr. Charles Sanderson of Sheffield, which fulfils all that is required. The crude metal is melted on the bed of a reverberatory furnace, and any chemical re-agent is added capable of disengaging oxygen during its decomposition. Carbonic acid or carbonic oxide gases are produced by the union of the oxygen with the carbon contained in the fluid iron which is thus eliminated; the gases so produced, being unable to re-enter the metal, either pass off in vapour, or act upon the silicates or other earthy compounds which the crude iron may contain, precipitating the metallic part and allowing the earthy matter to flow away as slag: a refined metal is thus produced of very great purity for the production of steel. The metal itself being to some extent decarbonised, the steel is more quickly produced, which secures economy in charcoal, time, and waste of metal, &c.; the purity of the metal also prevents the formation of those deleterious compounds, which, when they are incorporated with the steel seriously injure the quality. Natural steel manufactured from this purified iron has been found of very superior quality, and more uniform. The furnaces used for the production of natural steel are like the refineries in which charcoal iron is produced. In all countries their *general* construction is the same, but each has its own peculiar mode of working. We find therefore, the German, the Styrian, the Carinthian, and several other distinct methods, yet all producing steel from crude iron directly,

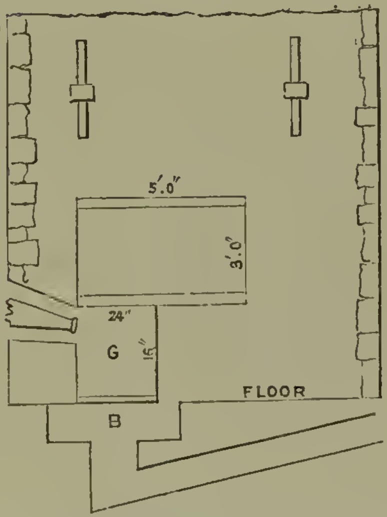
1695



1697



1696



although pursuing different modes of operation. These differences arise from the nature of the pig iron each country produces, and the peculiar habits of the workmen.

These modified processes do not affect the *theory* of the manufacture of the steel, but rather accommodate themselves to the peculiar character of the metal produced.

Fig. 1695 shows a ground-plan of the furnace; *fig.* 1696 an elevation; and *fig.* 1697 the form of the fire itself and the position of the metal within it. The fire, D, is 24 inches long and 24 inches wide; A, A, A are metal plates, surrounding the furnace.

Fig. 1696 shows the elevation, usually built of stone, and braced with iron bars. The fire, G, is 16 inches deep and 24 inches wide; before the tuyère, at B, a space is left under the fire, to allow the damp to escape, and thus keep the bottom dry and hot.

In *fig.* 1695 there are two tuyères, but only one tuyère iron, which receives both the blast nozzles, which are so laid and directed that the currents of air cross each other, as shown by the dotted lines; the blast is kept as regular as possible, so that the fire may be of one uniform heat, whatever intensity may be required.

Fig. 1697 shows the fire itself, with the metal, charcoal, and blast. A is a bottom of charcoal, rammed down very close and hard. B is another bottom, but not so closely beaten down; this bed of charcoal protects the under one, and serves also to give out carbon to the loop of steel during its production. C is a thin stratum of metal, which is kept in the fire to surround the loop. D shows the loop itself in progress.

When the fire is hot, the first operation is to melt down a portion of pig iron, say 50 to 70 pounds according as the pig contains more or less carbon; the charcoal is pushed back from the upper part of the fire, and the blast, which is then reduced, is allowed to play upon the surface of the metal, adding from time to time some hammer slack, or rich cinder, the result of the previous loop. All these operations tend to *decarbonise* the metal to a certain extent; the mass begins to thicken, and at length becomes solid. The workman then draws together the charcoal and melts down another portion of metal upon the cake; this operation renders the face of the cake again fluid, but the operation of decarbonisation being repeated in the second charge, it also thickens, incorporates itself with the previous cake, and the whole becomes hard; metal is again added until the loop is completed. During these successive operations, the loop is never raised before the blast, as it is in making iron, but it is drawn from the fire and hammered into a large bloom, which is cut into several pieces, the ends being kept separated from the middle or more solid parts, which are the best.

This operation, apparently so simple in itself, requires both skill and care; the workman has to judge, as the operation proceeds, of the amount of carbon which he has retained from the pig iron; if too much, the result is a very raw, crude, untreatable steel; if too little, he obtains only a steelified iron; he has also to keep the cinder at a proper degree of fluidity, which is modified from time to time by the addition of quartz, old slags, &c. It is usual to keep from two to three inches of cinder on the face of the metal, to protect it from the direct action of the blast. The fire itself is formed of iron plates, and the two charcoal bottoms rise to within nine inches of the tuyère, which is laid flatter than when iron is being made. This position of the tuyère causes the fire to work more slowly, but it insures a better result.

The quantity of blast required is about 180 cubic feet per minute. Good workmen make 7 cwt. of steel in 17 hours. The waste of the pig iron is from 20 to 25 per cent., and the quantity of charcoal consumed is 240 bushels per ton. The inclination of the tuyère is 12 to 15 degrees. The flame of the fire is the best guide for the workmen. During its working it should be a red bluish colour. When it becomes white the fire is working too hot.

From this description of the process, it will be evident that pig iron will require a much longer time to decarbonise than the cakes of metal which have been roasted, as already described; and, again, it must be evident, that a *purified* and *decarbonised* metal, must be the best to secure a good and equal quality to the steel, since the purified metal is more homogeneous than the crude iron.

When, therefore, care has been taken in melting down each portion of metal, and a complete and perfect layer of steel has been obtained after each successive melting, when the cinder has had due attention, so that it has been neither too thick nor too thin, and the heat of the fire regulated and modified during the progressive stages of the process, then a good result is obtained; a fine-grained steel is produced, which draws under the hammer, and hardens well. However good it may be, it possesses one great defect; it is this. During its manufacture, *iron* is produced along with the steel, and becomes so intimately mixed up with it, that it injures the otherwise good qualities of the steel; the iron becomes, as it were, interlaced throughout the mass, and thus destroys its hardening quality. When any tool or instrument is made from natural steel, without it has been well refined, it will not receive a *permanent* cutting edge; the iron part of the mass, of course, not being hard, the tool cuts only upon the steel portion, the edge, therefore, very soon becomes destroyed. There is another defect in natural steel, but it is of less importance. When too much carbon has been left, the steel is raw and coarse, and it draws very imperfectly under the hammer; the articles manufactured from such steel often break in hardening; thus it is evident, that in producing this kind of steel, every care, skill, and attention is required at the hands of the workman. These defects very materially affect the commercial value of the steel; the irregular quality secures no guarantee to the consumer that the tools shall be perfect, and, consequently, it is not used for the most important purposes; yet, when the raw steel is refined, it becomes a very useful metal, and is largely used in Westphalia for the manufacture of hardware, scythes, and even swords. It possesses a peculiarity of retaining its steel quality after repeated heating. This property renders it very useful for mining and many other purposes.

The raw steel, being so imperfect, is not considered so much an article of commerce with the manufacturer, but it is sold to the steel refiners, who submit it to a process of welding. The raw steel bloom is drawn into bars, one or two inches wide and half an inch thick, or less; a number of these are put together and welded; these bars are then thrown into water, and they are broken in smaller pieces to examine the fracture; those bars which are equally steelified are mixed together. In manufacturing refined steel, the degree of hardness is selected to suit the kind of article which it is intended to make. A bar, two to three feet long, forms the top and bottom of the bundle, but the inside of the packet is filled with the small pieces of selected steel. This packet is then placed in a hollow fire, and carefully covered from time to time with pounded clay, to form a coat over the metal, and preserve it from the oxidising influence of the blast. When it is at a full welding heat it is placed under a hammer, and made as sound and homogeneous as possible; it is again cut, doubled together, and again welded. For very fine articles, the refining is increased by several doublings, but this is not carried at present to so great an extent as formerly, since cast steel is substituted, being in many cases cheaper. Although the refined natural steel is very largely consumed in Germany, and also in Austria, yet a considerable quantity is exported to South America, the United States, and to Mexico. The Levant trade takes a large portion, and is supplied from the Styrian and Carinthian forges. This is shipped from Trieste; it is sold in boxes and bundles. That in boxes is marked No. 00, up to 4. The 00 is the smallest, being about $\frac{1}{4}$ in. square; number 4 is about $\frac{1}{2}$ in.; 0, 1, 2 and 3, being the intermediate sizes. It is broken in small pieces, about 3 to 7 inches long. In bundles of 100 lbs. the steel is drawn to various sizes, and is so packed. A large portion is sent to the East Indies, and also to the United States.

The average price of that sold in boxes is 20*l.* to 24*l.* per ton; in bundles, 17*l.* to 20*l.*; and the raw steel, as sold to the refiners, 15*l.* to 18*l.* per ton; whilst the refined steel increases in price according to the number of times it has been refined.

Natural steel being expensive many attempts were made in Westphalia to produce a kind of steel by puddling pig iron in a peculiar manner; a patent was taken out in England by Mr. Riepe, and a considerable quantity of this steel is produced. In Mr. Riepe's description of this process he says:—

"I employ the puddling furnace in the same way as for making wrought iron. I introduce a charge of about 280 lbs. of pig iron, and raise the temperature to redness. As soon as the metal begins to fuse and trickle down in a fluid state, the damper is to be partially closed in order to temper the heat. From 12 to 16 shovelfuls of iron cinder discharged from the rolls or squeezing machine are added, and the whole is to be uniformly melted down. The mass is then to be puddled with the addition of a little black oxide of manganese, common salt, and dry clay, previously ground together. After this mixture has acted for some minutes, the damper is to be fully opened, when about forty pounds of pig iron is to be put into the furnace, near the fire bridge, upon elevated beds of cinder prepared for that purpose. When this pig iron begins to trickle down, and the mass on the bottom of the surface begins to boil and throw out from the surface the well-known blue jets of flame, the said pig iron is raked into the boiling mass, and the whole is then well mixed together. The mass soon begins to swell up, and the small grains begin to form in it and break through the melted cinder on the surface. As soon as these grains appear, the damper is to be three-quarters shut, and the process closely inspected while the mass is being puddled to and fro beneath the covering layer of cinder. During the whole of this process the heat should not be raised above cherry redness, or the welding heat of shear steel. The blue jets of flame gradually disappear, while the formation of grains continues, which grains very soon begin to fuse together, so that the mass becomes waxy, and has the above mentioned cherry redness. If these precautions are not observed, the mass would pass more or less into iron, and no uniform steel product could be obtained. As soon as the mass is finished so far, the fire is stirred to keep the necessary heat for the succeeding operation—the damper is to be entirely shut, and part of the mass is collected into a ball, the remainder always being kept covered with cinder slack. This ball is brought under the hammer, and then worked into bars. The same process is continued until the whole is worked into bars. When I use pig iron made from sparry iron ore, or mixtures of it with other pig iron, I add only about 20 lbs. of the former pig iron at the later period of the process, instead of about 40 lbs. When I employ Welsh or pig iron of that description, I throw 10 lbs. of best plastic clay, in a dry granulated state, before the beginning of the process, on the bottom of the furnace. I add at the later period of the process, about 40 lbs. of pig iron as before described, but strew over it clay in the same proportion as just mentioned."

This steel is very useful for ships' plates, being very strong and rigid, and thus requiring less weight of metal; it may also eventually be used for rails and a great variety of purposes, for which at present strong charcoal or scrap iron is used. Its present price is about 25*l.* in plates, and 16*l.* in bars.

The Paal process may be considered as an improvement upon natural steel, the object being as far as possible to carbonise the iron fibres which this kind of steel always contains. The process is based upon the old one of Vanaccio; it consists in plunging iron into a bath of melted metal. The carbon of the metal combines with the iron, and in a very short time converts it into steel. This process was carried further by Vanaccio, who contrived to add wrought iron to the metal until he had decarbonised it sufficiently; this was found to produce a steel, but unfit for general use. That produced by plunging iron into metal was found to be very hard steel on the outside, but iron within; while that produced by adding iron to the metal was found too brittle to be drawn. The Paal method, however, is a decided improvement in the manufacture of refined natural steel. The packets, as already described in the refinement of natural steel, are welded and drawn to a bar; whilst hot they are plunged into a bath of metal for a few minutes, by which the iron contained in the raw steel becomes carbonised, and thus a more regular steel is obtained than that produced by the common process. The operation requires great care, for if the bars of steel be left in the metal too long they are more or less destroyed, or perhaps entirely melted. It commands a little higher price in the market, and is chiefly consumed by the home manufacturers, excepting a portion which is exported to Russia.

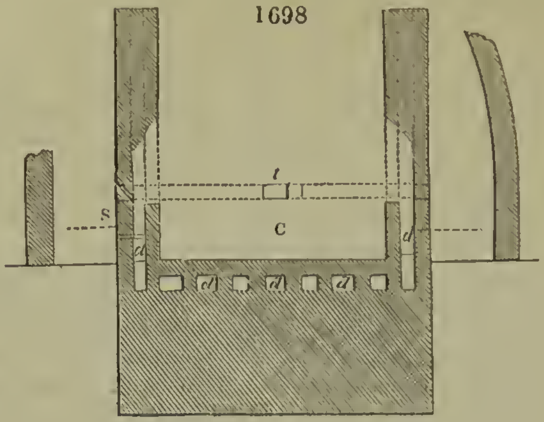
The foregoing kinds of steel may be classed under the first head of natural steel, being manufactured from the *crude iron direct.*

The next process is the production of steel by introducing carbon into malleable iron which is the reverse of the process already described. The iron to be converted is placed in a furnace, stratified with carbonaceous matter, and on heat being applied the iron absorbs the carbon, and a new compound is thus formed.

When this process was discovered is not known; at a very early period charcoal was found to harden iron, and to give it a better and more permanent cutting edge. It seems probable that from hardening small objects, bars of iron were afterwards submitted to the same process. To Reaumur certainly belongs the merit of first bringing the process of conversion to any degree of perfection. His work contains a vast amount of information upon the the theory of cementation; and although his investigations are not borne out by the practice of the present day, yet the first principles laid down by him are now the guide of the converter. Our furnaces are much larger than those used by Reaumur, and they are built so as to produce a more uniform and economical result. The furnace of cementation in which bar iron is converted into blistered steel is represented in *figs.* 1698, 1699, 1700.

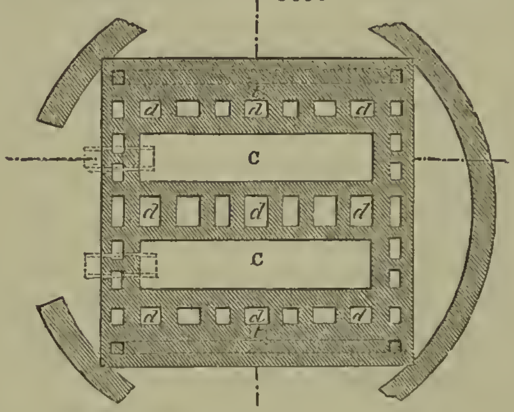
It is rectangular, and covered in by a semicircular arch, in the centre of which there is a circular hole left, 12 inches diameter, which is opened when the furnace is cooling. It contains two chests called "pots," C, C, made either of fire-stone or fire-bricks; each "pot" is 3 feet wide, 3 feet deep, and 12 feet long. One is placed on one side, and the other, on the contrary side of the fire-grate, A B, which occupies the whole length of the furnace, and is 13 to 14 feet long; the grate is 15 to 16 inches broad, and the bars rest from 10 to 12 inches below the inferior plane or bottom level of the "pots;" the height of the arch at the centre is 5½ feet above the top of the "pots," the bottoms of which are nearly level with the ground, so that the bars of iron do not need lifting so high when charging them into the furnace. The flame rises between the two "pots;" it passes also below and around them, through the horizontal and vertical flues, *d*, and issues from the furnace through the six small chimneys, H, into a large conical space which is built around the whole furnace, 30 to 40 feet high, open at the top. This cone increases the draft of the furnace, and carries away the smoke. There are three openings in the front of the arch; two, T, *fig.* 1700, above the pots serve to admit and remove the bars; they are about 8 inches square; in each a piece of iron is placed upon which the bars slide in and out of the furnace. The workman enters by the middle opening, P, to arrange the bars, which he lays flat in the pots and spread as layer of charcoal, ground small, between each layer; the bars are laid near each other, excepting those next to the side of the pot, which are placed an inch from it; the last stratum of iron is covered with a thick layer of charcoal, and the whole is carefully covered with loamy earth 4 to 5 inches thick. The iron is gradually heated, in about 4 days has become fully heated through, and the furnace

1698



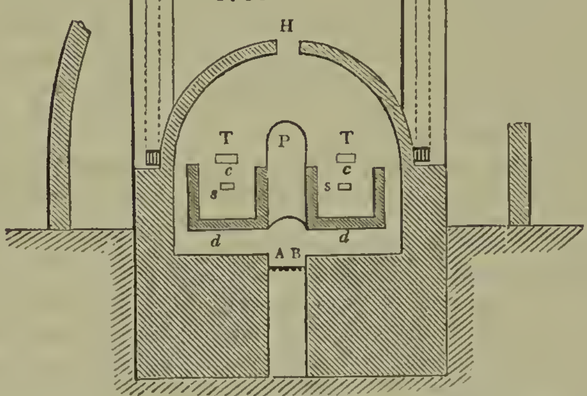
has then attained its maximum heat, which is maintained for 2 or 3 days until the first test bar is drawn out; the heat is afterwards regulated, according to the degree

1699



of hardness which may be required. The iron is converted in 8 days if for soft steel, and in 9 to 11 days if for harder purposes.

1700



Conversion usually commences in 60 to 70 hours after the furnace is lighted. The pores of the iron being opened by heat, the carbon is gradually absorbed by the mass of the bar, but the *carbonisation* or conversion is effected, as it were, in layers. To explain the theory in the clearest manner, suppose a bar to be composed of a number of laminæ—the combination of the carbon with the iron is first effected on the surface, and gradually extends from one lamina to another, until the whole is carbonised. To effect this complete carbonisation the iron requires to be kept at a considerable uniform heat for a length of time. Thin bars of iron are much sooner converted than thick ones. Reaumur states, in his experiments, that if a bar of iron 3-16ths of an inch thick is converted in 6 hours, a bar 7-16ths of an inch would require 36 hours to attain the same degree of hardness. The carbon introduces itself *successively*, the first lamina or surface of a bar combining with a portion of the carbon with which it is in contact, gives a portion of the carbon to the second lamina, at the same time taking up a fresh quantity of carbon from the charcoal; these successive combinations are continued until the whole thickness is converted; from which theory it is evident that from the exterior to the centre the dose of carbon becomes proportionately less. Steel so produced cannot be said to be perfect; it possesses in some degree the defect of natural steel, being more carbonised on the surface than at the centre of the bar. From this theory we perceive that steel made by cementation is different in its character from that produced directly from crude metal. In conversion the carbon is made successively to penetrate to the centre of the bar, whilst in the production of natural steel, the molecules of metal which compose the mass are *per se* charged with a certain percentage of carbon necessary for their steelification; not imbibed, but obtained by the decarbonisation of the crude iron down to a point requisite to produce steel.

During the process of cementation, the introduction of the carbon disintegrates the molecules of the metal, and in the harder steel produces a distinct crystallisation of a white silvery colour. Wherever the iron is unsound or imperfectly manufactured, the surface of the steel becomes covered with blisters thrown up by the dilation of the metal and introduction of carbon between those laminæ which are imperfectly welded. Reaumur and others have attributed this phenomena to the presence of sulphur, various salts, or zinc, which dilate the metal; but this is incorrect, because we find that a bar of cast steel which is homogeneous and perfectly free from internal imperfections never blisters, for although it receives the highest dose of carbon in the furnace, yet the surface is perfectly smooth. From this it is evident that the blisters are occasioned by imperfections in the iron. Iron increases, both in length and weight, during conversion. Hard iron increases *less* than soft. The augmentation in weight may be said to be $\frac{1}{200}$, and in length $\frac{1}{120}$, on an average.

The operation of conversion is extremely simple in its manipulation, nevertheless, it requires great care, and a long as well as a varied experience, to enable a manager to produce every kind or temper required by consumers. Considerable knowledge is required to ascertain the nature of the irons to be converted, because all irons do not convert equally well under the same circumstances; some require a different treatment from others, and, again, one iron may require to be converted at a different degree of heat from another. The furnace must have continual care, and be kept air-tight, so that the steel, when carbonised, may not again become oxidised. It is known amongst steel-makers, that if iron be brought in contact with carbon, and if heat be applied, it will become steel. This is the knowledge gleaned up by workmen, and also by too many owners of converting furnaces. The inconvenience arising from a want of care and knowledge of the peculiar state of the iron *during* its conversion, sometimes occasions great disappointment and loss. The success usually attained by workmen may, however, be attributable to an everyday attention to one object, thus gaining their knowledge from experience alone. The conversion or carbonisation of the iron, is the foundation of steel making, and, as such, may be considered as the first step in its manufacture. Before bar steel is used for manufacturing purposes, it has to be heated, and hammered or rolled. Its principal uses are for files, agricultural implements, spades, shovels, wire, &c., and in very large quantities for coach-springs.

Bar steel is also used for manufacturing shear steel. It is heated, drawn to lengths 3 feet long, then subjected to a welding heat, and some six or eight bars are welded together, precisely as described in the refinement of natural steel; this is called single shear. It is further refined by doubling the bar, and submitting it to a second welding and hammering; the result is a clearer and more homogeneous steel. During the last seven years the manufacture of this steel has been limited, mechanics preferring a soft cast steel, which is much superior, when properly manufactured, and which can be very easily welded to iron.

The price of bar steel varies according to the price of the iron from which it is made, but, as a general average, its price in commerce may be taken at 5*l.* per ton beyond the price of the iron from which it is made. Bar steel produced from the better irons is usually dearer than the commoner kind, on account of their scarcity.

Shear steel in ordinary size sells at 60*l.* per ton net.
Coach-spring steel from foreign iron, 22*l.* ,,
Coach-spring steel from English iron, 18*l.* ,,

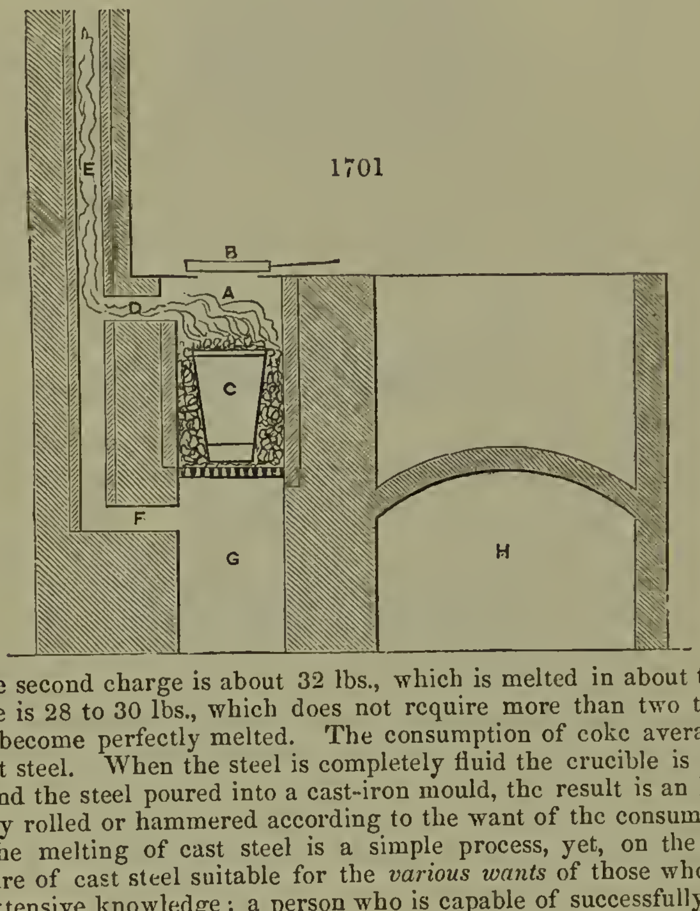
These may be taken as approximate prices in 1859-60.

Both natural, puddled, and converted steel have great defects in temper, clearness, and uniformity, and are unfit for most useful purposes. To obviate these defects, these steels are broken in pieces and melted in a crucible, thus freeing them from any deleterious matter they might contain; equality in texture and degree of hardness is thus obtained, whilst the steel is also capable of receiving a clear and beautiful polish.

The process of melting bar steel, and thus producing cast steel, was first practically carried on by Mr. Huntsman of Attercliffe; the process itself is very simple. *Fig.* 1701 shows a cross section of the furnace universally used.

The furnace A, is square, lined with fire-stone 12 inches by 22 wide, and 36 inches deep from the grate bar to the under side of the cover B. C is a crucible, of which two are placed in one "melting hole." D is the flue into the chimney, E, which is about 40 feet high, lined with fire-brick. There is an air flue which is used to regulate the draught at F. G is the ashpit, and H the cellar which is arched over.

The steel is broken in pieces and charged into the crucible, which is placed on a stand and provided with a cover; coke is used as a fuel, and an intense heat is obtained. The crucible is charged three times during the day, and is then burnt through; the first charge is usually 36 lbs., which requires from three to four hours



to melt it; the second charge is about 32 lbs., which is melted in about three hours; the last charge is 28 to 30 lbs., which does not require more than two to two and a half hours to become perfectly melted. The consumption of coke averages $3\frac{1}{2}$ tons per ton of cast steel. When the steel is completely fluid the crucible is drawn from the furnace, and the steel poured into a cast-iron mould, the result is an ingot, which is subsequently rolled or hammered according to the want of the consumer.

Although the melting of cast steel is a simple process, yet, on the other hand, the manufacture of cast steel suitable for the *various wants* of those who consume it requires an extensive knowledge; a person who is capable of successfully conducting a manufactory, must make himself master of the treatment to which the steel in manufactures will be submitted by every person who consumes it. Cast steel is not only made of many degrees of hardness, but it is also made of different qualities; a steel maker has, therefore, to combine a very intimate knowledge of the exact intrinsic quality of the iron he uses, or that produced by a mixture of two or three kinds together; he has to secure as complete and as equal a degree of carbonisation as possible, which can only be attained by possessing a perfect practical and theoretical knowledge of the process of converting; he has to know that the steel he uses is equal in hardness, in which without much practice he may easily be deceived; he must give his own instruction for its being carefully melted, and he must examine its fracture by breaking off the end of each ingot, and exercise his judgment whether or not proper care has been taken; besides all this knowledge and care, a steel maker has to adapt the *capabilities* of his steel to the *wants* and *requirements* of the consumer. There are a vast variety of defects in steel as usually manufactured; but there are a far greater number of instances in which steel is *not adapted* for the manufacture of the article for which it was expressly made. Cast steel may be manufactured for planing, boring, or turning tools; its defects may be, that the tools when made crack in the process of hardening, or that the tool whilst exceedingly strong in one part, will be found in another part utterly useless.

Cast steel may be wanted for the engraver. It may be produced apparently perfect, and with a clear surface, but may be so improperly manufactured, that when the plate has been engraved and has to be hardened, it is found covered with soft places. The trial is even greater when the engraving is transferred by pressure to another plate. It is, therefore, evident that a steel maker must not only attend to the intrinsic quality of his steel, but he has to use his judgment as regards the degree of hardness and tenacity which it should possess, so as to *adapt it to the peculiar requisites of its employment.*

The manufacture of cast steel is open to great temptations, which may be termed fraudulent. Swedish iron, as I have already stated, varies in price according to its usefulness for steel purposes; cast steel may, therefore, be manufactured from a metal selling at 20*l.* per ton, whilst the price charged for it to the consumer presumes it to have been made from a metal worth 30*l.* per ton. The exterior of the bar is perfect, the fracture appears to the eye satisfactory, and its intrinsic value is only discovered when it is put to the test; thus, whilst a steel maker has to exercise his knowledge, judgment, and care, he has a moral duty to perform, by giving to his customer a metal of the intrinsic value he professes it to be, and for which he makes his charge.

In manufacturing the commoner description of steel, particularly cast steel made from English iron, black oxide of manganese is added to the steel in the crucible, and acts as a detergent. The oxygen unites with a portion of the carbon in the steel, forming carbonic oxide gas, which acts upon the imperfectly metallic portions of the steel used, and liberates the metal whilst the deleterious matter is taken up and forms a slag with the manganese. There has been a great controversy regarding the invention which originated with Mr. Heath. This substance is not generally used when the Dannemora irons are melted, as they are very pure, and the addition of an oxide partially destroys the temper of the steel. The Indian steel, or wootz, is also a cast steel.

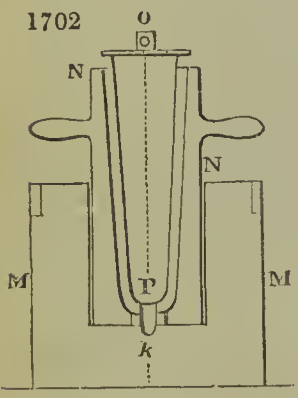
Indian steel, or wootz. — The wootz ore consists of the magnetic oxide of iron, united with quartz, in proportions which do not seem to differ much, being generally about 42 of quartz and 58 of magnetic oxide. Its grains are of various size, down to a sandy texture. The natives prepare it for smelting 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 *Cassia auriculata*, and the leaf that of the *Asclepias gigantea*, or the *Convolvulus laurifolius.* As soon as the clay plugs of the crucibles are dry, from twenty to twenty-four 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 a crucible. When the fusion has been perfect, the top of the cake is covered with striæ, 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 remelting 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 remelt 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. Stoddart, 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.

Fig. 1702 represents the mould for making the crucibles: each manufacturer makes his own; M, M, is a solid block of wood let into the floor, having a hole which admits a round piece of iron fixed in the centre of the plug P. The material of which the crucible is made consists of 22 lbs. of fire-clay got from Stannington near Sheffield, from the neighbourhood of Burton-on-Trent, or Stourbridge; 2 lbs. of the old crucible after it has been used, ground to powder, and about ½ lb. of ground coke. These quantities are sufficient for one crucible of the ordinary size. This composition is trodden for 8 or 10 hours on a metal floor; it is then cut into pieces of 26 to 28 lbs.; each piece is rolled round nearly to the size of the mould into which it is introduced, and the plug P is driven down with a mallet; the mould is furnished with a movable bottom: when the pot is made the mould is lifted up by the two handles, and fixing the bottom on a post, the mould falls, and leaves the crucible upon it. Converted bars, and also cast steel in ingots, are reduced to bars, rods, and sheets by hammering or rolling; when forged they are heated in a small furnace urged by blast, and drawn to bars under hammers of 7 to 9 cwt., giving 100 to 120 strokes per minute.

1702



When small rods are required they are "tilted," that is, they are heated and drawn under hammers of 3 or 4 cwt., striking 200 to 250 blows per minute. When steel is rolled the machinery used is of the same construction as that required for rolling iron, excepting that the rollers are usually hard on the surface. Hardening and tempering steel is a delicate operation; small articles of cutlery are usually hardened by first heating them to a red heat and plunging them in water, saws and such articles are when heated plunged into oil. All articles are tempered by carefully heating them when hardened, and the degree of temper is indicated by a change in the colour of the surface, which is first straw coloured, then blue, and deep blue: colour is thus made the most delicate test for the degree of temper given: after this operation steel is found to expand a little. Alloys of steel have been very carefully made by Messrs. Stoddart and Faraday, but no alloy has at present been found to give any addition to the intrinsic quality of steel; the empiric titles of "silver steel," "meteoric steel," &c., may be regarded simply as fanciful names to recommend the article, either as a raw material or in a manufactured state.

Those articles called "run steel" are made by melting pig-iron and pouring it into moulds of sand in which the required article has been moulded; they are then packed in round iron pots about 12 inches diameter, and 16 to 18 inches high, along with hæmatite iron ore crushed to powder; these pots are packed in a furnace, and heat is applied from 24 hours to several days; the oxygen abstracts the carbon from the metal of which the articles are made, and they become to a certain extent malleable, so much so, that pieces a quarter of an inch thick may be bent almost double, and can be drawn out under a hammer. Forks, table knives, scissors, and many other cheap articles are so made; also a vast variety of parts of cotton and flax machinery are so manufactured, especially those parts which are difficult to forge.

"Damascus" or Damasked "steel" is made by melting together iron and steel, or bars of steel of high and low degrees of carbonisation; it may also be produced by melting hard and soft steel in separate crucibles, mixing them together whilst fluid and immediately pouring the mixture into an ingot mould, the damask is shown by the application of dilute acid to the surface when brightened. The analysis of a genuine Damascus sword-blade has shown that it is not a homogeneous steel, but a mixture of steel and iron.

During the past few years a great many processes have been patented with a view of reducing the cost of cast steel; Mr. Bessemer, Mr. Marticu, Mr. Mushet, and several others have suggested modes of producing a serviceable steel from the common pig-iron. A full description of these proposed improvements would take up too much space, but can be examined in the "Repertory of Arts:" the whole of these processes are purposely omitted, because a description of them would necessarily demand some examination of their merits.

Statistical account of the manufacture of steel.— The manufacture of steel in England is chiefly confined to Sheffield, although it is also made at Newcastle and in Staffordshire. The importation of Swedish iron, combined with that furnished from English materials, amounts to from 40,000 to 50,000 tons per annum; of course this weight represents the quantity of steel manufactured of every description.

The number of furnaces in Sheffield and its neighbourhood are as follow:—

	Converting Furnaces.	Cast steel Furnaces. or holes.
1835	56	554
1842	97	774
1846	105	974
1853	160	1495

A converting furnace will produce 300 tons of steel per annum, but if each produce 250 tons, 160 converting furnaces would represent a make of 40,000 tons of steel a year in Sheffield alone. Again, there are 1495 melting holes; each furnace of 10 holes will melt 200 tons; this, therefore, shows a product annually of 29,900 tons, but as such furnaces may not all be in continual work from various causes, the quantity of cast steel manufactured in Sheffield may be estimated at 23,000 tons. The weight of coach-spring steel, estimated at 10,000 tons, leaving a remainder of 7000 tons of bar for the manufacture of German, faggot, single and double shear steel. As regards the price, I take cast steel at 45*l.* per ton; its commercial value varies from 35*l.* to 60*l.* per ton net, and as a large quantity of the cheaper steel is sold, 45*l.* per ton is an average. The price of bar steel is below the real value, since it includes all shear steel, the best of which sells at 60*l.* per ton, whilst, however, a portion of this 7000 tons sells only at 28*l.*, and some even lower. The price of coach springs is the price now paid for them.

The weight and value of the steel made in England may be estimated as follows:—

Tons.		£
23,000	of cast steel, all qualities, at 45*l* per ton	1,035,000
7,000	bar steel, including German, faggot, single and double shear steel, average 35*l.* per ton	245,000
10,000	coach-spring steel, 19*l.* per ton	190,000
40,000 Tons.		£1,470,000

The statistics of this metal give the following results:

	Tons.		£
France produces	14,954	average value of	443,850
Prussia "	5,453	"	170,824
Austria "	13,037	"	321,073
United States	10,000	"	212,500
England "	40,000	"	1,470,000

Such is the contrast of the manufacturing power of the steel-producing countries; it shows the eminent position of England, in both weight and value; this can only arise from the practical skill and scientific knowledge which we have brought to bear upon its manufacture; and the active energy which has enabled us to produce steel *suitable for every purpose in the arts.* This superiority not only enables our manufacturers to maintain the high position they now hold, but to increase it yet further; for we daily see our production expanding, not only to supply the wants of our home manufacturers, but also for the continent of Europe, as well as the United States of America and Canada.

Bessemer's malleable Iron and Steel.—In the article "Iron" will be found a statement of the process proposed by Mr. Bessemer for converting crude pig iron into malleable iron, which we believe to be a fair representation of all the facts up to the period when that paper was written. Since then the process has been tried in the manufacture of steel, and, certainly, it appears, with much more success than attended the early experiments made on iron. For the purpose of placing the matter, however, clearly before our readers, we extract a considerable portion of Mr. Henry Bessemer's paper "On the manufacture of malleable Iron and Steel," read before the Institution of Civil Engineers in May last.

"The want of success which attended some of the early experiments was erroneously attributed, by some persons, to the 'burning' of the metal, and by others, to the absence of cinder, and to the crystalline condition of cast metal. It was almost needless to say that neither of the causes assigned had anything to do with the failure of the process, in those cases where failure had occurred. Chemical investigation soon pointed out the real source of difficulty. It was found, that although the metal could be wholly decarbonised, and the silicium be removed, the quantity of sulphur and of phosphorus was but little affected; and as different samples were carefully analysed, it was ascertained that red-shortness was always produced by sulphur, when present to the extent of one tenth per cent., and that cold-shortness resulted from the presence of a like quantity of phosphorus; it, therefore, became necessary to remove those substances. Steam and pure hydrogen gas were tried, with more or less success, in the removal of sulphur, and various fluxes, composed chiefly of silicates of the oxide of iron and manganese, were brought in contact with the fluid metal during the process, and the quantity of phosphorus was thereby reduced. Thus, many months were consumed in laborious and expensive experiments; consecutive steps in advance were made, and many valuable facts were elicited. The successful working of some of the higher qualities of pig-iron caused a total change in the process, to which the efforts of Messrs. Bessemer and Longsdon were directed. It was determined to import some of the best Swedish pig-iron, from which steel of excellent quality was made, and tried for almost all the uses for which steel of the highest class was employed. It was then decided to discontinue, for a time, all further experiments, and to erect steel works at Sheffield for the express purpose of fully developing and working the new process commercially, and thus to remove the erroneous impressions so generally entertained in reference to the Bessemer process.

"In manufacturing tool steel of the highest quality, it was found preferable, for several reasons, to use the best Swedish pig-iron, and, when converted into steel by the Bessemer process, to pour the fluid steel into water, and afterwards to re-melt the shotted metal in a crucible, as at present practised in making blister-steel, whereby the small ingots required for this particular article were more perfectly and more readily made.

"It was satisfactory to know that there existed in this country vast, and apparently inexhaustible, beds of the purest ores fitted for the process. Of the hematite alone, 970,000 tons were raised annually, and this quantity might be doubled or trebled, whenever a demand arose. It was from the hematite pig-iron made at the Workington Iron Works, that most of the iron and steel was made. About 1 ton 13 cwts. of ore, costing 10*s.* per ton, would yield 1 ton of pig metal, with 60 per cent. less lime, and 20 per cent. less fuel, than were generally consumed when working inferior ores; while the furnaces using this ore alone yielded from 220 tons to 240 tons per week, instead of, say, 160 tons to 180 tons per week, when working with common ironstone. The Cleator Moor, the Weardale, and the Forest of Dean Iron Works also produced an excellent metal for this purpose.

"The form of converting vessel which had been found most suitable somewhat resembled the glass retort used by chemists for distillation. It was mounted on axes, and was lined with 'ganister' or road drift, which lasted during the conversion of thirty or forty charges of steel, and was then quickly and cheaply repaired, or renewed. The vessel was brought into an inclined position, to receive the charge of crude iron, during which time the tuyères were above the surface of the metal. As soon as the whole charge was run in, the vessel was moved on its axes, so as to bring the tuyères below the level of the metal, when the process was at once brought into full activity, and twenty small, though powerful, jets of air sprang upwards through the fluid mass; the air, expanding in volume, divided itself into globules, or burst violently upwards, carrying with it a large quantity of the fluid metal, which again fell back into the boiling mass below. The oxygen of the air appeared, in this process, first to produce the combustion of the carbon contained in the iron, and at the same time to oxidise the silicium, producing silicic acid, which, uniting with the oxide of iron, obtained by the combustion of a small quantity of metallic iron, thus produced a fluid silicate of the oxide of iron, or 'cinder,' which was retained in the vessel and assisted in purifying the metal. The increase of temperature which the metal underwent, and which seemed so disproportionate to the quantity of carbon and iron consumed, was doubtless owing to the favourable circumstances under which combustion took place. There was no intercepting material to absorb the heat generated, and to prevent its being taken up by the metal, for heat was evolved at thousands of points, distributed throughout the fluid, and when the metal boiled, the whole mass rose far above its natural level, forming a sort of spongy froth, with an intensely vivid combustion going on in every one of its numberless, ever-changing cavities. Thus by the mere action of the blast, a temperature was attained, in the largest masses of metal, in ten or twelve minutes, that whole days of exposure in the most powerful furnace would fail to produce.

"The amount of decarbonisation of the metal was regulated, with great accuracy, by a meter, which indicated on a dial the number of cubic feet of air that had passed through the metal; so that steel of any quality or temper could be obtained with the greatest certainty. As soon as the metal had reached the desired point (as indicated by the dial), the workmen moved the vessel, so as to pour out the fluid malleable iron or steel into a founder's ladle, which was attached to the arm of a hydraulic crane, so as to be brought readily over the moulds. The ladle was provided with a fire-clay plug at the bottom, the raising of which, by a suitable lever, allowed the fluid metal to descend in a clear vertical stream into the moulds. When the first mould was filled, the plug valve was depressed, and the metal was prevented from flowing until the casting ladle was moved over the next mould, when the raising of the plug allowed this to be filled in a similar manner, and so on until all the moulds were filled.

"The casting of large masses of a perfectly homogeneous malleable metal into any desired form rendered unnecessary the tedious, expensive, and uncertain operation of welding now employed wherever large masses were required. The extreme toughness and extensibility of the Bessemer iron was proved by the bending of cold bars of iron 3 in. square, under the hammer, into a close fold, without the smallest perceptible rupture of the metal at any part; the bar being extended on the outside of the bend from 12 in. to 16¾ in., and being compressed on the inside from 12 in. to 7¼ in., making a difference in length of 9½ in., between what, before bending, were the two parallel sides of a bar 3 in. square. An iron cable, consisting of four strands of round iron 1½ in. diameter, was so closely twisted, while cold, as to cause the strands at the point of contact to be permanently imbedded into each other. Each of these strands had elongated 12½ in. in a length of 4 ft., and had dimiuished 1-10th of an inch in diameter, throughout their whole length. Steel bars, 2 in. square and 2 ft. 6 in. in length, were twisted cold into a spiral, the angles of which were about 45 degrees; and some round steel bars, 2 in. in diameter, were bent cold under the hammer, into the form of an ordinary horse-shoe magnet, the outside of the bend measuring 5 in. more than the inside.

"The steel and iron boiler plates, left without shearing, and with their ends bent over cold, afforded ample evidence of the extreme tenacity and toughness of the metal; while the clear, even surface of railway axles and pieces of malleable iron ordnance were examples of the perfect freedom from cracks, flaws, or hard veins which forms so distinguishing a characteristic of the new metal. The tensile strength of this metal was not less remarkable, as the several samples of steel tested in the proving machine at Woolwich arsenal bore, according to the reports of Colonel Eardley Wilmot, R.A., a strain varying from 150,000 lbs. to 160,900 lbs. on the square inch, and four samples of iron boiler plate from 68,314 lbs. to 73,100 lbs.; while according to the published experiments of Mr. W. Fairbairn, Staffordshire plates bore a mean strain of 45,000 lbs.; and Low Moor and Bowling plates a mean of 57,120 lbs. per square inch.

"There was also another fact of great importance in a commercial point of view. In the manufacture of plates for boilers and for ship-building, the cost of production increased considerably with the increase of weight in the plate; for instance, the Low Moor Iron Company demanded 22*l.* per ton for plates weighing 2½ cwt. each; but if the weight exceeded 5 cwt., then the price rose from 22*l.* to 37*l.* per ton. Now with cast ingots, such as the one exhibited, and from which the sample plates were made, it was less troublesome, less expensive, and less wasteful of material, to make plates weighing from 10 cwt. to 20 cwt., than to produce smaller ones; and indeed there could be but little doubt that large plates would eventually be made in preference, and that those who wanted small plates would have to cut them from the large ones. A moment's reflection would, therefore, show the great economy of the new process in this respect; and when it was remembered that every riveted joint in a plate reduced the ultimate strength of each 100 lb. to 70 lb., the great value of long plates for girders and for ship-building would be fully appreciated.

"It would be interesting to those who were watching the advancement of the new process, to know that it was already rapidly extending itself over Europe. The firm of Daniel Elfstrand and Co., of Edsken, who were the pioneers in Sweden, had now made several hundred tons of excellent steel by the Bessemer process. Another large manufactory had since been started in their immediate neighbourhood, and three other companies were also making arrangements to use the process. The authorities in Sweden had fully investigated the whole process, and had pronounced in favour of it. Large steel circular saw-plates were made by Mr. Göranson, of Gefle, in Sweden, the ingot being cast direct from the fluid metal within fifteen minutes of its leaving the blast furnace. In France the process had been for some time carried on by the old established firm of James Jackson and Son, at their steel-works near Bordeaux. This firm was about to manufacture puddled steel on a large scale. They had already got a puddling furnace erected and in active operation, when their attention was directed to the Bessemer process, the apparatus for which was put up at their works last year; and they were now extending their field of operations, by putting up more powerful apparatus at the blast furnaces in the Landes. There were also four other blast furnaces in the South of France in course of erection, for the express purpose of carrying out the new process.

"The irons of Algeria and Saxony had produced steel of the highest quality.

"Belgium was not much behind her neighbours; the process was now being carried into operation at Liège, where excellent steel had been made from the native coke iron; while in Sardinia preparations were also being made for working the system. Professor Müller, of Vienna, and M. Dumas, from Paris, had visited Sweden, to inspect and report on the working of the new system in that country.

"That the process admitted of further improvement, and of a vast extension beyond its present limits, the author had no doubt; but those steps in advance would, he imagined, result chiefly from the experience gained in the daily commercial working of the process, and would most probably be the contributions of the many practical men who might be engaged in carrying on the manufacture of iron and steel by this system."

The following information is of interest:—

Comparative tensile strength of various kinds of Iron and Steel, in lbs. per square inch.

	lbs.	
Ordinary cast iron (which varies considerably) may be taken at - - - - -	18,656	Templeton.
Swedish cast iron used for ordnance - -	33,000	Woolwich Arsenal.
"Bessemer" iron in its cast, unhammered state, mean of 5 trials - - - - -	41,242	,,

Wrought Iron Plates; mean breaking weight with, and across, the fibre.

	lbs.	
Yorkshire plates; best - - - - - -	59,584	Fairbairn.
,, ordinary - - - - -	54,656	,,
Derbyshire ,, ,, - - - -	45,136	,,
Shropshire ,, ,, - - - -	50,176	,,
Staffordshire ,, ,, - - - -	45,472	,,
Mean of 4 trials of soft iron plates made by the "Bessemer process" - - - -	68,319	Woolwich Arsenal.
Boiler plates, made of very soft cast steel (approaching in quality to iron), made by the "Bessemer process" - - -	110,000	Trials at Manchester.

Iron bars, hammered or rolled.

	lbs.	
English bar iron - - - - - - -	55,872	Templeton.
,, ,, - - - - - - -	56,000	Rennie's Tables.
Swedish ,, - - - - - - -	72,000	,, ,,
,, ,, - - - - - - -	72,064	Templeton.
"Bessemer iron," mean of 8 trials - - -	72,643	Woolwich Arsenal.
,, maximum - - - -	82,110	,,
Cast steel, made by the "Bessemer process," in its unhammered state; mean of 8 trials -	63,022	,,
Sheffield cast steel - - - - -	130,000	Rennie's Tables.
Cast steel, made by "Krupp" of Essex - -	127,320	Woolwich Arsenal.
,, "Captain Uchatius" -	91,955	
Cast steel, made of Nova Scotia iron by the ordinary process - - - - -	128,043	
"Bessemer steel," mean of 7 trials - -	152,911	
,, maximum - - - -	162,970	

STEMPLES. *A mining term.* Strong pieces of timber, driven betwixt the sides of a vein, at short distances apart, to support the walls.

STEREOTYPE PRINTING signifies printing by fixed types, or by a cast typographic plate. This plate was formerly always, and is still sometimes, 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. The moulds are here exposed to air heated to fully 400° Fahr., 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, while by remaining fluid above, it continues to impart hydrostatic pressure during the shrinkage attendant on refrigeration. As it thus progressively contracts in volume, more metal is fed into the corners of the pan, in order to keep up the pressure upon the mould, and to secure a perfect impression, as well as a solid cast.

The whole process is greatly improved by the employment of a prepared bibulous paper, instead of the plaster of Paris. The paper employed is of French manufacture, and it is impregnated with some wax-like composition, the preparation of which is kept a profound secret by the inventor. The form of type being prepared, a sheet of this prepared paper is placed upon it, and the whole is subjected to considerable pressure. On removing the paper it is found to have received a most perfect impression of the type. This impressed paper mould is then placed in an iron box, which is fixed in a nearly vertical position, and the heavy cover being carefully closed, there only remains between it and the mould exactly the space which is necessary to ensure a proper thickness to the type metal. All being prepared, the melted metal is poured into the mould. It flows, of course, at once to the bottom of the mould, and as the liquid is rapidly supplied, the whole is filled, and, as in the case already given, some pressure is obtained by the lead of metal above the paper mould. The mass of metal (iron) forming the casting box, in comparison with the thin plate of type metal, ensures a rapid chilling of the latter, so that the plate can be removed in a very short time. The impression thus obtained is exceedingly perfect; and the whole process is one of great simplicity and exactness, and is capable of being executed with great rapidity.

The Times newspaper is regularly printed from stereotype plates made in the manner described. The advantages of a solid block over a form of loose type will be sufficiently obvious to all; and but for the security which is afforded by the use of the solid plate, there would be great risk in driving the printing machinery at such high rates of speed as are employed in *The Times* office, and other offices, where they re-

* Chase (*chassis*, frame, Fr.), quoin (*coin*, wedge, Fr.), are terms which show that the art of printing is indebted to our French neighbours for many of its improvements.

quire to throw off a very large impression within a very limited time. See PRINTING and PRINTING MACHINERY.

STEREOSCOPE (from στερεος, solid, and σκοπειν, to see). An instrument invented by Professor Wheatstone, and modified by Sir David Brewster, by means of which two images of the same object, depicted on paper, — as those images would be depicted upon the retina of each eye — are resolved into an apparent solid of three dimensions. The reflecting stereoscope of Professor Wheatstone was constructed by means of two mirrors, set at right angles to each other, so that while the right eye observed a reflected image of a picture placed on the right-hand side of the instrument, the left eye saw a reflected image of that on the left, and, as a result, saw — not two plane pictures, but one solid image. The refracting stereoscope, which is generally used, consists of two semi-lenses. This is a lens which is divided in the middle, and the two halves, with the edges towards each other, placed in a frame, at a distance from each other corresponding with the distances of the eyes apart. For the best result, two pictures are obtained by photography, as nearly as possible of the same character as the pictures impressed respectively upon the retina of each eye. These pictures, being placed below the lenses, are resolved into one image, and that image realises all the conditions of solidity, as in natural vision. See *Hunt's Manual of Photography.*

STILL. See DISTILLATION.

STIPPLE ENGRAVING is a process which was practised by Bartolozzi, Ryland, and others, in imitation of chalk drawings of the human figure. Stipple is performed with the graver, which is so managed as to produce the tints by small dots, rather than by lines, as in the ordinary method. It is very soft in its effect, but inferior to the more legitimate mode of engraving. See ENGRAVING.

STOCKING MANUFACTURE. See HOSIERY.

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. This is remarkably the case with the bridges of Westminster and Blackfriars; the foundations of which began to perish most visibly in the very lifetime of their constructors.

Stones for building, it is stated, may be proved as to their power of resisting the action of frost, by the 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 crystallisation, for example. Sulphate of soda, or Glauber's salt, answers the purpose perfectly, and it is 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. In opposition to this, Mr. C. H. Smith, one of the commissioners for selecting the stone for the Houses of Parliament, states — "Such treatment, compared with that of nature, will be found to vary materially, both in detail and result. If Glauber's salt expands in changing from a fluid to a crystalline state, it is so little as to be inappreciable; whereas water increases considerably in bulk while freezing." Many experiments selected from the

Report on Stone for the New Houses of Parliament (March 1839), show that in M. Brard's treatment the effect is in most instances opposite to that of the action of the weather on stones which have been exposed to its influence many years. Some of the specimens well known to decay rapidly in a building disintegrated least of all by Brard's process; others of the most durable quality disintegrated more than all the rest, under similar treatment; consequently Brard's method of testing is not to be depended upon, and is liable to lead to erroneous conclusions.

The most important building stones of the United Kingdom are the following :—

Granites — produced chiefly in Cornwall, Devonshire, Leicestershire, Aberdeenshire, and in Wickow and Carlow.

Porphyries, Syenites, Elvans —obtained from Cornwall, Devonshire, Leicestershire, and many parts of Scotland and Ireland.

Sandstones — the chief quarries of which are in Yorkshire, Derbyshire, Shropshire, Surrey, &c., and in several of the Scottish counties. The Portland, Cragleith, and other celebrated stones, belong to this class.

Millstone Grit is found largely in Derbyshire, in Yorkshire, and indeed in most of the coal-producing districts.

Dolomites, or Magnesian Limestones. Yorkshire, Durham, and Northumberland, Derbyshire, Nottinghamshire, produce these stones abundantly.

Oolites. The Bath Stone is a well-known example of this stone; the stone from the quarries of Ancaster and of Ketton being fine specimens of the class.

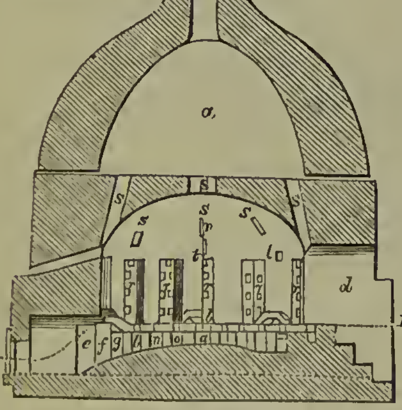
Limestones. These are very varied. The Purbeck marble, the Derbyshire marbles, the Lias bed, the Devonian Limestone, and the well-known mountain limestone being examples.

Slates. These are obtained in very great abundance in North Wales, in Devonshire, and in Cornwall; in some parts of Scotland and of Ireland.

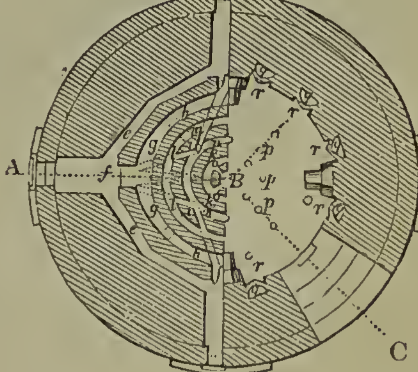
Such are the principal varieties, although many others exist which are exceedingly useful. Most of the above will be found described under their respective heads.

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, being in fact a Terra-Cotta, which see. His kilns, which are peculiar in form, and economical in fuel, deserve to be generally known. *Figs.* 1703 and 1704 represent his round kiln; *fig.* 1703 being an oblique section in the line A, B, C, of *fig.* 1704, which is a ground plan in the line D, *a*, *b*, E, of *fig.* 1703. 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 *h* 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

1703



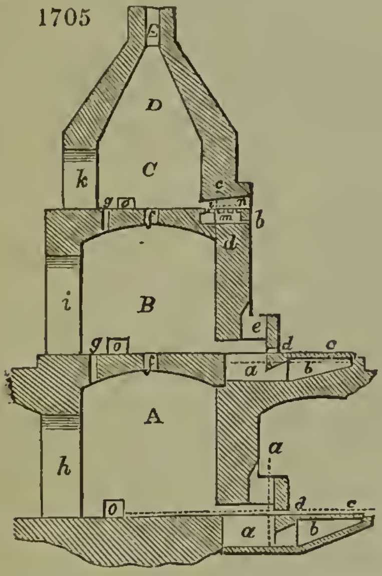
1704



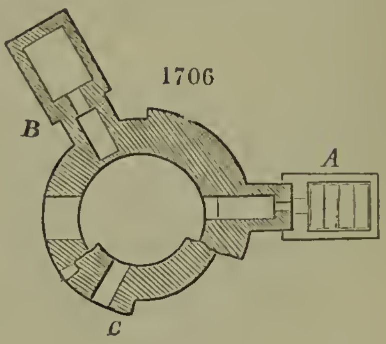
tops, the flame may be directed inwards and downwards; *s* are the vents for carrying off the flames into the upper space *u*, which is usually left empty. These vents can be closed by iron damper-plates, pushed in through the slide-slits of the dome. *t*, *t*, are peep-holes, for observing the state of ignition in the furnace; but they are most commonly bricked up. *Fig.* 1705 is a vertical section, and *fig.* 1706 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 E. *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.

Many ingenious arrangements have been made for the construction of artificial stone. We might, of course, group under this head many varieties of clay wares and cements. See BRICKS, MORTARS, and HYDRAULIC CEMENTS.

1705



1706



Amongst all the numerous plans which have been devised, few of them have altogether succeeded; they have either proved too expensive in the manufacture, or they have not endured the test of time.

Mr. Buckwell proposed the following plans for the construction of artificial stone. Taking fragments of stone sufficiently large to go freely into his mould, he fills up the interstices with stones of various sizes, and then pours in a mixture of chalk and Thames mud or Mersey mud burnt together. This cement being poured into the mould, the whole is rammed together by falling hammers, and as the mould is perforated the water is forced out, and the resulting stone is so hard, when removed from the mould, that it rings when struck. It will be evident to those acquainted with hydraulic mortars and the application of concrete that this is only an improved concrete. The cost of production has been too great to admit of the general introduction of this artificial stone.

Ransome's patent siliceous stone, being one of the most successful attempts to produce a permanent stone artificially, requires a little further attention.

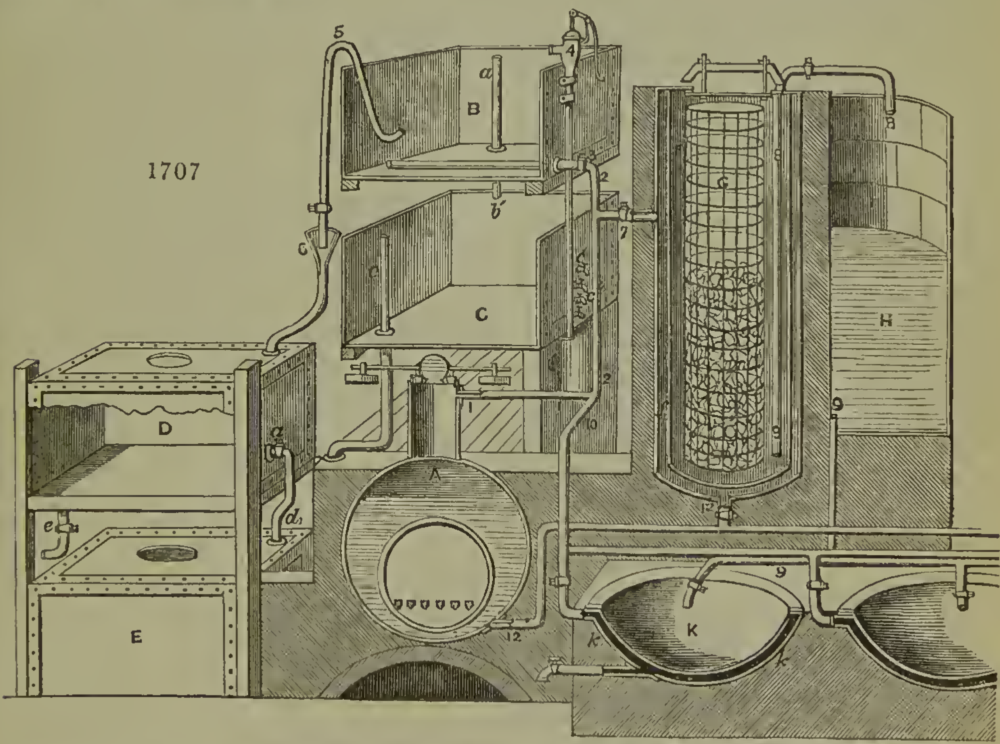
Mr. Ransome's attention was directed to the subject of artificial stone in 1844, while engaged as manager in the establishment of his relatives, the Messrs. Ransome, of the Orwell Works, Ipswich. At that time the above-named firm happened to have a considerable order for flour mills for the colonies; and, from the difficulty experienced in refacing the French burr stones, usually employed for the purpose, in situations where skilled labour was not attainable, it was proposed to obviate this difficulty by substituting for the stones surfaces of chilled cast iron. It was found, however, that after a while the grinding surfaces so constructed became glazed, and consequently unfit for the purpose for which they were intended. While overlooking the proceedings of a workman engaged in renewing, on one occasion, the worn-out ridges on a burr-stone, Mr. Ransome was struck by the apparent absurdity of having to chip away not only the soft parts of the stone, but also the hard siliceous prominences which constitute the real efficient portion of the surface. From the unequal and heterogeneous character of the burrs usually employed, one side was apt to wear away sooner than the other; and to bring the grinding surface to anything like a true bearing, the harder portions of the stone had to be cut away to the level of the lower and softer parts; thereby occasioning not only great labour in renewing the surface, but also a very rapid destruction of the whole material.

It at once occurred to Mr. Ransome that if he could procure a stone of perfect homogeneous texture, the surface would wear down equally, and this objectionable system of levelling the whole to the depth of the softer and most worn parts would be completely obviated. Unfortunately, however, all natural stones were, from their very nature, of unequal texture, even within the limits of the small segments usually employed in the construction of mill-stones. Gathering up a handful of the chips struck off by the tools of the workmen and pressing them together, the idea flashed across his mind that if he could discover any means of cementing those particles together he would be able to produce a stone of nearly uniform hardness throughout. The most convenient material for this purpose that first suggested itself was plaster of Paris. This idea was immediately put in execution; and, although the results at first offered some slight prospect of success, a little subsequent experience showed the utter fallaciousness of the hopes he had entertained concerning them. But from the first moment that the scheme of cementing together the loose and disintegrated fragments of the mill-stone entered his mind, he comprehended by anticipation the whole of the results, which, after twelve years of assiduous application, he has succeeded in carrying to a triumphant conclusion.

After numerous failures, it occurred to Mr. Ransome that a solution of silica as a cementing material would be superior to any other, and he accordingly started on the inquiry after an easy method of producing a solution of flints. Experiment proved to the inventor that flints subjected to heat, under pressure in a boiler with a solution of soda or potash, were dissolved.

The accompanying illustration gives a sectional view of the apparatus employed in preparing the siliceous cement.

1707



A is a steam boiler, capable of generating a sufficiency of steam for heating the dissolving and evaporative vessels, and usually worked at a pressure of about 70 lb. to the square inch. B is the upper ley-tank for dissolving the carbonate of soda. It is supplied with steam by the pipes 1, 2, 3, communicating with the boiler.

The first operation is to reduce the ordinary soda ash of commerce to the condition of caustic soda. For this purpose the ash is first dissolved in the tank B, the water in which is heated by means of the perforated steam-pipe *b*. A quantity of quick lime is then added, and the mixture well stirred. The soda is by this means deprived of the carbonic acid which it contains, by the quick lime forming with it a carbonate of lime. To ascertain when the ley is quite caustic, a small portion is taken out in a test tube, and a few drops of hydrochloric acid added. If there is no effervescence it may be assumed that the soda is entirely deprived of its carbonic acid, and is consequently caustic. When the lime, now converted into chalk, has subsided to the bottom of the tank, the clear supernatant ley is drawn off by the siphon 5, into the funnel 6, leading into a closed vessel D, to prevent the carbonic acid of the atmosphere combining with it, and destroying its causticity. When the ley has been drawn off from B, the sediment remaining at the bottom of the tank is allowed to fall into the lower tank C, by withdrawing the plug *a*, from the pipe b^1. Any undissolved crystals of the carbonate of soda which have been entangled among the particles of the lime are now washed out and pumped back to the upper tank B, where it forms a portion of the next charge.

The clear caustic being contained in the closed tank D, has a further process of depuration to undergo before it is ready to be used as a solvent for the flints. The ordinary soda ash of commerce is always more or less adulterated with a sulphate of soda, which although an inert substance in itself, if allowed to remain in the cement subsequently makes its appearance in an ugly efflorescence on the surface of the finished stone. To get rid of the sulphate, the caustic solution of soda has added to it, in the tank D, a quantity of caustic baryta, obtained by burning the commercial carbonate of baryta with wood charcoal. The caustic baryta seizes upon the sulphuric acid contained in the sulphate of soda, and forms with it an insoluble sulphate of baryta, which is precipitated on the bottom of the tank. The depurated ley is then drawn off by the pipe *d*, into the lower closed tank E, and the sulphate of baryta sediment passes off by the cock at the bottom. From E, the prepared solution of the caustic soda is pumped into the vertical boiler or digester F. This digester, in which the process of dissolving the flints is effected, is a cylindrical vessel, having a steam jacket *f*, into which steam from the boiler A is supplied by the pipes 1, 2, *y*. The inner cylinder F, is provided with a wire basket G, reaching the whole length of the vessel, and serving to hold a collection of nodules of common flint. When F has been filled with the caustic ley, and the basket with flints, the manhole at the top is closed and well screwed down, so as to be able to resist a pressure of at least 60 lb. on the square inch. The cock at *y* is then opened, and the full pressure of steam from the boiler passes into the jacket *f*, and causes the ley in F to rise to the same temperature. The condensed steam in the jacket *f* returns to the boiler by the pipe 12, which it enters below the water line. The pressure maintained in the digester is generally about 60 lb., and this is continued about 36 hours; at the end of which time the strength of the solution is tested. The workmen employed to superintend this part of the process generally use the tongue as the most delicate test. If the solution has a decidedly caustic alkaline taste they conclude that there is still too much free soda in the cement, and the boiling is allowed to continue until the cement has a slightly sweetish taste, which occurs when the alkali has been nearly neutralised by combination with the silicic acid of the flints. A more scientific mode of testing the strength of the solution is to take a wine-glassful and drop a little hydrochloric acid into it; by this means the whole of the silica in the solution is thrown down by the acid combining with the soda, so as to form chloride of sodium. The precipitated silica presents an appearance resembling half dissolved snow, and its comparative volume gives a good idea of the strength of the solution of the alkaline silicate.

When it is judged that the alkali has taken up as much of the silica as it is capable of doing, at the temperature to which it is subjected in the digester, the stop cock *y*, in the steam pipe communicating with the jacket, is shut, and a cock in the pipe 8 is opened. The pressure of the steam in F then forces the fluid silicate through the pipe 8 into the vessel H, where it is allowed to stand for a short time to deposit any sediment which it may contain. From H it is then conveyed by the pipe 9 to the evaporating pan, K, which has a steam jacket, *k*, supplied with steam by the pipe 10. The cement is then boiled in the evaporating pan until it becomes of the consistency of treacle, when it is taken out. The specific gravity of the cement when ready for use is about 1·600. The general proportions of the materials used in making up the artificial stone is about the following:—

10 pints of sand, 1 pint of powdered flint, 1 pint of clay, and 1 pint of the alkaline solution of flint.

These ingredients are first well mixed in a pug-mill, and kneaded until they are thoroughly incorporated and the whole mass becomes of a perfectly uniform consistency. When worked up with clean raw materials, the compound possesses a putty-like consistence which can be moulded into any required form, and is capable of receiving very sharp and delicate impressions.

The peculiarity which distinguishes this from other artificial stones consists in the employment of silica both as the base and the combining material. Most of the varieties of artificial stone hitherto produced are compounds, of which lime, or its carbonate, or sulphate, forms the base, and in some instances they consist in part of organic matters as the cement, and having inorganic matters as the base.

To produce different kinds of artificial stone, adapted to the various purposes to which natural stones are usually applied, both the proportions and the character of the ingredients are varied as circumstances require. By using the coarser description of grits, grinding stones of all kinds can be formed, and that with an uniformity of texture never met with in the best natural stones. Any degree of hardness or porosity may also be given, by varying the quantity of silicate employed and subjecting it to a greater or less degree of heat.

For some descriptions of goods a portion of clay is mixed with the sand and other ingredients, for the double purpose of enabling the material to stand up during the process of firing in the kiln and to prevent its getting too much glazed on the surface.

The plastic nature of the compound allows of the most complex and undercut patterns being moulded with greater ease than by almost any other material we are acquainted with, if we except gutta percha, which, however, has the drawback of being affected by common temperatures.

The moulds employed are generally of plaster of Paris, and are so divided as to allow of the different pieces which cannot be withdrawn together being separately removed from the putty-like substance with which it has been filled. In filling the moulds the workmen use a short stick, with which they ram in the material, much in the way in which green sand is forced into contact with the pattern in an iron foundry, only with the difference, that the sand in this case is mixed with glutinous cement, which enables it to retain the form impressed upon it with much greater persistency and sharpness than is practicable with dry sand, or even loam. The casts, after being taken from the mould, are first washed over with a diluted mixture of the silicate, technically called "floating." The whole surface is then carefully examined, and any broken or rough portions are sleeked with a tool. It should have been mentioned that the plaster of Paris moulds, before being filled, are first painted over with oil and then dusted with finely powdered glass to prevent them adhering to the cast.

In attempting, however, to carry out his plan, two difficulties of a rather formidable character presented themselves. It was found that, in the process of desiccation, the surface of the stone parted with the moisture contained in the soluble silicate, and became hardened into a tough impervious coating, which prevented the moisture escaping from the interior of the mass. Any attempt to dislodge the water retained in combination with the silicate in the interior of the stone, by raising the temperature of the whole above 212 degrees, had merely the effect of breaking this outer skin of desiccated silicate, and rendering the surface cracked and uneven.

Instead therefore of allowing the stones to be dried in an open kiln they were placed in a closed chamber or boiler, surrounded with a steam-jacket, by which the temperature of the interior chamber could be regulated. In order that no superficial evaporation should take place while the stones were being raised to the temperature of the steam in the jacket, a small jet of steam was allowed to flow into the chamber, and condense among and on the surface of the goods; until, as the temperature of the interior of the stones rose to 212° and upwards, they became enveloped in an atmosphere of steam, which effectually prevented any hardening of the surface. The minute vents or spiracles formed by the steam as it was generated in the interior of the masses, remained open, when the vapour contained in the closed chamber was allowed slowly to escape, and afforded a means of egress to any moisture which might still be retained among the particles of sand and cement. The whole of the moisture contained in the silicate of soda having been thus vaporised before it left the stone, an opportunity was afforded it by opening a communication with the external atmosphere, to pass off, leaving the interior of the stone perfectly dry. Simple as this arrangement may seem, we will venture to say that not one of our readers has hit upon the expedient through his own cogitations on the subject.

The process, in effect, consists in stewing the stones in a closed vessel, and when all the moisture which they contain is converted into vapour, allowing it to escape, so that no one part of the mass can be dried before another. By this means Mr. Ransome was enabled to desiccate his artificial stone without any risk of the cracking or warping which had hitherto been the result of his attempts to harden them by exposure in an open stove.

After being thoroughly dried they are taken to the kiln, but, instead of being placed in *seggars* or boxes of clay, as is usually done in the potter's kiln, the goods are first bedded up with dry sand, to prevent any risk of their bending or losing their shape while burning. Flat slabs of fire clay are then used to separate the various pieces laterally, and similar slabs are placed over them to form a shelf, on which another tier of goods is placed. The temperature of the kiln is very gradually raised for the first twenty-four hours; the intensity is then augmented until at the end of forty-eight hours a bright red heat is attained, when the kiln is allowed to cool gradually for four or five days, when the goods are ready to be taken out.

The purposes to which this artificial stone is now applied are of the most miscellaneous description, comprising groundstones, whetstones for sharpening scythes, gothic foliage and mouldings for ecclesiastical decorations, tombstones and monumental tablets, chimneypieces, fountains, garden stands for flowers, statuary, &c.

From being composed almost entirely of pure siliceous matter, it is not acted upon by acids, and is apparently quite insoluble, even in boiling water.

By proportioning the amount of cement, and varying the character of the sand which enters into the composition of the stone, it can be made porous or non-porous, as may be desired. The average absorbent power is less than that of the Bolsover Moor Dolomite used in the erection of the Houses of Parliament, and a little more than that of the Cragleight Sandstone.

Dippenhall Silica Works, Farnham, Surrey.

The manufactory which bears this name was built for the production of artificial stone, from a material only recently discovered, and never before employed for this purpose: *soluble silica*. By this term is meant that kind of silica which is found to be readily dissolved by boiling in open vessels with solutions of caustic potash or soda; thus distinguished from the silica of flint, which is only soluble in such solutions at a temperature of about 300° Fahr. in a steam-tight boiler; and from that of quartz or sand, which is altogether insoluble. Up to the period when this discovery was made, silica had been only known to exist naturally in the two latter forms, and the former was merely a chemical product, derived from one of them by artificial means. This was at any rate the case in England; but it is right to state that a somewhat similar deposit was mentioned by M. Sauvage, a French chemist, before the researches were made to which this paper relates, as existing in the Département des Ardennes. This information, however, has not been turned to any practical account; and therefore a short history of the English discovery may not be uninteresting, as the latter has introduced to the world a new material applicable to a great variety of purposes.

About ten years ago the late Mr. Paine, of Farnham, proposed to the Chemical Committee of the Royal Agricultural Society of England that a complete analysis should be made of all the soils of the kingdom, for the purpose of ascertaining their value as natural manures. He undertook, for his own share, the strata of the chalk formation; and his thorough geological knowledge, aided by the chemical science of Professor Way, then consulting chemist to the Royal Agricultural Society, enabled him fully to complete the inquiry.

Some of the results of this joint investigation were communicated to the public by Messrs. Paine and Way, in the 12th volume of the Journal of the Royal Agricultural Society, in a paper entitled "On the Strata of the Chalk Formation." The soluble silica deposit is thus described: — "Immediately above the gault, with the upper member of which it insensibly intermingles, lies a soft white-brown rock, having the appearance of a rich limestone. It is very remarkable on account of its low specific gravity, and still more so considering its position, by reason of the very small quantity of carbonate of lime which it contains. It is one of the richest subsoils of the whole chalk series, being admirably adapted for the growth of hops, wheat, beans, &c.

"The section of rock at Farnham is about 40 feet in thickness. The analysis gives as follows: —

	Per cent.
Combined water and a little organic matter	4·15
Soluble in dilute acids, 57·10	
Silicic acid (silica)	46·28
Carbonic acid	none.
Sulphuric acid	trace.
Phosphoric acid	ditto.
Chlorine	none.
Lime	0·26
Magnesia	·07
Potash	·79
Soda	·43
Protoxide and peroxide of iron	6·12
Alumina	3·15
Insoluble in acids, 38·75	
Lime	2·91
Magnesia	traces.
Potash	1·51
Soda	·60
Alumina with a little oxide of iron	14·20
Silicic acid and sand	19·53
	100·00"

At the end of the paper it is remarked that a careful study of this rock may throw light upon the composition of soils.

The same authors contributed another article to the 14th volume of the "Journal," on "the Silica Strata of the Lower Chalk," in which they state that "when the former paper was published, they were not unaware that this stratum contained a large proportion of silica in the form which chemists call "soluble;" but that they wished, before making public their discovery, to ascertain whether it existed in sufficient quantity to render it available for agricultural use." They then detail the result of their researches during the intervening two years, as far as they concern agriculture, mentioning all the localities in which this stratum may be found in England, and the various ways of employing it beneficially as a manure. They allude to the fact that it will be found useful in its application to the arts, and conclude with these remarks on its probable formation: "It is not infusorial, for with the exception of a few foraminifera, no traces of animal life can be observed in the rock by microscopical examination. It cannot have been subjected to heat of any intensity, or it would have been rendered insoluble in alkalies. It is plainly the result of aqueous decomposition; and it seems very reasonable to suppose that silicate of lime in solution derived from the older rocks may have met with carbonic acid produced either by vegetable and animal decay, or by volcanic agency, and at one and the same time carbonate of lime and gelatinous or soluble silica would have been formed. It should be remembered that we find these beds in immediate contact with the chalk; we find chalk without silica, silica without chalk, and in other cases, both intimately blended. There is therefore good reason for supposing that these productions have been in some way connected."

While these investigations were going on, it was also found that the new material was useful in a variety of ways quite distinct from agriculture. Mr. Way's experiments led to the conviction that it would be serviceable in sugar refining, in soap-making, in making animal charcoal, as a deodoriser, and above all, in the production of artificial stone.

The two investigators chiefly turned their attention to this latter branch of the subject; and in 1852 they took out a patent for "Improvements in the Manufacture of Burned and Fired Ware." In their specification they lay claim to the production of a superior class of burned goods by using the "soluble silica," with such admixtures of ordinary clay or lime as may be required. By these means they propose to make any kind of artificial stone, more or less resembling natural stone; blocks or slabs, excellent building bricks of any colour, and good fire bricks. They do not claim any novelty in moulding or burning, except that they consider that in some cases, articles might be burned to a slight degree of hardness, then finished up by the use of tools, and afterwards reburned to any hardness that might be required.

Mr. Paine's many other duties for some time prevented his carrying this patent into effect; but at last, feeling it to be incumbent on him to make public so important a discovery, in spite of failing health and arduous occupation he commenced building the "Dippenhall Silica Factory" in 1856. Unhappily he was not able to give his personal attention to the manufacture, so that it never had the benefit of his experience and scientific knowledge, and his death in 1858 put an end to his discoveries.

The factory has therefore been carried on from the first under serious disadvantages; but enough has been done to prove that its founder was not mistaken in the importance which he attributed to the invention. It is at present managed in a very simple manner. The material is carefully ground, either wet or dry, according to the purpose for which it is required, and mixed with clays or chalk when necessary. The bricks, vases, and other articles are moulded in the ordinary way, and burned in round kilns. The building bricks, vases, and terra-cotta wares of all descriptions are generally acknowledged to be superior to anything of the same kind hitherto produced, both in appearance, finish, and durability. There are at present practical difficulties in the manufacture of large blocks of stone, which do not seem to have been contemplated by the projectors; and the fire bricks cannot yet be called superior to the Stourbridge manufacture, as was confidently expected. They are perfectly infusible under any amount of heat, but they are friable, and cannot bear a sudden change of temperature. Still, when it is remembered that the works have been carried on without any assistance from without, these difficulties only serve as incentives to further endeavours; and the present proprietor is convinced that all that is required to overcome them, and to raise the reputation of the "Dippenhall Silica Works" to the height to which their originator expected it to attain, is a man of equal scientific attainment, to resume the labours which were so prematurely arrested. — C. P.

STONE COAL. Anthracite, which see.

STONE, PRESERVATION OF. The attention of the scientific world has for some time past been directed to the importance of providing a means for protecting the stone of our public buildings from the ravages of time and the injurious effects of the polluted atmospheres of our manufacturing and populous districts.

The principal cause of the ruinous decay which is so apparent in the national edifices, churches, mansions, &c., of this country, is generally admitted to be the absorption of water charged with carbonic or other acid gases, which by its chemical action either decomposes the lime or argillaceous matter forming the combining medium uniting the several siliceous or other particles of which the stone is composed, or mechanically disintegrates those particles by the alternate expansion and contraction caused by variations of temperature.

Many processes have from time to time been suggested, and several patents secured, for filling up the pores of the stone, and thus preventing the admission of these deleterious agents, but they have been mostly if not entirely composed of oleaginous or gummy substances or compounds, which, although possessing for a time certain preservative properties, become decomposed themselves upon exposure, and constantly require to be renewed; whilst from the nature of these applications the discoloration necessarily produced is highly objectionable.

A little reflection will be sufficient to satisfy a thoughtful mind, that in seeking for a means of preserving the stone of our national buildings, &c., we ought not to rest satisfied simply with the application *of any organic substances*, however great may be their apparent preservative qualities for a time, but should endeavour to supply the defects of nature with an *indestructible mineral* incapable of change by any atmospheric iufluences.

The process of silicatisation introduced by Kuhlmann has the disadvantage of requiring some considerable time before the atmosphere can do its work of effecting the necessary combination between the silica applied in solution to the stone, and the lime contained in it, and therefore when it is applied to the external parts of any building it is liable to be washed out before solidification has been secured. Mr. Frederick Ransome, advancing from his siliceous stone process a step further, meets the condition by effecting a chemical change at once within the stone. Mr. Ransome thus describes his process :—

"Haviug been led to consider the importance of preserving the stonework of our public and private edifices from the decay resulting from the variable condition of our climate, and other causes, I directed my attention to the existing processes proposed for effecting such an object, and more especially to that which has been for some time in use on the continent, in which a soluble silicate is employed, and I found that this process, though having for its base so important and indestructible a mineral as silica, was nevertheless very imperfect in its results. It appeared to me that one great cause of failure arose from the fact that the silicate, being applied in a soluble form, was liable to be removed from the surface by rain, or even the humidity of the atmosphere, before the alkali in the silicate could absorb sufficient carbonic acid to precipitate the silicate in an insoluble form. But another great and serious defect in this process still existed, viz., that even were it possible to effect the precipitation of the silicate, still it would be simply in the form of an impalpable powder possessing no cohesive properties in itself, and therefore able to afford but little, if any, real protection to the stone. It seemed to me, therefore, necessary not only to adopt a process which should insure an insoluble precipitate being produced, independently of the partial and uncertaiu action of the atmosphere, but that, to render such means efficient, a much more tenacious substance than merely precipitated silica must be introduced; and in the course of my experiments I discovered that, by the application of a second solution, composed of chloride of calcium, a silicate of lime would be produced, possessing the strongest cohesive properties, and perfectly indestructible by atmospheric influences. The mode of operation is simply this:—The stone or other material, of which a building may be composed, should be first cleaned by the removal of any extraneous matter on the surface, and then brushed over with a solution of silicate of soda or potash (the specific gravity of which may be raised to suit the nature of the stone or other material); this should be followed by a solution of chloride of calcium, applied also with a brush; the lime immediately combines with the silica, forming silicate of lime in the pores of stone; whilst the chloride combines with the soda, forming chloride of sodium, or common salt, which is removed at once by an excess of water. From the foregoing description it will be apparent that this invention has not only rendered the operation totally independent of any condition of the atmosphere in completing the process, but the work executed is unaffected by any weather, even the most excessive rains. Experience has shown that where once applied to the stone it is impossible to remove it, unless with the surface of the stone itself. I do not confine myself solely to the solutions above referred to; in some cases I prefer to use, first a solution of sulphate of alumina, and then a solution of caustic baryta, when a precipitate of sulphate of baryta and alumina is formed, the main object being to obtain by two or more solutions, which upon being brought into contact mutually decompose each other and produce an indestructible mineral precipitate in the structure and upon the surface of the stone.

The application is one of extreme simplicity, and the material used perfectly indestructible. The rationale of the process is thus explained: a liquid will enter any porous body to saturation, whilst a solid cannot go any further than the first interstices next the surface. Take, then, two liquids capable of producing, by mutual decomposition, a solid, and by the introduction of these liquids into the cells of any porous body, a solid is produced by their mutual decomposition internally; *ergo*, if a solid could not go in as a solid it cannot come out as a solid, and chemical decomposition having destroyed the solvents, they will never again be in a state of solution. The patentee has secured to himself the application of this important principle, and whilst we name silicate of soda and chloride of calcium as the agent under mutual decomposition by contact for producing the chloride of sodium, and the imperishable silicate of lime, there are many other ingredients that are capable of producing like results.

Several large buildings in London — the Baptist chapel in Bloomsbury, amongst others — Glasgow, and other cities, have been treated by Mr. Ransome's process; a portion of the Houses of Parliament have been experimented on, and the result, so far as the time which has passed can test its merits, leaves nothing to be desired.

STONEWARE. (*Fayence*, Fr.; *Steingut*, Germ.) See POTTERY.

STORAX, STYRAX. *Liquid storax* is obtained from the storax plant, *Styrax officinalis*. The finest is a pellucid liquid, having the consistency and tenacity of Venice turpentine, a brownish colour and a vanilla-like odour. The common, which is imported from Trieste in casks, is opaque, of a grey colour, and of the consistence of bird-lime. This has been frequently confounded with liquid amber. See AMBAR — LIQUID.

Common storax. — *Styrax calamita*. This is imported in large round cakes, of a brown or reddish-brown colour. "It appears to consist of some liquid resin mixed with fine sawdust or bran."—*Pereira*.

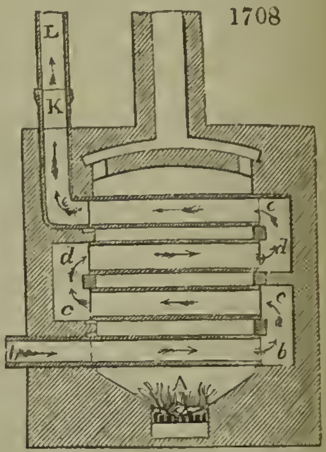
Storax in the tear. — This is imported in yellowish or reddish-white tears, about the size of peas. There are some other varieties, but these are not of sufficient importance to be noticed here. Storax has but little use, except as a pharmaceutical article.

STOVE (*Poele, 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. Some arrangements have been introduced for close stoves, in which charcoal or coke was burnt, and which required little or no chimney. When coke or charcoal 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° Fahr.; 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.

Dr. Ure says:—"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-vomiting 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° Fahr., 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 aërial 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.

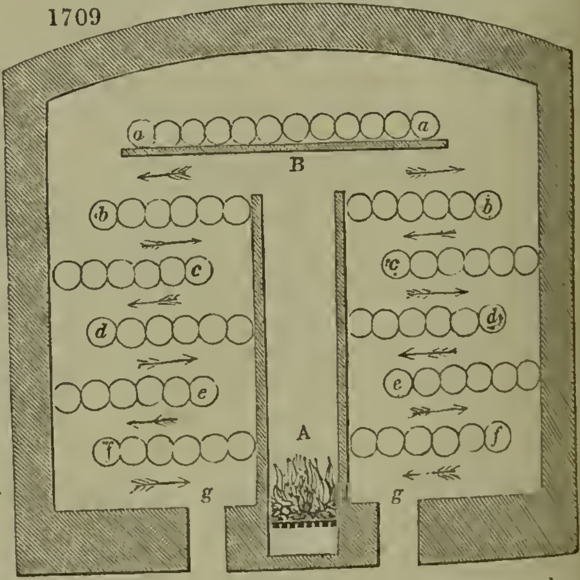
1708



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.* 1708 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 *b*, and conduct it up through the series, till it issues highly heated at K, 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. 1709 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 B, 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 gaslight 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;

1709



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.

In connection with this subject Dr. Ure published in the last edition of this Dictionary some extracts from a paper communicated to the Royal Society on warming and ventilating apartments. A portion of this is still retained, as it exemplifies in a striking manner many of the evils resulting from the want of attention to this particular subject. Dr. Ure was engaged to inquire into the condition of the Long Room in the Custom-house, London, in which the air was so bad that illness continually prevailed. He thus describes the facts:—

"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 confusion 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 Examiners' 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

"The bell, or cockle, apparatus for heating the Long Room and the Examiner's apartment in the Custom-house 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.

"The fetid burned odour of the stove air, and its excessive avidity for moisture, are 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.

"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 to 62° Fahr." Open fireplaces are, and probably will ever remain, favourites in this country. There is no doubt that the ordinary arrangement of our fireplaces is very defective. Much heat is lost — there is not an equal diffusion, and those sitting in the apartment are exposed to annoying drafts of cold air. Arranged as our buildings are, it is not easy to perceive how any very great improvement could be made so long as we desire the enjoyment of an open fire, and the luxury of light and air.

In the greater number of stoves proper, the objections mentioned by Dr. Ure are obvious to every one. In the more common kinds of stove the fire is surrounded directly by the surface to be heated, which, being placed unprotected in the room, radiates heat and warms the air by direct contact. All such are liable to become overheated, and then the unpleasant smell imparted to the air is highly objectionable. Such stoves also dry the air, and the result is that headaches and other annoying sensations are produced. The common stove need not be described. Dr. Arnott introduced, some years since, a stove in which the arrangements were very complete; and as the combustion was regulated with much facility, they were economical. The chief feature of Arnott's stove was a mode of adjusting the amount of air supplied to the fire. A regulating valve is fitted to the aperture of the ashpit, consisting of a frame nicely balanced, and turning with the slightest force upon a centre; to this is attached a steel yard, in which are several holes for the insertion of a weight. This determines exactly the size of the opening, and of course regulates the quantity of air admitted to the fire.

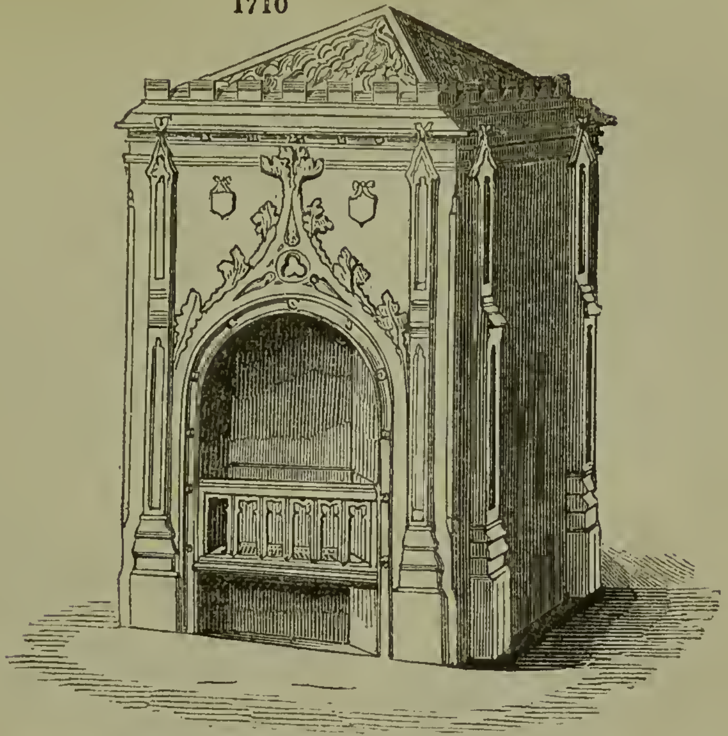
Dr. Ure states that in these stoves there is a tendency, when the stove is not heated above 250° or 300°, to the formation of considerable quantities of carbonic acid, which finds its way into the room from the ashpit door; and when the combustion is languid, carbonic oxide is often formed, which passes away by the chimney unconsumed, involving a loss of heat.

Space will not admit of our describing the Dutch or American stoves, which are mainly modifications of the ordinary forms, which are sufficiently well known. Pierce's pyro-pneumatic stove grate, shown *fig.* 1710, appears to meet the requirement of a stove, of an open fire, and good ventilation, in a remarkable manner.

In the annexed sketch is delineated the operation of the pyro-pneumatic stove, when employed in a large room *fig.* 1711. The channel B, serves to supply pure air from any source external to the building. The amount of the supply is regulated by the valve at B, and the direction of the currents is shown by the arrows. The fresh air is warmed in its course through the stove, and ascends to the ceiling, where it becomes diffused, and then descends, passing off by the smoke flue. A special tube, D, is provided for ventilating the gas lights, as exhibited in *fig.* 1711.

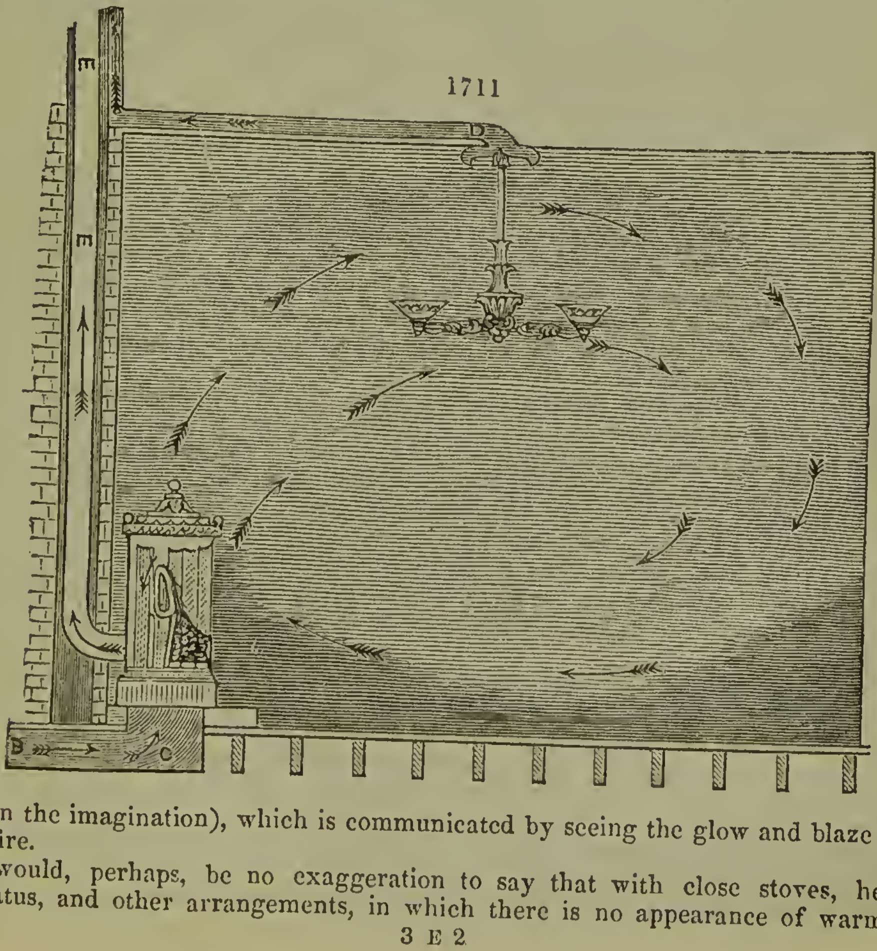
The application of the pyro-pneumatic stove to the warming of churches is extremely simple, and its effects are found highly satisfactory. It gives an abundant supply of fresh air, warmed to the desired temperature, and thereby prevents the influx of an impure atmosphere from vaults and other sources of pollution. It carries off the vitiated air by the smoke flue, or in cases where a more rapid ventilation may be desirable, the warmth which it imparts to the air is sufficient to create an ample current in any shaft or ventilator that may be provided in the roof or spire of the building.

1710



In all cases this apparatus is economical in a high degree, not only from the smallness of its first cost, but also from the fact that the full effect of the fuel consumed in it is secured to the uses of warming and ventilation. One element of economy cannot be too strongly insisted on, viz. the feeling of warmth and comfort (even if it only

1711



exist in the imagination), which is communicated by seeing the glow and blaze of an open fire.

It would, perhaps, be no exaggeration to say that with close stoves, heating apparatus, and other arrangements, in which there is no appearance of warmth, a *much higher temperature of the atmosphere is required to make it even feel* as warm as in that of an apartment heated by an open fire. Indeed it may be fairly asserted that most persons will tolerate inconvenience and submit to expense, provided they see the cheerful blaze of the open fire, which they are at liberty to approach at will, and in the ever varying embers of which they can conjure up visions of the past and fancies of the future.

One of the large pyro-pneumatic stove graves, when in full operation, is found to be capable of heating an apartment containing 50,000 cubic feet of air. In a very large church, containing upwards of 175,000 cubic feet of air, and capable of accommodating a congregation of 1,500 persons, four of these stoves of moderate size, arranged in convenient positions towards the angles of the building, so that every individual of the congregation may see the fire, are found to be sufficient in the coldest weather, and do not even require to be sustained in full action, except during a few hours in the morning. One of these stove-grates placed in the hall or lower part of a staircase, warms and tempers the internal climate of a large house, and gives the whole building a plentiful supply of pure fresh air. One of the smaller grates is capable of warming a large room. And whether in dwelling houses, schools, churches, or apartments, the arrangements can readily be brought into operation at a moderate cost, and without any (beyond the most trifling) interference with existing structural arrangements.

The same inventor has introduced what he calls the fresh air fire-lump stove grate, which may be thus described:—This grate is formed of the purest and best fire-clay, moulded in suitable forms, adapted to the varied arrangements that are found necessary, and consists of the open fire-grate bars in front, surrounded at the sides and back by the fire-clay lumps, around which lumps an air-chamber is formed, communicating with the external atmosphere, admitting air to a cavity in the lower part of the grate, which communicates with the mouths of the vertical channels in the earthen lumps that surround the fire. The warmth, which is communicated to the air through the body of these lumps, and which, from their small conducting power, rarely exceeds 90°, and can never be excessive, causes it to ascend through openings in the upper part of the casing into the apartment; its place being supplied by fresh accessions of air from below. The warm air thus admitted into the apartment floats above, and gradually descends as it cools, its place being supplied by warmer air from the stove-grate, and taking with it to the fire all the impurities of respiration, which is carried away by the flue, in which the heat maintains a constant upward current. Valves are provided for regulating the quantity and temperature of the fresh air admitted, and its distribution into the apartment when warmed.

STRASBURG TURPENTINE. See Abietine.

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 act 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 cannot be bleached by a solution of chloride of lime, as this preparation always turns the straw yellow. For this 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.

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 (a *miner's term*). The name given by the Cornish miners to the small filamentous ramifications of a metallic vein.

STRIPPING LIQUID, SILVERSMITH'S, consists of 8 parts of sulphuric acid and 1 part of nitre.

STRONTIA (*oxide of strontium*), one of the alkaline earths, of which *strontium* is the metallic basis, occurs in a crystalline state, as a carbonate (*strontianite*), in the lead mines of Strontian, in Argyleshire — whence its name. The sulphate (*celestine*) is found crystallised near Bristol, in New Red marl, and in several other parts of the world; but strontian minerals are rather rare. The pure earth is prepared exactly like baryta, from either the carbonate or the sulphate. It is a greyish-white porous mass, infusible in the furnace, not volatile, of a specific gravity between 3·0 and 4·0 : 3·9321 (*Karsten*), having an alkaline reaction on vegetable colours, an acrid, burning taste, sharper than lime, but not so corrosive as baryta, potash, or soda. It becomes hot when moistened, and slakes into a white pulverulent hydrate, dissolves at 60° in 50 parts of water, 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 60·9 per cent. of water, are soluble in 52 parts of water at 60°, and in 2·4 parts of boiling water; when heated they part with 50 per cent. of water, but retain the other parts, even at a red heat. The dry earth consists of 84·6 of base, and 15·4 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 precipitates 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.—H. W. B.

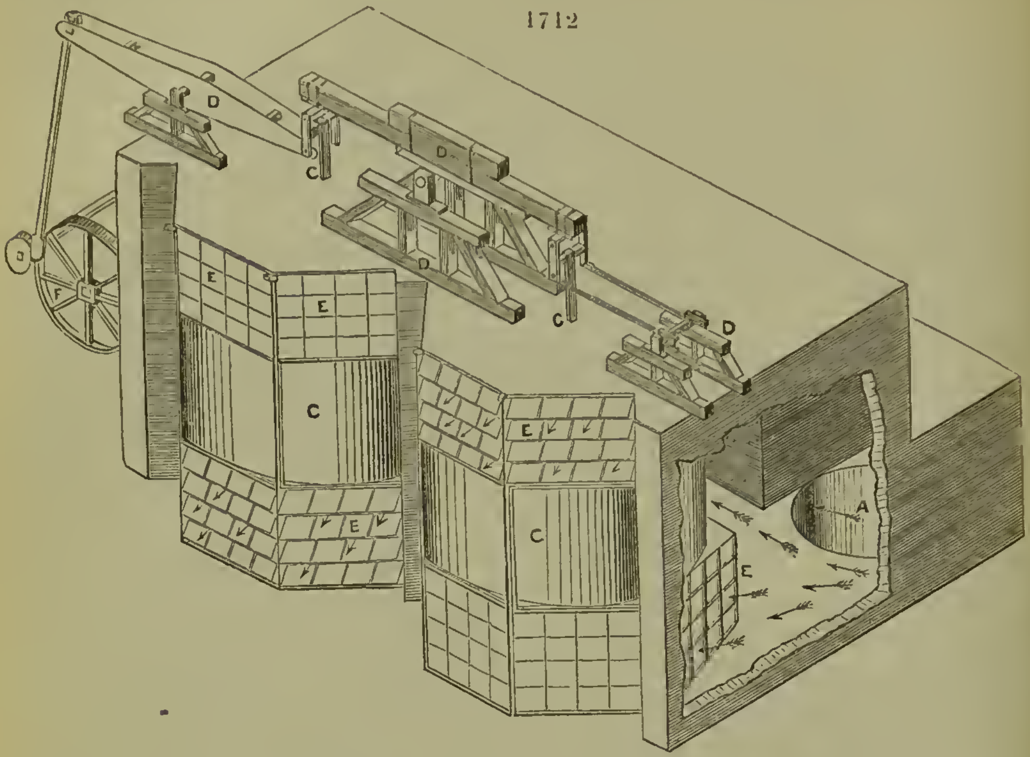
STRONTIA, NITRATE OF. (*Nitrate de strontiane*, Fr.; *Salpetersaürer strontian*, Germ.) This salt is usually prepared from the sulphide of strontium, obtained by decomposing sulphate of strontia with charcoal, by strong ignition of the mixed powders in a crucible. This sulphide being treated with water, and the solution being filtered, is to be neutralised 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. Its principal use is the preparation of "red fire" for pyrotechnic works and theatrical effects. A very beautiful exhibition of red fire is obtained by preparing a gun-paper, by treating ordinary bibulous paper with nitric and sulphuric acids, and then well washing it; when quite free from acid, it is to be dried, and then saturated with a solution of the chloride of nitrate of strontia.—H. W. B.

STRONTIUM. The metallic base of the earth strontia; first obtained by Sir Humphry Davy, in 1808. It is prepared in the same way as barium. See BARIUM. —H. W. B.—See *Ure's Chemical Dictionary*.

STRUVE'S MINE VENTILATOR. The striking novelty of this ventilator is the gigantic scale upon which it has been constructed. Although in principle a pump of the simplest form, some of the pistons have been made 20 feet in diameter, and two pumps are about being constructed 21 feet in diameter. See *fig.* 1712.

In some mines to which the machine has been applied, the rarefaction and ventilation has proved so strong as to prevent single doors being opened, unless protected by supplemental doors. The circumstance of the air not being compressed in the

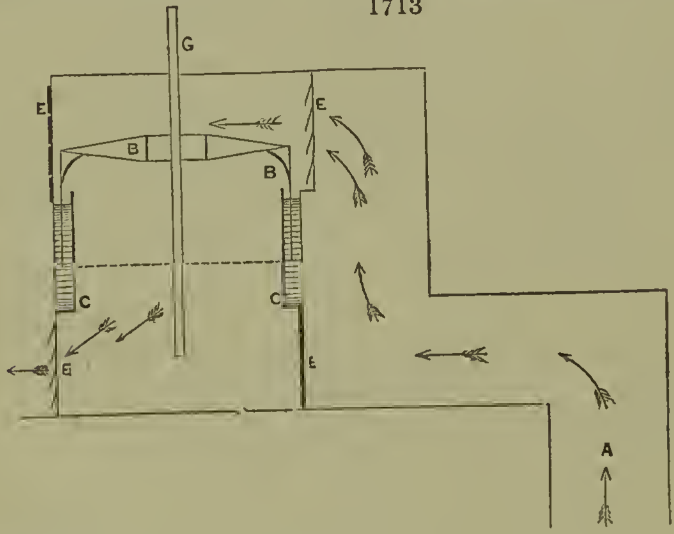
1712



machine, admits of large valve spaces, so that there is scarcely any appreciable resistance to the passage of the air through the machine.

The annexed drawing, *fig.* 1712, represents the machine in operation at the Go-

1713



A. The upcast pit.
B. Hollow pistons, made of wrought iron.
C. Wrought iron tanks, resting on two blocks of masonry, and on six iron pillars.
D. Beam work, resting on three blocks of masonry.
E. The valve work and framing, fastened to sixteen upright pieces of timber, 9 inches square.
F. Crank wheel of steam engine.
G. Piston rods.

vernor and Company's large collieries at Cwm Avon, Glamorganshire, and the following list of licences granted to several large colliery proprietors, is a convincing proof that this invention ranks high among the modern improvements of mining.

The sectional view explains the internal construction, the darts showing the air-currents ascending the upcast pit A, from the interior of the mine into the machine.

The piston B, is shown immersed in water, which forms an air-tight packing.

The front or outlet valves E, are shown in the external view of the ventilator The end of the machine is represented open in the drawing, for the convenience of showing the inlet valves E, and of explaining the internal construction.

Mine ventilators of this construction, and of capacities varying from 20,000 to 100,000 cubic feet of air per minute, have been erected at the following collieries:—

The Eaglesbush colliery: 2 of 12 feet in diameter.

The Westminster colliery, near Wrexham: 2 of 17 feet in diameter.

The Mynidd-Bach-y-Glo colliery, near Swansea: 2 of 16 feet in diameter.

The Bryndu colliery, near Bridgend: 2 of 17 feet in diameter.

The Millwood colliery, near Swansea: 1 of 12 feet in diameter.

The Middle Dyffryn colliery, Aberdare, T. Powell, Esq.: 2 of 20 feet in diameter.

Cwm Avon collieries, the English Copper Company: 2 of 18 feet in diameter.

The Neath Abbey Coal Company, Neath, now erecting: 2 of 16 feet diameter.

Rhimney Valley, near Cardiff, Thomas Powell, Esq.: 2 pumps, 20 feet diameter each.

The Risca Coal Company, Newport, Monmouthshire: 2 pumps of 20 feet diameter each.

The Lletti Schenheir colliery, Aberdare: 2 pumps of 21 feet diameter each.

The air-ports, or valve-work, can be made three-fourths of the area of the pistons, thus reducing the assistance of the air-current through the machine to a minimum.

These machines can be applied to winding shafts.

Cost of machines about 200*l.*, for capacities of 10,000 cubic feet of air per minute.

STRYCHNINE. $C^{42}H^{22}N^{2}O^{4}$. The bitter poisonous principle contained in the different varieties of *strychnos*. It is usually extracted for commercial purposes from the nux vomica bean, the seed of the *S. nux vomica*. It is a well-marked alkali, and yields a great number of crystalline salts with acids and metallic chlorides. Its true constitution has been fully made out by the researches of Messrs. Nicholson and Abel. Although a most valuable medicine in paralytic affections, when employed in very small doses, it is a dangerous remedy in unskilful hands, and has been the cause of numerous deaths arising from carelessness, without reckoning the many who have been destroyed by it at the hands of the poisoner. Some years ago a panic was occasioned by a rumour of its employment for the purpose of giving a bitter flavour to beer; this has been shown to be incorrect. Still the quantities of it produced annually by various manufacturers could not fail to excite attention and uneasiness. As much as 1000 ounces have been known to be purchased at one time. It has been proved, however, that the chief use is for the destruction of wild animals in Australia and other thinly peopled localities. A great number of processes have been devised for its preparation, but, after having been subjected to the extractive operations, the bean is generally found almost as bitter as before, indicating a want of economy in the methods. Probably the best method of extraction would be to disintegrate the beans with strong sulphuric acid (which is without action on strychnine), and then, after the addition of excess of alkali, to dissolve out the base with benzole or chloroform. The latter being distilled off would leave the strychnine nearly pure, and only requiring crystallisation. It has been shown by John Williams, that one bean will by this process yield a considerable quantity of crystals of pure strychnine.

The detection of strychnine has unhappily become a problem of only too frequent occurrence in chemical laboratories. It is, therefore, most important that ready and accurate methods should be known for the purpose. The following process may be relied on; it is founded on that adopted by Graham and Hofmann for the detection of it when present in beer. The stomach or other organic substance is to be cut small and boiled with dilute hydrochloric acid for a quarter of an hour. The acid fluid, after filtration, is to be carefully neutralised with potash, and then digested with recently ignited ivory black. The charcoal is to be separated by filtration, and, when well drained, is to be boiled with spirit of wine. The strychnine which will have been absorbed by the charcoal will be dissolved out by the spirit. The latter is then to be distilled off on the water bath. The contents of the retort being transferred to an evaporating basin are to be exposed on the water bath until dry. The residue is then to be tasted; if bitter, the process may be completed, but if no bitterness is observed it is scarcely worth while to proceed, as the merest trace of strychnine is capable of exciting the sense of extreme bitterness. The residue is to have a slight excess of potash added, and is to be shaken up with chloroform. The chloroform being separated is to be evaporated off. The operation must be repeated if the product be coloured. The substance thus obtained is to have a little strong oil of vitriol added, and a piece of bichromate of potash is to be rubbed on the parts where the strychnine is supposed to be; if present, rich deep purple streaks will become evident.—C. G. W.

STUCCO. See STONE, ARTIFICIAL.

SUBERIC ACID (from *Suber*, *bark*, Lat.; *korksaure*, Germ.) is prepared by digesting grated cork with nitric acid. It forms crystals, which sublime in white vapours when heated.

It may also be obtained by boiling nitric acid with stearic, margaric, or oleic acids. Its formula is $C^8H^6O^3,HO$.

SUBSALT. A salt in which the acid is insufficient to saturate the base. For a full examination of the theory of salts see *Ure's Dictionary of Chemistry*.

SUBLIMATE, is any solid matter resulting from condensed vapours. See CORROSIVE SUBLIMATE.

SUBLIMATION, the process by which volatile matter is vaporised by heat, and then condensed into a crystalline mass. For example, if gum benzoin is kept in a melted state, and even a cap of paper kept above it, the benzoic acid is first volatilised and then condensed on the paper. See AMMONIUM CHLORIDE, for an example of sublimation.

SUCCINIC ACID, *Acid of Amber* (*Acide Succinique*, Fr.; *Bernsteinsäure*, Germ.), was formerly obtained by the destructive distillation of amber, in which process it was accompanied by an essential oil, and a little acetic acid; it was purified by being precipitated as succinate of lead, which, after being well washed, was decomposed by the equivalent quantity of sulphuric acid; the solution of succinic acid, thus obtained, was evaporated, and allowed to cool, when the succinic acid crystallised out. It seems to exist ready formed in amber.

It is easily obtained artificially by acting on stearic or palmitic acid with nitric acid. It also occurs in the leaves of the wormwood, and in many of the resins of the pine tribe. It may likewise be obtained by fermentation from asparagin, and from malic acid, malate of lime yielding nearly one-third of its weight of it.

In order to produce it from malic acid, 3 lbs. of crude malate of lime are to be diffused through a gallon of warm water, and four ounces of decayed cheese added to the mixture, which is to be kept at the temperature of 100° for about a week. Carbonic acid is disengaged, whilst a mixture of crystallised carbonate and succinate of lime is deposited, and acetate of lime remains in solution.

$$\overbrace{3(2CaO,C^8H^4O^8)}^{\text{Malate of lime.}} = \overbrace{2(2CaO,C^8H^4O^6)}^{\text{Succinate of lime.}} + \overbrace{CaO,C^4H^3O}^{\text{Acetate of lime.}} + CaO,CO^2 + 3CO^2 + HO.$$

The succinate of lime is to be washed with cold water, and decomposed by hydrochloric acid, and the succinic acid purified by crystallisation. Sometimes there is in this process some lactic acid, and perhaps butyric acid formed; butyric acid by the action of nitric acid is converted into succinic acid.

$$\overbrace{HO,C^8H^7O^3}^{\text{Butyric acid.}} + O^6 = \overbrace{2HO,C^8H^4O^6}^{\text{Succinic acid.}} + 2HO.$$

Succinic acid crystallises in large, regular rhombic tables, soluble in five parts of cold and two of boiling water. It is freely soluble in alcohol, but only sparingly so in ether. It melts between 347° and 356°, but if suddenly heated to 455°, it melts and sublimes completely. It may be obtained anhydrous by distilling it with anhydrous phosphoric acid. Its principal use is for the precipitation of the persalts of iron from neutral solutions, when we wish to separate iron from nickel, cobalt, and magnanese; for this purpose it is used in the form of succinate of ammonia.—H. K. B.

SUET. See TALLOW.

SUGAR (*Sucre*, Fr.; *Zucker*, Germ.) is, with some slight exception, the sweet constituent of vegetable and animal products. It may be distinguished into three principal species. The first, which occurs in the sugar-cane, the beet-root, and the maple, crystallises in oblique four-sided prisms, terminated by two-sided summits; it has a sweetening power which may be represented by 100; and in circumpolarisation it bends the luminous rays to the right. The second occurs ready 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 circumpolarisation it bends the rays to the left. Berthelot has lately shown that a moderately strong solution of glycerine, in contact with certain animal membranes, is found, after some weeks, to produce a substance with the properties of grape sugar. One pint of glycerine in 10 pints of water is added to the membrane, which may amount to $\frac{1}{20}$th of the weight of the glycerine. The time required is 10 to 12 weeks. If putrefaction begins it is destroyed. The third variety is found in fruits, and also in sugar which has been long boiled, or heated with acids; this is called fruit sugar. Besides these three principal kinds, the sugar of milk, and the sugar of manna, or *mannite*, are found closely allied, and may be called two other species. Allied to these is *sorbine*, extracted from the elderberry, and *mosite*, which occurs in the flesh of animals.

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; that of the beet is said to surpass the other two in cohesive force, since larger and firmer crystals of it are obtained from a clarified solution of equal density; but this probably arises from the superiority of European over tropical manufacture. Sugar melts at 320° Fahr., and on cooling forms a transparent substance usually called *barley sugar*. When heated to between 400° and 410° Fahr. it loses two equivalents of water and becomes brown. Sugar thus fused is no longer capable of crystallisation, 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 uncrystallisable. 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 crystallise. Thus, if oxalic or tartaric acid be added to sugar in solution, and boiled, no crystals of sugar can be obtained by evaporation, even though the acids be neutralised by chalk or carbonate of lime. By boiling cane sugar with dilute sulphuric acid, and keeping it at least at 150° Fahr., it is changed into grape sugar, and then entirely into uncrystallisable sugar. Nitric acid converts sugar into oxalic acid. 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 lime has been used in clarifying the juice of the cane or the beet.

Manufacturers of sugar should, therefore, be particularly watchful against the formation of acid from decomposition, or the introduction of any excess of alkali, or alkaline earth.

When one piece of lump sugar is rubbed against another in the dark, 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 crystals. Caramelised and uncrystallisable sugar dissolve 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, at least 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, by the action of the air; it then passes into acetic acid, when it may be still farther decomposed.

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 neutralised by sulphuric acid, the sugar recovers partially its sweet taste, and may be separated from the sulphate of potash by alcohol, but it will no longer crystallise.

That syrup possesses the property of dissolving the alkaline earths, lime, magnesia, strontia, baryta, &c., was demonstrated long ago by Mr. Ramsay, of Glasgow. He says that syrup is capable of dissolving half as much lime as it contains of sugar; and as much strontia as sugar.

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 the 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. 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 will show the composition of the various sugars, and their principal combinations with bases:—

Cane sugar, or sucrose - - -	$C^{12}H^{11}O^{11}$
Grape or starch sugar, or glucose -	$C^{12}H^{12}O^{12},2HO$
Fruit sugar, or fructose - - -	$C^{12}H^{12}O^{12}$ at 212° F.
Milk sugar, or lactose - - -	$C^{24}H^{19}O^{19},5HO$
Manna sugar, or mellitose - -	$C^{24}H^{24}O^{24},4HO$

Compounds of cane sugar called sugarates.

With soda - - - - -	$NaO,C^{12}H^{11}O^{11}$
With potash - - - - -	$KO,C^{12}H^{11}O^{11}$
With lime - - - - -	$CaO,C^{12}H^{11}O^{11}$
With baryta - - - - -	$BaO,C^{12}H^{11}O^{11}$
With lead - - - - -	$C^{24}\frac{H^{18}}{Pb^{4}}O^{22}$, or $2PbO,C^{12}H^{9}O^{9}$
With common salt - - - -	$NaCl,C^{24}H^{21}O^{21}$

Compounds of grape sugar, or glucose.

With baryta - - - - -	$C^{24}\frac{H^{22}}{Ba^{2}}O^{24},6HO$, or $3BaO,C^{24}H^{28}O^{28}$
With lime - - - - -	$C^{24}\frac{H^{22}}{Ca^{2}}O^{24},6HO$, or $3CaO,C^{24}H^{28}O^{28}$
With lead - - - - -	$C^{24}\frac{H^{18}}{Pb^{3}}O^{24},4HO$, or $6PbO,C^{24}H^{21}O^{21}$
With common salt - - - -	$C^{24}H^{24}O^{24},NaCl,2HO$

Cane sugar is soluble in all proportions in boiling water, and in ⅓ of cold. It is sparingly soluble in alcohol of 70 pc. and insoluble in absolute alcohol. The following table, by Payen shows the quantity of sugar contained in saccharine solutions of various specific gravity at 59° F. :—

Parts of sugar.		Parts of water.		Specific gravity.
100	dissolved in	50	give a syrup of	1·345
100	„	60	„	1·322
100	„	70	„	1·297
100	„	80	„	1·281
100	„	90	„	1·266
100	„	100	„	1·257
100	„	120	„	1·222
100	„	140	„	1·200
100	„	160	„	1·187
100	„	180	„	1·176
100	„	200	„	1·170
100	„	250	„	1·147
100	„	350	„	1·111
100	„	450	„	1·089
100	„	550	„	1·074
100	„	650	„	1·063
100	„	750	„	1·055
100	„	945	„	1·045
100	„	1145	„	1·030
100	„	1945	„	1·022
100	„	2445	„	1·018
100	„	2945	„	1·015

The following table appeared in a previous edition of this work, and has been much used :—

Sugar in one hundred parts by weight.	Sp. gr. at 60°.	Sugar in one hundred parts by weight.	Sp. gr. at 60°.
66·666 - - -	1·3260	25·000 - - -	1·1045
50·000 - - -	1·2310	21·740 - - -	1·0905
40·000 - - -	1·1777	20·000 - - -	1·0820
33·333 - - -	1·1400	16·666 - - -	1·0685
31·250 - - -	1·1340	12·500 - - -	1·0500
29·412 - - -	1·1250	10·000 - - -	1·0395
26·316 - - -	1·1110		

The annexed table, constructed by Neimann for the normal temperature of 63°, with the same object, is also submitted:—

Sugar.	Water.	Specific Gravity.	Sugar.	Water.	Specific gravity.
0	100	1·0000	36	64	1·1582
1	99	1·0035	37	63	1·1631
2	98	1·0070	38	62	1·1681
3	97	1·0106	39	61	1·1731
4	96	1·0143	40	60	1·1781
5	95	1·0179	41	59	1·1832
6	94	1·0215	42	58	1·1883
7	93	1·0254	43	57	1·1935
8	92	1·0291	44	56	1·1989
9	91	1·0328	45	55	1·2043
10	90	1·0367	46	54	1·2098
11	89	1·0410	47	53	1·2153
12	88	1·0456	48	52	1·2209
13	87	1·0504	49	51	1·2265
14	86	1·0552	50	50	1·2322
15	85	1·0600	51	49	1·2378
16	84	1·0647	52	48	1·2434
17	83	1·0698	53	47	1·2490
18	82	1·0734	54	46	1·2546
19	81	1·0784	55	45	1·2602
20	80	1·0830	56	44	1·2658
21	79	1·0875	57	43	1·2714
22	78	1·0920	58	42	1·2770
23	77	1·0965	59	41	1·2826
24	76	1·1010	60	40	1·2882
25	75	1·1056	61	39	1·2933
26	74	1·1103	62	38	1·2994
27	73	1·1150	63	37	1·3050
28	72	1·1197	64	36	1·3105
29	71	1·1245	65	35	1·3160
30	70	1·1293	66	34	1·3215
31	69	1·1340	67	33	1·3270
32	68	1·1388	68	32	1·3324
33	67	1·1436	69	31	1·3377
34	66	1·1484	70	30	1·3430
35	65	1·1538			

The specific gravity of crystallised cane sugar is 1·594. Crystallised cane sugar seems to be the most complete type of sugar known. Its crystals are the largest and most regular, and its taste the sweetest. These crystals are rhomboidal prisms, and appear largest in the form of sugar candy. When boiled much or heated with acids it would appear that a lower form of sugar resulted, namely, grape-sugar. This sugar crystallises with difficulty in tufts of small needles. When the same treatment is further continued the power to crystallise is entirely lost. It has been attempted, but without success, to reverse these processes. The solution of this problem would be of great value to the world, and already much time and talent have been expended upon it.

At 300° sugar loses 0·6 per cent., and remains uninjured after seven hours; it melts at 320°, and at this point it seems to have lost some of its sweetness, and probably a portion of water. The same result is obtained at a lower temperature if more time is allowed. The colour is changed to an orange-yellow at 410°: the sugar loses three equivalents of water, becomes gradually brown, has an empyreumatic taste, and is called *caramel*. With a heat approaching to a red heat, carburetted hydrogen, carbonic acid, acetic acid, and empyreumatic oils are produced, and carbon remains, amounting to 25 per cent. of the original mass. This disengagement of gases occurs with immense enlargement of volume, so that the carbonaceous residue is rendered exceedingly porous. If these gaseous products are inflamed, which may be done at 500°, the amount of heat disengaged is very great. It is believed generally that a perfectly pure solution of cane sugar in water will not decompose: this certainly is found to be the case in very dense solutions, at least after the lapse of several years; but when weak solutions are used, decomposition is effected in the course of a few months, even though the sugar is pure, the water distilled, and the vessel remain unopened.

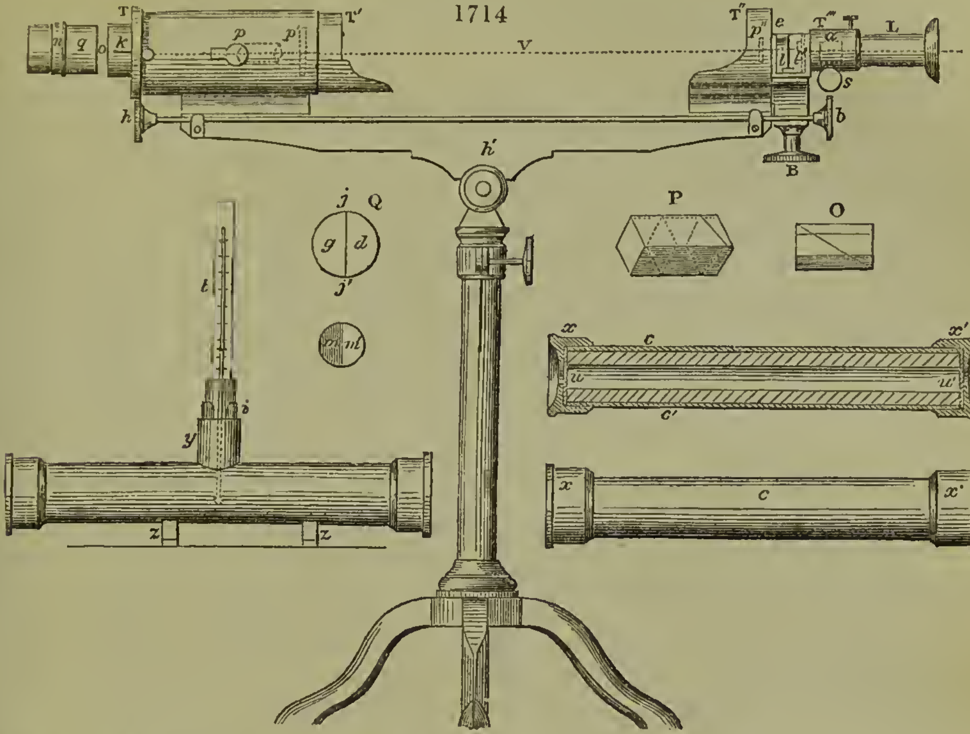
Solutions of sugar are readily decomposed by acids as well as by acid salts of every kind. They are decomposed also almost as readily by caustic alkaline solutions, and by hot solutions of the carbonated fixed alkalies. Under the name alkaline solutions must be included both baryta and lime, if heat is to be long used, but both of these substances form compounds with sugar, the first of which will be treated of when beet-root sugar is under consideration. The compound of sugar and lime is very soluble in cold water, but is precipitated on heating. The amount dissolved is shown to be a true equivalent, by the inquiries of Peligot, who has proposed an ingenious method of ascertaining the amount of sugar in a solution by the estimation of the lime which it will dissolve. The lime in this process is estimated alkalimetrically by means of an acid. The following table has been constructed by M. Peligot for calculating the results:—

Quantity of sugar dissolved in 100 parts of water.	Density of syrup.	Density of syrup when saturated with lime.	100 parts of residue dried at 120° contain	
			Lime.	Sugar.
40·0	1·122	1·179	21·0	79·0
37·5	1·116	1·175	20·8	79·2
35·0	1·110	1·166	20·5	79·5
32·5	1·103	1·159	20·3	79·7
30·0	1·096	1·148	20·1	79·9
27·5	1·089	1·139	19·9	80·1
25·0	1·082	1·128	19·8	80·2
22·5	1·075	1·116	19·3	80·7
20·0	1·068	1·104	18·8	81·2
17·5	1 060	1·092	18·7	81·3
15·0	1·052	1·080	18·5	81·5
12·5	1·044	1·067	18·3	81·7
10·0	1·036	1·053	18·1	81·9
7·5	1·027	1·040	16·9	83·1
5·0	1·018	1·026	15·3	84·7
2·5	1·009	1·014	13·8	86·2

Sugar has the capacity of reducing many of the higher to lower oxides, and also of entirely reducing the oxides of some of the metals. At the same time it effects the oxidation of some of the commoner metals, and keeps the oxides in solution. As an example of these actions, the hydrated peroxide of iron is reduced to protoxide, and retained in solution, whilst the hydrated oxide of copper is reduced to the sub-oxide and precipitated in solutions both of grape sugar and uncrystallisable sugar. This action has been proposed as a mode of estimating the proportion of grape and uncrystallisable sugar in saccharine solutions, as will be shown. Iron is readily acted upon by grape and uncrystallisable sugar, and is retained in solution by sugar of every kind. Neither iron, zinc, nor lead are thrown down from sugar solutions by the usual alkaline reagents, bnt sulphide of ammonium separates them entirely.

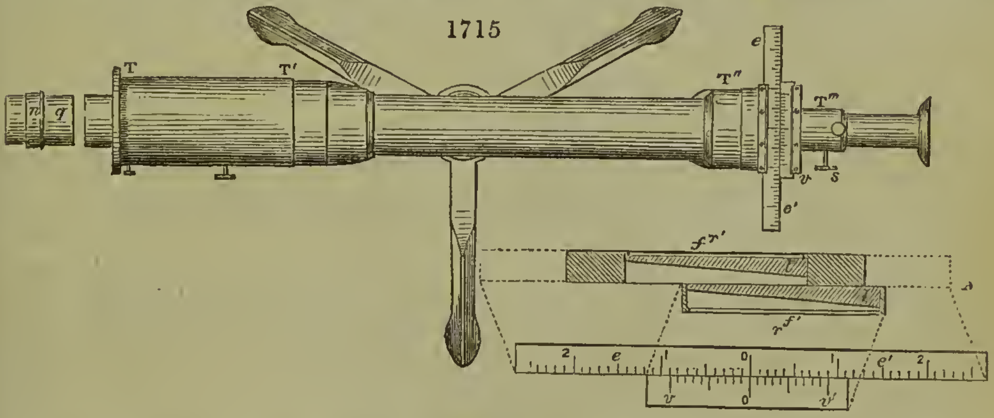
Saccharimetry.—We now come to the estimation of sugar, which is most simply performed by the hydrometer, when the solutions are pure and the kind of sugar known. But commercially it is required to ascertain the proportions of cane sugar, uncrystallisable sugar, water and impurities, and this is accomplished most successfully by means of the polarising saccharometer proposed by Biot and improved by Soleil. The following is a description of this beautiful instrument:— Two tubular parts, T T′, and T″ T‴, *figs.* 1714 and, 1715, constitute the principal part of the saccharometer. The light enters *n*, through a Nicol's prism *q*, shown separately, *fig.* 1714, at O, and passes first an achromatic polarising prism *p*, and shown separately at P and afterwards through a plate of quartz of double rotation at *p′*, which is also shown at Q. This plate is composed of two semi-discs cut perpendicularly to the axis of crystallisation, but though exactly of equal thickness and equal rotating power, the one turns the ray to the right, while the other turns it to the left. At *p″*, the ray passes a plate of quartz of single rotation, and at *l l′*, two wedges of quartz endued with the power of rotation, but in a contrary direction to the preceding plate. These two wedges are again represented in 1715 A, and are so made that by turning the milled head B, the sum of their thickness can be increased or diminished at pleasure, while the amount of thickness is shown by the ivory graduated scale *e e′*, and vernier *v v′*. Finally the ray traverses an analysing prism *a*, and an eye-piece L. If the instrument is directed to the light the observer will see a luminous disc, bisected by a central line (produced by the junction of the two semi-discs of quartz) of exactly the same tint, but which tint may be varied at pleasure, by rotating the Nicol's prism n, by means of the milled

1714



head b. If, however, we interpose between p' and p'', the tube c, *fig.* 1714, filled with a solution of cane sugar, and the ends closed with glass, the semi-discs will be

1715



differently coloured. Cane sugar, possessing the power of circular polarisation, combines with the rotating power of the half disc which turns the ray to the right, but tends to neutralise the half disc, whose direction is the reverse. By increasing or diminishing the thickness of the wedges of quartz $l l'$, to the extent required for counteracting their rotation to the right, and causing the semi-discs to reassume the same colours, we have a means by the graduated scale e e', v v', of measuring the rotating power, which is exactly proportional to the amount of cane sugar, temperatures being equal, and no foreign substance having the power of circular polarisation being present.

To apply this method, the deviation must be known which is produced by a solution of sugar of known strength. For this purpose a given weight, ϵ, of sugar is dissolved in such a quantity of distilled water that the solution occupies a given volume, V. Sufficient of this solution is taken to fill a tube of a certain length, and the deviation suffered by the plane of polarisation of the luminous ray passing through this tube is measured. Let this deviation be α. Let then other quantities of sugar be dissolved in sufficient water to give the same volume of solution, V; and let the deviations produced by these solutions in the same tube be α' α'', α''', &c.; then the quantities of sugar contained in the volume, V, of these liquids will be represented by the products $\epsilon\frac{\alpha'}{\alpha}$, $\epsilon\frac{\alpha''}{\alpha}$, $\epsilon\frac{\alpha'''}{\alpha}$, &c., respectively. If the sugar examined, instead of being pure, is mixed with other but inactive substances, it is evident that these same products express the absolute weights of pure sugar contained in the weights of substances employed in the formation of the liquids of the given volume, V. It is possible to employ proof tubes of different lengths; but it is then necessary to reduce by calculation the observed deflections to those which would have been produced in the same tube.

It often happens that solutions of sugar which have to be examined are turbid or strongly coloured. When this interferes with the examination, they must be clarified and rendered either quite colourless, or when this is not possible the colour must be at least reduced. This is often effected by precipitating the colouring matter of the syrups with subacetate of lead; but the most accurate method is by a filter of animal charcoal. The filtrates are then examined. When syrups contain, besides cane sugar, other constituents which exert an action upon the plane of polarisation, the amount of cane sugar present may be determined by inverting, by means of hydrochloric acid, the rotary power of the cane sugar. No other saccharine substance is, in fact, known which suffers a similar change under the same circumstances.

If, for instance, the liquid under examination contains besides cane sugar, glucose, whose rotary action on the plane of polarisation is in the same direction as that of cane sugar; if α' be the deviation observed to be produced by the liquid, then α' is evidently the sum of the separate deflections of the cane sugar x, and of the glucose, y. About one-tenth of its volume of hydrochloric acid is added to the syrup, and it is kept for ten minutes at a temperature of 140°—154°. The cane sugar is thereby completely transformed into noncrystallisable sugar, which turns the plane of polarisation to the left, while the rotary power of the glucose undergoes no alteration. When this change has been effected, the new deviation, α'', of the liquid is observed. It is now the difference between the deviation y of the glucose and that of the noncrystallisable sugar derived from the cane sugars. But the degree of dilution of the liquid having been changed by the addition of the hydrochloric acid, the deviation observed α'', must be replaced by the deviation, $\frac{10}{9}\alpha''$, which would have been observed if the inversion could have been produced without the addition of hydrochloric acid. Admitting therefore that a quantity of cane sugar which effects a deviation, x, gives rise to a quantity of noncrystallisable sugar which effects a deviation, $r\,x$, we have—

Before the inversion, $x+y=\alpha'$.

After the inversion, $y+r\,x=\frac{10}{9}\alpha''$.

From these two equations the quantities x and y may be determined. The coefficient of inversion, r, is determined once for all by a special experiment performed upon pure cane sugar at the temperature at which the experiments have afterwards to be made. According to Biot, this coefficient is 0·038 for hydrochloric acid at a temperature of 71·6°.

The process is the same when the cane sugar is mixed with noncrystallisable sugar, turning the plane of polarisation to the left. In this case the initial deviation, α', of the liquid is the difference between the deviation to the right, r, of the cane sugar, and the deviation, z, to the left of the noncrystallisable sugar. After treating with hydrochloric acid, the deviation, α'', is composed of the deviations of the original noncrystallisable sugar, and of that produced by the action of the hydrochloric acid. We then have—

Before inversion, $x - z = \alpha'$.

After inversion, $z + r\,x = \frac{10}{9}\alpha''$.

It is important in examining optically noncrystallisable sugar always to employ the same temperature, because a change of temperature materially affects the rotary power of this kind of sugar.

The table appended includes each degree of temperature from +10 to +35 centigrade, and for qualities increasiug in hundredths, this range being found sufficient for all practical purposes either in Europe or the colonies.

To note the temperature at which the observation is made, a tube $z\,z$, *fig.* 1714, provided with a vertical branch, is employed. In this branch a thermometer, t, is placed.

The following are two examples of the use of the table:

1. A solution of a saccharine substance prepared iu the normal proportions of weight and volume recommended, and giving before acidulation a notation on the left-hand part of the scale of - - - - 75 divisions.

And after the inversion (the temperature being +15°) a notation in the opposite direction of - - - - - - - - - 20 divisions.

Sum of the inversions - - - - - - 95 divisions.

TABLE FOR THE ANALYSIS OF SACCHARINE SUBSTANCES.

NOTE.—For liquids not submitted to acidulation the last two columns constitute a special table; in which case the figures in column A represent the number of degrees found, and those of column B the weight in grammes and centigrammes of sugar contained in a litre of liquid.

The numbers furnished by an analysis of solid sugars are necessarily comprised in the first hundred lines of the table; the thirty following lines have been added for the analysis of the principal natural saccharine fluids of high density. If liquors of a still greater density are presented, they will be comprised within the table by diluting them with a known quantity of water.

SUMS OR DIFFERENCES OF THE DIRECT AND INVERSE NOTATIONS, THE LATTER BEING DETERMINED AT A TEMPERATURE (CENTIGRADE) OF																										DEGREES.	
10°	11°	12°	13°	14°	15°	16°	17°	18°	19°	20°	21°	22°	23°	24°	25°	26°	27°	28°	29°	30°	31°	32°	33°	34°	35°	by wt. A	by vol. B
1,4	1,4	1,4	1,4	1.4	1,4	1,4	1,3	1,3	1.3	1,3	1,3	1,3	1,3	1,3	1,3	1,3	1,3	1,3	1,3	1,3	1,3	1,3	1,3	1,3	1,3	1	1,65
2,8	2,8	2,8	2,7	2,7	2,7	2,7	2,7	2,7	2,7	2,7	2,7	2,6	2,6	2,6	2,6	2,6	2,6	2,6	2,6	2,6	2,6	2,6	2,5	2,5	2,5	2	3,27
4,2	4,1	4,1	4.1	4,1	4,1	4,1	4.1	4,0	4,0	4,0	4,0	4,0	4,0	4,0	3,9	3,9	3,9	3,9	3,9	3,9	3,8	3,8	3,8	3,8	3,8	3	4,90
5,6	5,5	5,5	5,5	5.5	5.5	5,4	5,4	5,4	5,4	5,4	5,3	5,3	5.3	5,3	5,3	5,2	5,2	5,2	5,2	5,2	5,1	5,1	5,1	5.1	5,1	4	6,54
6,9	6,9	6,9	6,9	6,8	6.8	6.8	6,8	6,7	6,7	6,7	6,7	6,6	6,6	6.6	6,6	6,5	6,5	6,5	6,5	6,4	6,4	6,4	6,4	6,3	6,3	5	8.17
8,3	8,3	8,3	8,2	8,2	8,2	8,2	8,1	8,1	8,1	8,0	8,0	8,0	7,9	7,9	7,9	7,9	7,8	7,8	7,8	7,7	7,7	7,7	7,7	7,6	7,6	6	9,81
9,7	9,7	9.7	9,6	9,6	9,5	9,5	9,5	9,4	9,4	9,4	9,3	9,3	9,3	9,2	9,2	9,2	9,1	9,1	9,1	9,0	9,0	9,0	8,9	8,9	8,8	7	11.44
11,1	11,1	11,0	11,0	11,0	10,9	10,9	10,8	10,8	10,8	10,7	10,7	10,6	10,6	10,6	10,5	10,5	10,4	10,4	10,4	10,3	10,3	10,2	10,2	10,2	10,1	8	13,08
12,5	12,5	12,4	12,4	12,3	12,3	12,2	12,2	12,1	12,1	12,1	12,0	12,0	11,9	11,9	11,8	11,8	11,7	11,7	11,6	11,6	11,6	11.5	11,5	11,4	11,4	9	14,71
13,9	13,8	13,8	13,7	13,7	13,6	13,6	13,5	13,5	13,4	13,4	13,3	13,3	13,2	13,2	13,1	13,1	13,0	13,0	12,9	12,9	12,8	12,8	12,7	12,7	12,6	10	16,35
15,3	15,2	15,2	15.1	15,1	15,0	15,0	14,9	14,8	14,8	14,7	14,7	14,6	14,6	14,5	14,5	14,4	14,3	14,3	14,2	14,2	14,1	14,1	14.0	14,0	13,9	11	17,98
16,7	16,6	16,6	16,5	16,4	16,4	16,3	16,3	16,2	16,1	16.1	16,0	16,0	15,9	15,8	15,8	15,7	15,7	15,6	15,5	15,5	15,4	15,4	15,3	15,2	15,2	12	19,62
18,1	18,0	17,9	17,9	17,8	17,7	17,7	17,6	17,5	17,5	17,4	17,3	17,3	17,2	17,2	17,1	17,0	17,0	16,9	16,8	16,8	16,7	16,6	16,6	16,5	16,4	13	21,25
19,5	19,4	19,3	19,2	19,2	19,1	19,0	19,0	18,9	18,8	18,8	18,7	18,6	18,5	18,5	18,4	18,3	18,3	18,2	18,1	18,1	18,0	17,9	17,8	17,8	17,7	14	22,89
20,8	20,8	20,7	20,6	20,5	20,5	20,4	20,3	20,2	20,2	20,1	20,0	19,9	19,9	19,8	19,7	19,6	19,6	19,5	19,4	19,3	19,3	19,2	19,1	19,0	19,0	15	24,52
22,2	22,2	22,1	22,0	21,9	21,8	21,8	21,7	21,6	21,5	21,4	21,4	21,3	21,2	21,1	21,0	21,0	20,9	20,8	20,7	20,6	20,6	20,5	20,4	20,3	20,2	16	26,16
23,6	23,5	23,5	23,4	23,3	23,2	23,1	23,0	22,9	22,9	22,8	22,7	22,6	22,5	22,4	22,3	22,3	22,2	22,1	22,0	21,9	21,8	21,7	21,7	21,6	21,5	17	27,79
25,0	24,9	24,8	24,7	24,7	24,6	24,5	24,4	24,3	24,2	24,1	24,0	23,9	23,8	23,8	23,7	23,6	23,5	23,4	23,3	23,2	23,1	23,0	22,9	22,9	22,8	18	29,43
26,4	26.3	26,2	26,1	26,0	25,9	25,8	25,7	25,6	25,5	25,5	25,4	25,3	25,2	25,1	25,0	24,9	24,8	24,7	24,6	24,5	24,4	24,3	24,2	24,1	24,0	19	31,06
27,8	27,7	27,6	27,5	27,4	27,3	27,2	27,1	27,0	26,9	26,8	26,7	26,6	26,5	26,4	26,3	26,2	26,1	26,0	25,9	25,8	25,7	25,6	25,5	25,4	25.3	20	32.70
29,2	29,1	29,0	28,9	28,8	28,7	28,6	28,4	28,3	28,2	28,1	28,0	27,9	27,8	27,7	27,6	27,5	27,4	27,3	27,2	27.1	27,0	26,9	26,8	26,7	26,6	21	34,33
30,6	30,5	30,4	30,2	30,1	30,0	29,9	29,8	29,7	29,6	29,5	29,4	29,3	29,1	29,0	28,9	28,8	28,7	28,6	28,5	28,4	28,3	28,2	28,0	27,9	27,8	22	35,97
32,0	31,8	31,7	31,6	31,5	31,4	31,3	31,2	31,0	30,9	30,8	30,7	30,6	30,5	30,4	30,2	30,1	30,0	29,9	29,8	29,7	29,5	29,4	29,3	29,2	29,1	23	37,60
33,4	33.2	33,1	33,0	32,9	32,8	32,6	32,5	32,4	32,3	32,2	32,0	31,9	31,8	31,7	31,6	31.4	31,3	31,2	31,1	30,9	30,8	30,7	30,6	30,5	30,4	24	39.24
34,7	34,6	34.5	34,4	34,2	34,1	34,0	33,9	33,7	33,6	33,5	33,4	33,2	33,1	33,0	32,9	32,7	32,6	32,5	32,4	32,2	32,1	32,0	31,9	31,7	31,6	25	40,87
36,1	36,0	35,9	35,7	35,6	35,5	35,4	35,2	35,1	35,0	34,8	34,7	34,6	34,4	34,3	34,2	34,1	33,9	33,8	33,7	33,5	33,4	33,3	33,1	33,0	32,9	26	42,51
37,5	37.4	37,3	37,1	37,0	36,8	36,7	36,6	36,4	36.3	36,2	36,1	35,9	35,8	35,6	35,5	35,4	35,2	35,1	35,0	34,8	34,7	34,6	34,4	34,3	34,1	27	44.14
38,9	38,8	38,6	38,5	38,4	38,2	38,1	37.9	37,8	37,7	37,5	37.4	37,2	37,1	37,0	36,8	36,7	36,5	36,4	36,3	36,1	36,0	35,8	35,7	35,6	35,4	28	45,78
40.3	40,2	40,0	39,9	39,7	39,6	39,4	39,3	39,1	39,0	38,9	38,7	38,6	38,4	38,3	38,1	38,0	37,8	37,7	37,3	37,4	37,3	37,1	37,0	36,8	36,7	29	47,41
41,7	41,5	41,4	41,2	41,1	40,9	40,8	40,6	40,5	40,3	40,2	40,0	39,9	39,7	39,6	39,4	39,3	39,1	39,0	38,8	38,7	38,5	38,4	38,2	38,1	37,9	30	49,05
43,1	42,9	42,8	42,6	42,5	42,3	42,2	42,0	41,8	41,7	41,5	41,4	41,2	41,1	40,9	40,8	40,6	40,4	40,3	40,1	39,9	39,8	39,7	39,5	39,4	39,2	31	50,68
44,5	44,3	44,2	44,0	43,8	49,7	43,5	43,4	43,2	43,0	42,9	42,7	42,6	42,4	42,2	42,1	41,9	41,8	41,6	41,4	41,3	41,1	41,0	40,8	40,6	40,5	32	52,32
45,9	45,7	45,5	45,4	45,2	45,0	44,9	44,7	44,5	44,4	44,2	44,0	43,9	43,7	43,6	43,4	43,2	43,1	42,9	42,7	42,6	42,4	42,2	42,1	41,9	41,7	33	53,95
47,3	47,1	46 9	46,7	46.6	46,4	46,2	46,1	45,9	45,7	45,6	45,4	45,2	45,0	44,9	44,7	44,5	44,4	44,2	44,0	43,9	43,7	43,5	43,3	43,2	43,0	34	55,59
48.6	48,5	48,3	48,1	47,9	47,8	47,6	47,4	47,2	47,1	46,9	46,7	46,5	46,4	46,2	46,0	45,8	45,7	45,5	45,3	45,1	45,0	44,8	44,6	44,4	44,3	35	57,22
50,0	49,9	49,7	49,5	49,3	49,1	49,0	48,8	48,6	48,4	48.2	48,1	47,9	47,7	47,5	47,3	47,2	47,0	46,8	46,6	46.4	46,3	46,1	45,9	45,7	45,5	36	58,86
51,4	51,2	51,1	50,9	50,7	50,5	50,3	50,1	49.9	49.8	49.6	49,4	49,2	49.0	48.8	48,6	48,5	48,3	48.1	47,9	47,7	47.5	47,4	47,2	47.0	46,8	37	60,49
52,8	52,6	52,4	52,2	52,1	51,9	51,7	51,5	51,3	51,1	50,9	50,7	50,5	50.3	50,2	50,0	49,8	49,6	49,4	49,2	49,0	48,8	48,7	48,4	48,3	48 1	38	62,13

Sums or differences of the direct and inverse notations, the latter being determined at a temperature (centigrade) of																										Degrees.	
10°	11°	12°	13°	14°	15°	16°	17°	18°	19°	20°	21°	22°	23°	24°	25°	26°	27°	28°	29°	30°	31°	32°	33°	34°	35°	by wt. A	by vol. B
54,2	54,0	53,8	53,6	53,4	53,2	53,0	52,8	52,6	52,4	52,3	52,1	51,9	51,7	51,5	51,3	51,1	50,9	50,7	50,5	50,3	50,1	49,9	49,7	49,5	49,3	39	63,76
55,6	55,4	55,2	55,0	54,8	54,6	54,4	54,2	54,0	53,8	53,6	53,4	53,2	53,0	52,8	52,6	52,4	52,2	52,0	51,8	51,6	51,4	51,2	51,0	50,8	50,6	40	65,40
57,0	56,8	56,6	56,4	56,2	56,0	55,8	55,5	55,3	55,1	54,9	54,7	54,5	54,3	54,1	53,9	53,7	53,5	53,3	53,1	52,9	52,7	52,5	52,3	52,1	51,9	41	67,03
58,4	58,2	58,0	57,7	57,5	57,3	57,1	56,9	56,7	56,5	56,3	56,1	55,9	55,6	55,4	55,2	55,0	54,8	54,6	54,4	54,2	54,0	53,8	53,5	53,3	53,1	42	68,67
59,8	59,5	59,3	59,1	58,9	58,7	58,5	58,3	58,0	57,8	57,6	57,4	57,2	57,0	56,8	56,5	56,3	56,1	55,9	55,7	55,5	55,2	55,0	54,8	54,6	54,4	43	70,30
61,2	60,9	60,7	60,5	60,3	60,1	59,8	59,6	59,4	59,2	59,0	58,7	58,5	58,3	58,1	57,9	57,6	57,4	57,2	57,0	56,8	56,5	56,3	56,1	55,9	55,7	44	71,94
62,5	62,3	62,1	61,9	61,6	61,4	61,2	61,0	60,7	60,5	60,3	60,1	59,8	59,6	59,4	59,2	58,9	58,7	58,5	58,3	58,0	57,8	57,6	57,4	57,1	56,9	45	73,57
63,9	63,7	63,5	63,2	63,0	62,8	62,6	62,3	62,1	61,9	61,6	61,4	61,2	60,9	60,7	60,5	60,3	60,0	59,8	59,6	59,3	59,1	58,9	58,6	58,4	58,2	46	75,21
65,3	65,1	64,9	64,6	64,4	64,1	63,9	63,7	63,4	63,2	63,0	62,7	62,5	62,3	62,0	61,8	61,6	61,3	61,1	60,9	60,6	60,4	60,2	59,9	59,7	59,4	47	76,84
66,7	66,5	66,2	66,0	65,8	65,5	65,3	65,0	64,8	64,6	64,3	64,1	63,8	63,6	63,4	63,1	62,9	62,6	62,4	62,2	61,9	61,7	61,4	61,2	61,0	60,7	48	78,48
68,1	67,9	67,6	67,4	67,1	66,9	66,6	66,4	66,1	65,9	65,7	65,4	65,2	64,9	64,7	64,4	64,2	63,9	63,7	63,4	63,2	63,0	62,7	62,5	62,2	62,0	49	80,11
69,5	69,2	69,0	68,7	68,5	68,2	68,0	67,7	67,5	67,2	67,0	66,7	66,5	66,2	66,0	65,7	65,5	65,2	65,0	64,7	64,5	64,2	64,0	63,7	63,5	63,2	50	81,75
70,9	70,6	70,4	70,1	69,9	69,6	69,4	69,1	68,8	68,6	68,3	68,1	67,8	67,6	67,3	67,1	66,8	66,5	66,3	66,0	65,8	65,5	65,3	65,0	64,8	64,5	51	83,38
72,3	72,0	71,8	71,5	71,2	71,0	70,7	70,5	70,2	69,9	69,7	69,4	69,2	68,9	68,6	68,4	68,1	67,9	67,6	67,5	67,1	66,8	66,6	66,3	66,0	65,8	52	85,02
73,7	73,4	73,1	72,9	72,6	72,3	72,1	71,8	71,5	71,3	71,0	70,7	70,5	70,2	70,0	69,7	69,4	69,2	68,9	68,6	68,4	68,1	67,8	67,6	67,3	67,0	53	86,65
75,1	74,8	74,5	74,2	74,0	73,7	73,4	73,2	72,9	72,6	72,4	72,1	71,8	71,5	71,3	71,0	70,7	70,5	70,2	69,9	69,7	69,4	69,1	68,8	68,6	68,3	54	88,29
76,4	76,2	75,9	75,6	75,3	75,1	74,8	74,5	74,2	74,0	73,7	73,4	73,1	72,9	72,6	72,3	72,0	71,8	71,5	71,2	70,9	70,7	70,4	70,1	69,8	69,6	55	89,92
77,8	77,6	77,3	77,0	76,7	76,4	76,2	75,9	75,6	75,3	75,0	74,8	74,5	74,2	73,9	73,6	73,4	73,1	72,8	72,5	72,2	72,0	71,7	71,4	71,1	70,8	56	91,56
79,2	79,0	78,7	78,4	78,1	77,8	77,5	77,2	76,9	76,7	76,4	76,1	75,8	75,5	75,2	74,9	74,7	74,4	74,1	73,8	73,5	73,2	73,0	72,7	72,4	72,1	57	93,19
80,6	80,3	80,0	79,7	79,5	79,2	78,9	78,6	78,3	78,0	77,7	77,4	77,1	76,8	76,6	76,3	76,0	75,7	75,4	75,1	74,8	74,5	74,2	73,9	73,7	73,4	58	94,83
82,0	81,7	81,4	81,1	80,8	80,5	80,2	79,9	79,6	79,3	79,1	78,8	78,5	78,2	77,9	77,6	77,3	77,0	76,7	76,4	76,1	75,8	75,5	75,2	74,9	74,6	59	96,46
83,4	83,1	82,8	82,5	82,2	81,9	81,6	81,3	81,0	80,7	80,4	80,1	79,8	79,5	79,2	78,9	78,6	78,3	78,0	77,7	77,4	77,1	76,8	76,5	76,2	75,9	60	98,10
84,8	84,5	84,2	83,9	83,6	83,3	83,0	82,6	82,3	82,0	81,7	81,4	81,1	80,8	80,5	80,2	79,9	79,6	79,3	79,0	78,7	78,4	78,1	77,8	77,5	77,2	61	99,73
86,2	85,9	85,6	85,2	84,9	84,6	84,3	84,0	83,7	83,4	83,1	82,8	82,5	82,1	81,8	81,5	81,2	80,9	80,6	80,3	80,0	79,7	79,4	79,0	78,7	78,4	62	101,37
87,6	87,2	86,9	86,5	86,3	86,0	85,7	85,4	85,0	84,7	84,4	84,1	83,8	83,5	83,2	82,8	82,5	82,2	81,9	81,6	81,3	80,9	80,6	80,3	80,0	79,7	63	103,00
89,0	88,6	88,3	88,0	87,7	87,4	87,0	86,7	86,4	86,1	85,8	85,4	85,1	84,8	84,5	84,2	83,8	83,5	83,2	82,9	82,6	82,2	81,9	81,6	81,3	81,0	64	104,64
90,3	90,0	89,7	89,4	89,0	88,7	88,4	88,1	87,7	87,4	87,1	86,8	86,4	86,1	85,8	85,5	85,1	84,8	84,5	84,2	83,8	83,5	83,2	82,9	82,5	82,2	65	106,27
91,7	91,4	91,1	90,7	90,4	90,1	89,8	89,4	89,1	88,8	88,4	88,1	87,8	87,4	87,1	86,8	86,5	86,1	85,8	85,5	85,1	84,8	84,5	84,1	83,8	83,5	66	107,91
93,1	92,8	92,5	92,1	91,8	91,4	91,1	90,8	90,4	90,1	89,8	89,4	89,1	88,8	88,4	88,1	87,8	87,4	87,1	86,8	86,4	86,1	85,8	85,4	85,1	84,8	67	109,54
94,5	94,2	93,8	93,5	93,2	92,8	92,5	92,1	91,8	91,5	91,1	90,8	90,4	90,1	89,8	89,4	89,1	88,7	88,4	88,1	87,7	87,4	87,0	86,7	86,4	86,0	68	111,18
95,9	95,6	95,2	94,9	94,5	94,1	93,8	93,5	93,1	92,8	92,5	92,1	91,8	91,4	91,1	90,7	90,4	90,0	89,7	89,3	89,0	88,7	88,3	88,0	87,6	87,3	69	112,81
97,3	96,9	96,6	96,2	95,9	95,5	95,2	94,8	94,5	94,1	93,8	93,4	93,1	92,7	92,4	92,0	91,7	91,3	91,0	90,6	90,3	89,9	89,6	89,2	88,9	88,5	70	114,45
98,7	98,3	98,0	97,6	97,3	96,9	96,6	96,2	95,8	95,5	95,1	94,8	94,4	94,1	93,7	93,4	93,0	92,6	92,3	91,9	91,6	91,2	90,9	90,5	90,2	89,8	71	116,08
100,1	99,7	99,4	99,0	98,6	98,3	97,9	97,6	97,2	96,8	96,5	96,1	95,8	95,4	95,0	94,7	94,3	94,0	93,6	93,2	92,9	92,5	92,2	91,8	91,4	91,1	72	117,72
101,5	101,1	100,7	100,4	100,0	99,6	99,3	98,9	98,5	98,2	97,8	97,4	97,1	96,7	96,4	96,0	95,6	95,3	94,9	94,5	94,2	93,8	93,4	93,1	92,7	92,3	73	119,35
102,9	102,5	102,1	101,7	101,4	101,0	100,6	100,3	99,9	99,5	99,2	98,8	98,4	98,0	97,7	97,3	96,9	96,6	96,2	95,8	95,5	95,1	94,7	94,3	94,0	93,6	74	120,99
104,2	103,9	103,5	103,1	102,7	102,4	102,0	101,6	101,2	100,9	100,5	100,1	99,7	99,4	99,0	98,6	98,2	97,9	97,5	97,1	96,7	96,4	96,0	95,6	95,2	94,9	75	122,62
105,6	105,3	104,9	104,5	104,1	103,7	103,4	103,0	102,6	102,2	101,8	101,5	101,1	100,7	100,3	99,9	99,6	99,2	98,8	98,4	98,0	97,7	97,3	96,9	96,5	96,1	76	124,26
107,0	106,6	106,3	105,9	105,5	105,1	104,7	104,3	103,9	103,6	103,2	102,8	102,4	102,0	101,6	101,2	100,9	100,5	100,1	99,7	99,3	98,9	98,6	98,2	97,8	97,4	77	125,89
108,4	108,0	107,6	107,2	106,9	106,5	106,1	105,7	105,3	104,9	104,5	104,1	103,7	103,3	103,0	102,6	102,2	101,8	101,4	101,0	100,6	100,2	99,8	99,4	99,1	98,7	78	127,53
109,8	109,4	109,0	108,6	108,2	107,8	107,4	107,0	106,6	106,2	105,9	105,5	105,1	104,7	104,3	103,9	103,5	103,1	102,7	102,3	101,9	101,5	101,1	100,7	100,3	99,9	79	129,16
111,2	110,8	110,4	110,0	109,6	109,2	108,8	108,4	108,0	107,6	107,2	106,8	106,4	106,0	105,6	105,2	104,8	104,4	104,0	103,6	103,2	102,8	102,4	102,0	101,6	101,2	80	130,80
112,6	112,2	111,8	111,4	111,0	110,6	110,2	109,7	109,3	108,9	108,5	108,1	107,7	107,3	106,9	106,5	106,1	105,7	105,3	104,9	104,6	104,1	103,7	102,2	102,9	102,5	81	132,43
114,0	113,6	113,2	112,7	112,3	111,9	111,5	111,1	110,7	110,3	109,9	109,5	109,1	108,6	108,2	107,8	107,4	107,0	106,6	106,2	105,9	105,4	105,0	104,5	104,1	103,7	82	134,07
115,4	114,9	114,5	114,1	113,7	113,3	112,9	112,5	112,0	111,6	111,2	110,8	110,4	110,0	109,6	109,1	108,7	108,3	107,9	107,5	107,2	106,6	106,2	105,8	105,4	105,0	83	135,70
116,8	116,3	115,9	115,5	115,1	114,7	114,2	113,8	113,4	113,0	112,6	112,1	111,7	111,3	110,9	110,5	110,0	109,6	109,2	108,8	108,5	107,9	107,5	107,1	106,7	106,3	84	137,34

SUMS OR DIFFERENCES OF THE DIRECT AND INVERSE NOTATIONS, THE LATTER BEING DETERMINED AT A TEMPERATURE (CENTIGRADE) OF

Degrees by wt. A	10°	11°	12°	13°	14°	15°	16°	17°	18°	19°	20°	21°	22°
85	118,1	117,7	117,3	116,9	116,4	116,0	115,6	115,2	114,7	114,3	113,9	113,5	113,0
86	119,5	119,1	118.7	118.2	117,8	117,4	117,0	116,5	116 1	115,7	115,2	114,8	114,4
87	120,9	120,5	120,1	119,6	119,2	118,7	118,3	117,9	117,4	117,0	116 6	116,1	115,7
88	122,3	121,9	121,4	121,0	120.6	120,1	119,7	119,2	118,8	118,4	117,9	117,5	117,0
89	123,7	123,2	122,8	122,4	121,9	121,5	121,0	120,6	120,1	119,7	119,3	118,8	118.4
90	125,1	124.6	124,2	123,7	123,3	122,8	122,4	121,9	121,5	121,0	120,6	120,1	119,7
91	126,5	126,0	125,6	125,1	124,7	124.2	123,8	123,3	122,8	122,4	121,9	121,5	121,0
92	127,9	127,4	127,0	126,5	126,0	125,6	125,1	124,7	124,2	123,7	123,3	122,8	122,4
93	129,3	128,8	128,3	127,9	127,4	126,9	126,5	126,0	125,5	125,1	124,6	124,1	123,7
94	130,7	130,2	129,7	129,2	128,8	128,3	127,8	127,4	126,9	126,4	126,0	125,5	125,0
95	132,0	131,6	131,1	130.6	130,1	129,7	129,2	128,7	128,2	127,8	127,3	126,8	126,3
96	133,4	133,0	132,5	132,0	131,5	131,0	130,6	130,1	129,6	129,1	128,6	128,2	127,7
97	134,8	134,3	133,9	133,4	132,9	132,4	131,9	131,4	130,9	130,5	130,0	129,5	129,0
98	136,2	135,7	135,2	134,7	134,3	133,8	133.3	132,8	132,3	131,8	131.3	130,8	130,3
99	137,6	137,1	136,6	136,1	135,6	135,1	134.6	134,1	133,6	133,1	132,7	132,2	131,7
100	139,0	138,5	138,0	137,5	137,0	136,5	136,0	135,5	135,0	134,5	134,0	133,5	133,0
101	140,4	139,9	139,4	138,9	138,4	137,9	137,4	136,8	136,3	135,8	135,3	134,8	134.3
102	141,8	141,3	140,8	140,2	139,7	139,2	138,7	138,2	137,7	137,2	136,7	136,2	135,7
103	143,2	142,6	142,1	141.6	141,1	140,6	140,1	139,6	139,0	138,5	138,0	137.5	137,0
104	144,6	144,0	143,5	143,0	142,5	142,0	141,4	140,9	140,4	139,9	139,4	138,8	138,3
105	145,9	145,4	144,9	144,4	143,8	143,3	142,8	142,3	141,7	141,2	140,7	140,2	139,6
106	147,3	146,8	146,3	145,7	145,2	144,7	144,2	143,6	143,1	142,6	142,0	141,5	141,0
107	148,7	148,2	147,7	147,1	146,6	146,0	145,5	145,0	144,5	143,9	143,4	142,8	142,3
108	150,1	149,6	149,0	148,5	148,0	147,4	146,9	146,3	145,8	145,3	144,7	144,2	143,6
109	151.5	151,0	150,4	149,9	149,3	148,8	148,2	147,7	147,1	146,6	146,1	145,5	145,0
110	152,9	152,3	151,8	151,2	150,7	150,1	149,6	149,0	148,5	147,9	147,4	146,8	146,3
111	154,3	153,7	153,2	152,6	152,1	151,5	151.0	150,4	149,8	149,3	148,7	148,2	147,6
112	155,7	155,1	154,6	154,0	153,4	152,9	152,3	151,8	151,2	150,6	150,1	149,5	149,0
113	157,1	156,5	155,9	155,4	154,8	154,2	153,7	153,1	152,5	152,0	151,4	150,8	150,3
114	158,5	157,9	157,3	156,7	156,2	155,6	155,0	154,5	153,9	153,3	152,8	152,2	151,6
115	159,8	159,3	158,7	158,1	157,5	157,0	156,4	155,8	155,2	154,7	154,1	153,5	152,9
116	161,2	160,6	160,1	159.5	158,9	158,3	157,8	157,2	156,6	156,0	155,4	154,9	154,3
117	162,6	162,9	161,5	165,9	160,3	159,7	159,0	158,5	157,9	157,4	156,9	156,2	155,6
118	164,0	163,4	162.8	162,2	161,7	161,1	160,5	159,9	159,3	158,7	158.1	157,5	156,9
119	165,4	164,8	164,2	163,6	163.0	162,4	161,8	161,2	160,6	160,0	159,5	158,9	158,3
120	166,8	166,2	165,6	165,0	164,4	163,8	163.2	162,6	162,0	161,4	160,8	160,2	159,6
121	168,2	167,6	167,0	166,4	165,8	165 2	164,6	163,9	163,3	162,7	162,1	161.5	160,9
122	169,6	169,0	168,4	167,7	167,1	166,5	165,9	165,3	164,7	164,1	163,5	162,9	162,3
123	171,0	170,3	169,7	169.1	168,5	167,9	167,3	166,7	166,0	165,4	164,8	164,2	163,6
124	172,4	171,7	171,1	170,5	169,9	169,3	168,6	168,0	167,4	166,8	166,2	165,5	164,9
125	173,7	173,1	172,5	171,9	171,2	170,6	170,0	169,4	168,7	168,1	167,5	166,9	166.2
126	175,1	174,5	173,9	173,2	172,6	172.0	171,4	170,7	170,1	169,5	168,8	168,2	167,6
127	176,5	175,9	175,3	174,6	174,0	173,3	172,7	172,1	171,4	170,8	170,2	169,5	168,9
128	177,9	177,3	176,6	176,0	175,4	174,7	174,1	173,4	172,8	172.2	171,5	170,9	170,2
129	179,3	178,7	178,0	177,4	176,7	176,1	175,4	174,8	174,1	173,5	172.9	172,2	171,6
130	180,7	180,0	179,4	178,7	178,1	177,4	176,8	176,1	175,5	174,8	174,2	173,5	172,9

Degrees by wt. A	23°	24°	25°	26°	27°	28°	29°	30°	31°	32°	33°	34°	35°	Degrees by vol. B
85	112,6	112.2	111,8	111,3	110,9	110,5	110,1	109,7	109,2	108,8	108,4	107,9	107,5	138,97
86	113,9	113,5	113.1	112,7	112,2	111,8	111,4	111,0	110,5	110,1	109,6	109,2	108,8	140,61
87	115,3	114,8	114,4	114.0	113,5	113,1	112,7	112,3	111,8	111,4	110,9	110,5	110,0	142,24
88	116,6	116,2	115,7	115,3	114,8	114,4	114,0	113,6	113,1	112,6	112,2	111,8	111,3	143,88
89	117,9	117,5	117,0	116,6	116,1	115,7	115,2	114,9	114,4	113,9	113,5	113,0	112,6	145.51
90	119.2	118,8	118,3	117,9	117.4	117,0	116,5	116,2	115,6	115.2	114,7	114,3	113,9	147.15
91	120,6	120,1	119,7	119,2	118,7	118,3	117,8	117,5	116,9	116,5	116,0	115,6	115,1	148 78
92	121,9	121,4	121,0	120,5	120,1	119,6	119,1	118,8	118.2	117,8	117,3	116.8	116.4	150.42
93	123,2	122,8	122,3	121,8	121,4	120.9	120,4	120,1	119,5	119,0	118,6	117,1	117,6	152,05
94	124,5	124,1	123,6	123,1	122,7	122,2	121,7	121,4	120,8	120,3	119,8	119,4	118,9	153.69
95	125.9	125,4	124,9	124,4	124,0	123,5	123,0	122,6	122,1	121,6	121,1	120,6	120,2	155.32
96	127,2	126.7	126,2	125,8	125,3	124,8	124,3	123,9	123,4	122,9	122,4	121,9	121,4	156,96
97	128,5	128,0	127,5	127,1	126,6	126,1	125.6	125,2	124,6	124,2	123,7	123,2	122,7	158,59
98	129,8	129,4	128,9	128,4	127,9	127,4	126,9	126,5	125,9	125,4	124,9	124,5	124,0	160,23
99	131,2	130,7	130,2	129,7	129,2	128,7	128,2	127,8	127,2	126,7	126,2	125,7	125.2	161,86
100	132,5	132,0	131,5	131,0	130,5	130.0	129,5	129,0	128,5	128,0	127,5	127,0	126,5	163,50
101	133,8	133,3	132,8	132,3	131,8	131,3	130,8	130,3	129,8	129,3	128,8	128,3	127,8	165,15.
102	135.1	134,6	134,1	133,6	133,1	132,6	132,1	131,6	131,1	130,6	130,0	129.5	129,0	166.77
103	136,5	136,0	135,4	134,9	134,4	133,9	133,4	132,9	132,4	131,8	131,3	130,8	130,3	168,40
104	137,8	137,3	136,8	136,2	135,7	135.2	134,7	134,2	133,6	133,1	132,6	132,1	131,6	170,04
105	139,1	138,6	138,1	137,5	137,0	136,5	136,0	135,4	134,9	134,5	133,9	133,3	132,8	171,67
106	140,5	139,9	139.4	138,9	138,3	137,8	137,3	136,7	136,2	135,7	135,1	134,6	134,1	173.31
107	141,8	141,2	140,7	140,2	139,6	139,1	138,6	138,0	137,5	137,0	136,4	135,9	135,3	174,94
108	143,1	142,6	142,0	141,5	140,9	140,4	139,9	139,3	138,8	138,2	137,7	137,2	136,6	176,58
109	144,4	143,9	143,3	142,8	142,2	141,7	141,1	140,6	140,1	139,5	139,0	138.4	137,9	178,21
110	145,7	145,2	144,6	144,1	143,5	143,0	142,4	141,9	141,3	140,8	140.2	139.7	139,1	179,85
111	147,1	146,5	146,0	145.4	144.8	144,3	143,7	143,2	142,6	142,1	141,5	141,0	140,4	181,48
112	148,4	147,8	147,3	146,7	146,2	145,6	145,0	144,5	143,9	143,4	142,8	142,2	141,7	183,12
113	149,7	149,2	148,6	148,0	147,5	146,9	146,3	145,8	145.2	144.6	144,1	143.5	142.9	184,75
114	151,0	150,5	149,9	149,3	148,8	148,2	147,6	147,1	146,5	145.9	145,3	144.8	144,2	186,39
115	152,4	151,8	151,2	150,6	150,1	149,5	148,9	148,3	147,8	147,2	146,6	146,0	145.5	188.02
116	153,7	153.1	152 5	152,0	151,4	150,8	150,2	149,6	149,1	148,5	147,9	147,3	146,7	189.66
117	155,0	154,4	153,8	153,3	152,7	152,1	151.5	150,9	150,3	149,8	149,2	148,6	148,0	191.29
118	156.3	155,8	153,2	154,6	154,0	153,4	152,8	152,2	151.6	151,0	150,4	149,9	149,3	192.93
119	157,7	157,1	156,5	155,9	155,3	154,7	154,1	153,5	152,9	152,3	151,7	151,1	150,5	194.56
120	159,0	158,4	157,8	157,2	156,6	156,0	155,4	154,8	154,2	153,6	153,0	152,4	151,8	196,20
121	160,3	159,7	159,1	158,5	157,9	157,3	156,7	156,1	155,5	154,9	154,3	153,7	153,1	197.83
122	161,6	161,0	160,4	159,8	159,2	158,6	158,0	157,4	156,8	156,2	155.5	154,9	154,3	199.47
123	163.0	162,4	161,7	161,1	160,5	159,9	159,3	158,7	158,0	157,4	156,8	156,2	155,6	201,10
124	164,3	163,7	163,1	162.4	161,8	161,2	160,6	160,0	159,3	158,7	158,1	157,5	156,9	202,74
125	165,6	165.0	164,4	163,7	163,1	162,5	161,9	161,2	160,6	160,0	159,4	158.7	158,1	204.37
126	166,9	166,3	165,7	165,1	164,4	163,8	163,2	162,5	161,9	161,3	160,6	160.0	159.4	206.01
127	168,3	167.6	167,0	166,4	165,7	165,1	164,5	163,8	163,2	162,6	161,9	161,3	160,6	207,64
128	169.6	169,0	168,3	167.7	167,0	166,4	165,8	165,1	164,5	163.8	163,2	162,6	161,9	209 28
129	170.9	170,3	169,6	169,0	168,3	167,7	167,0	166.4	165,8	165,1	164,6	163,8	163,2	210.91
130	172,2	171,6	170,9	170,3	169,6	169,0	168,3	167,7	167,0	166,4	165,7	165,1	164,4	212,55

2. Another liquor similarly prepared, giving before the inversion a notation on the left of - - - - - - - - - - - 80 divisions.

And after the inversion, at the temperature of + 20°, another notation of the same direction, but only of - - - - - - - - 26 divisions.

Difference expressing the value of the inversion - 54 divisions.

The strength of the two solutions will be found thus; for the first, by seeing what is the figure of the column representing 15°, which is the nearest to the sum of the inversion, 95 divisions: it will be observed that this figure is 95·5, and that it corresponds to quality 70, shown on the same horizontal line in the last column but one, A; hence we conclude that the substance contained 70 per cent. of sugar.

As to the second solution, the figure nearest 54 is 53·6, in the column for the temperature of + 20°, and the strength sought will be 40% on the same line in the column of qualities. Finally, we shall find, besides, in the last column, B, of the table, the quantity in grammes and centigrammes of the sugar contained per litre in the solutions, which is 114 gr. 45 for the first, and 65 gr. 40 for the second.

Other methods for the estimation of sugar have been adopted. We have already described Peligot's method by means of lime. When sugar is formed from starch, its complete saccharification may be determined by the action of sulphuric acid, for if on a strong solution of imperfectly formed grape sugar, nearly boiling hot, one drop of strong sulphuric acid be added, no perceptible change will ensue, but if the acid be dropped into solutions of either cane or perfectly formed grape sugar, black carbonaceous particles will make their appearance.

The black oxide of copper is not affected by being boiled in solution of starch sugar.

"If a 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 $\frac{1}{100000}$ 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 an exact result, very great nicety must be used in the dose of alkali, which is found extremely difficult to hit. With a regulated alkaline mixture, however, an exceedingly small portion of starch sugar, is readily detected, even when mixed with Muscovado sugar.

Fehling has reduced this to a quantitative test, and makes a solution of copper that will keep permanently. This is seen by the following:—

40 grammes of sulphate of copper,
160 grammes of neutral tartrate of potassa, or 200 grammes of tartrate of soda, dissolved and added to
700—800 cub. c. (grammes) of caustic soda, specific gravity 1·12.

This is diluted with water to 1154·5 cub. c.

Of this solution 1 cub. c. = 0·0050 grape sugar, or
0·00475 cane sugar.

Grains may be used instead of grammes, and then 1 grain = 0·0050 grape sugar, without change of calculation.

100 parts of grape sugar, - - -		
95 ,, cane sugar, - - -	= 220·5 CuO, or 198 Cu^2O.	
90 ,, starch, - - - -		

Urine may be tested with this. It should be first diluted 10 to 20 times with water; when the test is added, it should be boiled a few seconds, when the suboxide of copper falls. Very constant results may be obtained.

Caramelin is the name given by E. Maumené to a brown substance, insoluble in acids and alkalies, which is produced by evaporating sugar with fifteen to thirty times its weight of chloride of tin, and heating it to about 220° Fahr. It is $C^{12}H^4O^4$, and being constant has been proposed by him to be used as a test of the presence and quantity of sugar.

Horsley detects minute quantities of sugar by means of chromate of potash.

Of the sugar cane, and the extraction of sugar from it.—Though we have no direct authority for believing that the sugar *cane* was known to the ancients, we find scattered through their writings notices of the occasional use of sweet substances different from honey.

The writers alluded to are these: Theophrastus, Dioscorides, Galen, Strabo, and Pliny: some of them speak distinctly of canes and reeds. 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, 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.

Twenty-eight sugar works established by the Spaniards existed in St. Domingo in 1518. Sugar was first brought to England in 1563, by Admiral Hawkins, and a century later English planters were realising great wealth in Barbadoes.

It has been supposed to have been introduced into Hayti by Columbus himself, at his first voyage, along with other productions of Spain and the Canaries, and that therefore 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, Chili, 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. 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, reddish, 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 is propagated 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. The 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 a d 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.

Another variety is the Otaheitan 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 weighs a third more, affords a sixth more juice, and a fourth more sugar, than the common variety. It yields 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 crystallised, and of a fairer colour.

Another variety, valuable chiefly from its hardiness, is the *purple violet* from Java. It grows from eight to ten feet high. This cane is covered with a resinous film which is difficult to grind; but as the sugar yielded is of excellent quality, this variety is of considerable value in bordering cane fields, protecting them from the inroads of cattle.

There is a caste in Ceylon, called *jaggeraros*, 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).


1716

Several sorts of cane are cultivated in India.

The *cadjoolee* (*fig.* 1716) 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.

The manufacture of sugar in Bengal is conducted by the natives in the most primitive manner possible; the poverty and ignorance of the ryots or peasants being serious obstacles to the introduction of any system different from that practised by their forefathers. Early in June the soil is brought into a soft muddy state; slips of the cane, with one or two joints, are planted in rows about three feet six inches apart, and one foot six inches asunder in the rows; when about three inches above ground the earth is partially loosened, and in August trenches are cut, to drain off any superfluous moisture. From three to six canes spring from each slip. When about three feet high the lower leaves are wrapped round the canes and the whole from each slip supported by bamboos. The cutting commences in January or February, the canes being then eight or ten feet high, and one to one and a half inch thick, and are passed through a mill of the rudest construction, which will be fully described when sugar-mills are treated of.

The juice of the date tree is collected in pots by tapping the stem, and afterwards undergoes the same process as cane juice.

The cost of cultivating an acre of land in the neighbourhood of Calcutta may be estimated as follows:—

	C. Rupees and pice.			£	s.	d.	£	s.	d.
To ground rent	2	8	per biggah, equal per acre to about	0	17	6			
„ ploughing	1	0	„ „ „	0	7	0			
„ weeding	2	8	„ „ „	0	17	6			
„ watering	1	4	„ „ „	0	8	9			
„ seeds	4	8	„ „ „	1	11	6			
„ cutting	3	0	„ „ „	1	1	0			
„ crushing	15	0	„ „ „	5	5	0			

	C. Rupees and Pice.			£ s. d.	£ s. d.
To pots, bags, &c.	1	0	per biggah, equal per acre to about	0 7 0	
„ profit	14	14	„ „ „	1 9 9	
					£12 5 0
By Khaur, 9 Bengal maunds per biggah at C.R. 3.8, equal per acre to 23 cwts. 1 qr. 1lb. at 9*s.* 6*d.* - - -				11 1 0	
By Molasses, 7 Bengal maunds per biggah at C.R. 10, equal per acre to 17 cwts. 3qrs. 25 lbs. at 1*s.* 4*d.* - - -				1 4 0	£12 5 0

Such is the return from the rich plains of India under the wretched system carried on by the natives. In the West Indies similar land produces a much larger quantity, and greatly superior in quality. In the above calculations the expenses are those payable for contract work, but the ryot and his family being in many cases nearly the only labourers on their small patches of land, the wages may be considered as a portion of their profit. The climate and soil of India are all that can be desired for the cultivation of sugar, and land and labour being abundant and cheap, no country can hold out a better prospect of success for the prosecution of such a trade by the English capitalist, with improved machinery, if coupled with science and industry.

Some years ago returns were made to the Indian Government by the magistrates of the various districts of Bengal and North-Western Provinces, of the estimated product and local consumption of sugar throughout the country, which gave the following quantities:—

	Bengal Maunds.		Tons.
Production per annum - - - -	18,734,909	=	693,885
Local consumption - - - - -	11,778,356	=	436,223
	6,956,553		257,662
The largest quantity ever exported from Calcutta was about -			70,000
Which leaves unaccounted for about - - - - -			187,662

These returns were not considered very satisfactory; no great reliance can, therefore be placed on their correctness.

The China cane is said to be extremely hardy, standing both cold and drought, and, with abundant rain, giving out as many as thirty shoots. It resists the inroads of the white ants, which cannot penetrate its hard crust, whilst it is also proof against the teeth of the jackals. It requires, however, a stronger mill for grinding than the other varieties mentioned. Mr. Wray asserts that the Salangore cane is the finest in the Straits of Singapore, and perhaps in the world. He says that he has cut five from one stool, which were of a weight of from 17 lbs. to 25 lbs. They have been known to produce 7200 lbs. of undrained sugar per acre, equal to 5800 lbs. of dry sugar for shipping.

Dr. Livingstone says that sugar is cultivated in the Shire valley, as well as many parts of Africa near the Zambesi, and may be had for as little as one halfpenny per pound. There is field enough for great enterprise in that direction. The amount obtainable has not been investigated.

In all the colonies of the New World the sugar cane flowers, but it then sends forth a shoot (*arrow*), that is, its stem elongates, and the seed-vessels prove abortive. For this reason, the bud-joints must there be used for its propagation. It is said to grow 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 4 or 6 feet asunder, in which rows the canes are planted from 2 to 5 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 2½ 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, 2½ tons of sugar per acre. The proper season for planting the cane-slips 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. It is a great error for the colonist to plant 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 last eight leafless joints of two canes, which are cut the same day, have exactly 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 *rejettons*) 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 rattoons; the second year's growth, second rattoons; and so on, according to their age. Instead of stocking up his rattoons, 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.

When the planted canes are ripe, they are cut close above the ground by an oblique section, and the leaves and shoots being stripped off, they are 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 rattoons than when left projecting in the common way.

The amount of sugar yielded per acre is very variously stated. In fact. the yield must vary with the different variety of canes cultivated, with the nature of the soil, the character of the season, and, more than all, with the more or less perfect apparatus used in manufacturing the sugar. The yield, from these causes, will vary from half a ton to two and a half tons of solid sugar per acre.

The following table by M. Duprez is given. The average amount of juice from 100 lbs. of canes was: —

1. By mills having horizontal rollers—motive power not stated—probably steam	61·2
2. By mills, motive power steam	60·9
3. By mills, motive power wind and steam	59·3
4. By mills having vertical rollers	59·2
5. By mills, motive power cattle	58·5
6. By mills, motive power wind	56·4

Dr. Evans gives the products of an acre of canes in Barbadoes as: —

Weight of canes.	Weight of juice.	Extract.	Extract per 100 lbs. of juice.	Extract per 100 lbs. of canes.
30 tons	60,480 lbs.	10,886 lbs.	18·0	16·20
30 „	47,040 „	8,467 „	18·0	12·6
30 „	33,600 „	3,500 „	10·0	5·0
30 „	33,600 „	7,280 „	21·6	10·8

An acre may be said to yield 30 tons of canes. The following table gives the produce in juice and sugar in such a case according to Mr. Wray: —

Juice obtained per cent.	Juice in pounds.	Pounds of Sugar. At 18 per cent.	At 20 per cent.	At 22 per cent.
70	47,040	8,468	9,408	10,348
75	50,400	9,092	10,080	11,088
80	53,760	9,676	10,752	11,827

Juice obtained per cent.	Juice in pounds.	Subtract for Molasses and Skimmings, at 12 per cent. At 18 per cent.	At 20 per cent.	At 22 per cent.	Pounds of dry Sugar yielded by one Acre. At 18 per cent.	At 20 per cent.	At 22 per cent.
70	47,040	705	792	862	7,763	8,616	9,486
75	50,400	757	840	924	8,335	9,240	10,164
80	53,760	806	896	994	8,871	9,856	11,173

Matured cane is better shown in the annexed table by Payen:—

Otaheite Cane at Maturity.

	Centesimally.
Water - - - - - - - - - - - - -	71·04
Sugar - - - - - - - - - - - - -	18·00
Cellulose, ligneous matter, pectin, and pectic acid - - - - -	9·56
Albumen and three other nitrogenous matters - - - - - - -	0·55
Cerosin, green matter, yellow colouring substance, substance capable of being dyed brown, and carmin, fatty matter, resins, essential oil, aromatic matter, and a deliquescent substance - - - - -	0·37
Insoluble salts 0·12; soluble 0·16: consisting of phosphates of lime and magnesia, alumina, sulphate and oxalate of lime, acetates, malate of lime, potassa, and soda, alkaline chlorides, and sulphates - - -	0·28
Silica - - - - - - - - - - - - -	0·20
	100·00

Cane only at a Third of its Development.

	Centesimally.
Water - - - - - - - - - - - - -	79·70
Sugar - - - - - - - - - - - - -	9·06
Cellulose and incrusted ligneous matter - - - - - - -	7·03
Albumen and three other nitrogenous substances - - - -	1·17
Starch, cerosin, green matter, yellow colouring substance, and bodies colourable to brown and carmin - - - - - - -	1·09
Fatty, aromatic, and hygroscopic substances, essential oil, soluble and insoluble salts, alumina, and silica - - - - - - -	1·95
	100·00

M. Casaseca has analysed the creole cane at Havana, and found:—

	Cane entire.	Cane peeled.	The rind.
Water - - - - -	77·0	77·8	69·5
Sugar and soluble substances -	12·0	16·2	11·5
Ligneous matter - - -	11·0	6·0	19·0

M. Casaseca states that the juice is richer in sugar at the base of the cane and becomes gradually poorer towards the top; the middle third of the cane being the average.

The specific gravity of cane juice varies from 1046 to 1110, but is generally found from 1070 to 1090, being from 10° to 13° Baumé. It is opaque, frothy, and of a yellowish-green colour. On boiling, a green scum rises, consisting of chlorophylle, cellulose, ligneous fibre, and albumen, and the liquid remains of a pale yellow colour. The green scum, as analysed by Avequin, consists of—

	Per cent.
Cerosie—a peculiar wax - - - - - -	50·0
Green matter - - - - - - - -	10·0
Albumen and ligneous fibre - - - - -	22·7
Phosphate of lime - - - - - - -	3·3
Silica - - - - - - - - -	14·0
	100·0

The pure juice is composed of the following—

	Per cent.
Water - - - - - - - - - -	81·00
Sugar - - - - - - - - - -	18·20
Organic matter, precipitated by lead salts - -	0·45
Saline matter - - - - - - - -	0·35
	100·00

The ashes of the cane, according to Dr. Stenhouse, yield—

Silica	46·46	41·37	46·48	50·00
Phosphoric acid	8·23	4·59	8·16	6·56
Sulphuric acid	4·65	10·93	7·52	6·40
Lime	8·91	9·11	5·78	5·09
Magnesia	4·50	6·92	15·61	13·01
Potassa	10·63	15·99	11·93	13·69
Soda	—	—	0·57	1·33
Chloride of potassium	7·41	8·96	—	—
Chloride of sodium	9·21	2·13	3·95	3·92
	100·00	100·00	100·00	100·00

The following elaborate analysis of cane juice after being manufactured into sugar and molasses, and after having passed through various iron and copper vessels, is given by Dr. Richardson:—

	Sugar.	Molasses.
Potassa	19·42	36·23
Lime	14·67	12·72
Magnesia	10·72	11·14
Oxide of iron	6·55	2·62
Oxide of copper	0·71	trace of both
Protoxide of manganese	trace	
Chloride of potassium	8·03	1·58
Chloride of sodium	15·46	25·87
Sulphuric acid	10·85	7·91
Silica	13·59	1·93
Ashes	1·33	3·60

Molasses alone were analysed by Payen, and 12 kilogrammes were found to contain—

Sugar	7·561·00
Acetate of potash	0·209·30
Chloride of potassium	0·114·60
Sulphate of potash	0·085·50
Mucilaginous matter	0·076·30
Phosphate of lime	0·052·00
Nitrogenous substances	0·050·00
Silica	0·023·90
Acetate of lime	0·016·20
Phosphate of copper	0·000·20
Water	1·800·00
Glucose and uncrystallisable sugar	1·561·00

The proportion of salts varies considerably with the soil on which the canes are grown. It is highly important that soluble salts, especially of alkalies, should not be added to the ground in the form of manure, for if absorbed into the cane juice, they cannot be removed in the process of manufacture, but convert a proportion of cane sugar (many times their own weight) into the uncrystallisable form.

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.

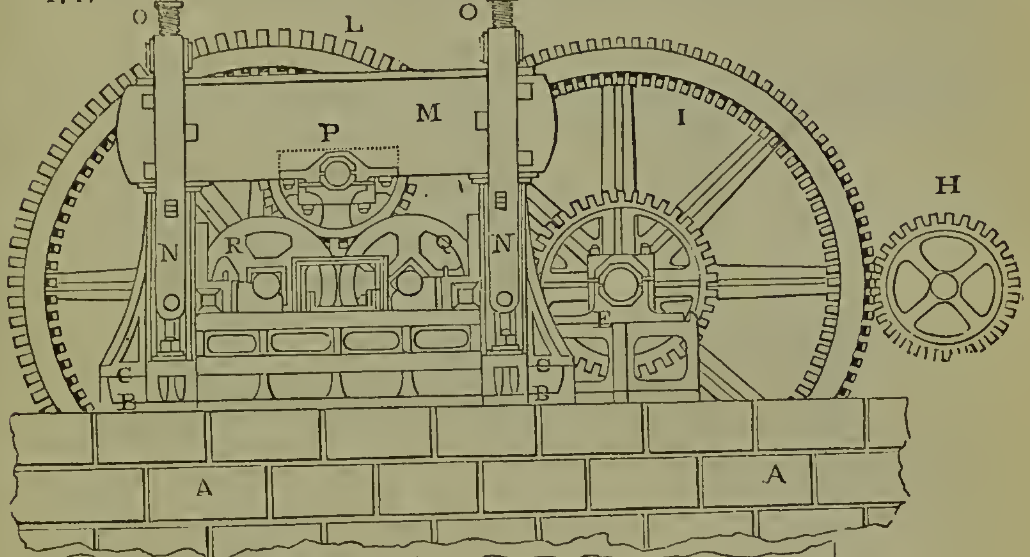
Specification of, and Observations on, the Construction and Use of the best Horizontal Sugar-mill.

Fig. 1719, front elevation of the entire mill. *Fig.* 1718, horizontal plan. *Fig.*

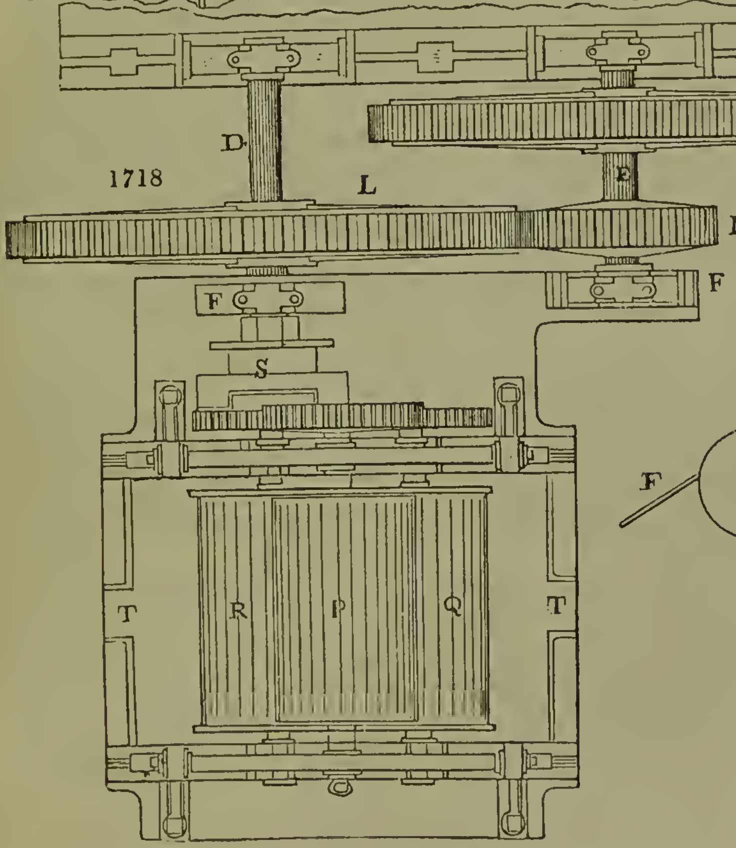
1717, end elevation. *Fig.* 1720, diagram, showing the dispositions of the feeding and delivering rollers, feeding board, returner, and delivering board.

Fig. 1717, A, A, solid foundation of masonry; B, B, bed plate; C, C, headstocks or standards; D, main shaft (seen only in *fig.* 1718); E, intermediate shaft; F, F, plummer-blocks of main shaft D (seen only in *fig.* 1718); H, driving pinion on the fly-wheel shaft of engine; I, first motion mortise wheel, driven by the pinion; K, second motion

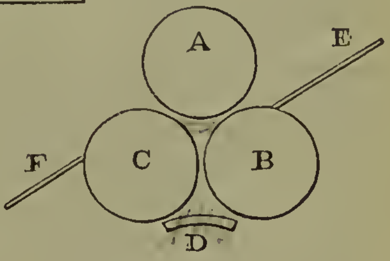
1717



1718



1720



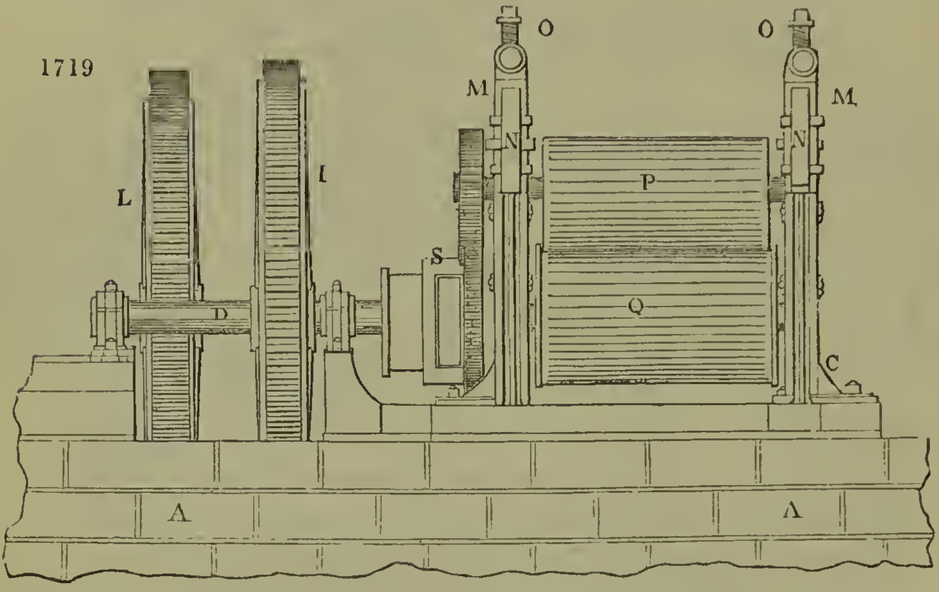
pinion, on the same shaft; L, second motion mortise-wheel, on the main shaft; M, brays of wood, holding the plummer-blocks for shaft D; N, wrought-iron straps connecting the brays to the standards C, C; O, O, regulating screws for the brays; P, top roller and gudgeons; Q and R, the lower or feeding and delivering rollers; S, clutch for the connexion of the side of lower rollers Q and R, to the main shaft (seen only in *fig.* 1718); T, T, the drain gutters of the mill-bed (seen only in *fig.* 1718).

The same letters of reference are placed respectively on the same parts of the mill in each of *figs.* 1717, 1718, and 1719.

The relative disposition of the rollers is shown in the diagram, *fig.* 1720, in which A is the top roller; B, the feeding roller; C, the delivering roller; D, the returner; E, the feed board; F, the delivering board.

The rollers are made $2\frac{1}{4}$ inches to $2\frac{1}{2}$ inches thick, and ribbed in the centre. The feeding and delivering rollers have small flanges at their ends (as shown in *fig.* 1717), between which the top roller is placed; these flanges prevent the pressed canes or

1719



megass 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 grooves carrying round a portion of liquor, which is speedily absorbed by the spongy megass, as well as in breaking the megass itself, and thus causing great waste.

The feed plate 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 plate is of cast iron, fitted close to the roller, to detach any megass that may adhere to it and otherwise mix with the liquor.

In some cases a liquor pump, with two barrels and three adjustments of stroke, is attached to the mill. 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 about $\frac{1}{8}$th of an inch from it.

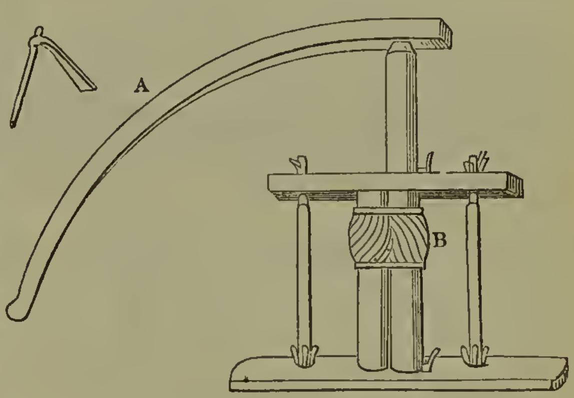
The canes are thrown upon the feed board, and spread so that they may cross each other as little as possible. They are taken in by the feed rollers, which split and slightly press them; the liquor flows down, and, the returner guiding the canes between the top and delivering rollers, they receive the final pressure, and are turned out on the mill-floor, while the liquor runs back and falls into the mill-bed. The megass, 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 megass house for fuel. By an improvement in this stage of the process, the megass is carried to the megass-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 megass 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 require to be adopted.

The sugar-mill at Chica Ballapura is worked by a single pair of buffaloes or oxen, *fig.* 1721, 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 four spiral grooves and four 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.

1721

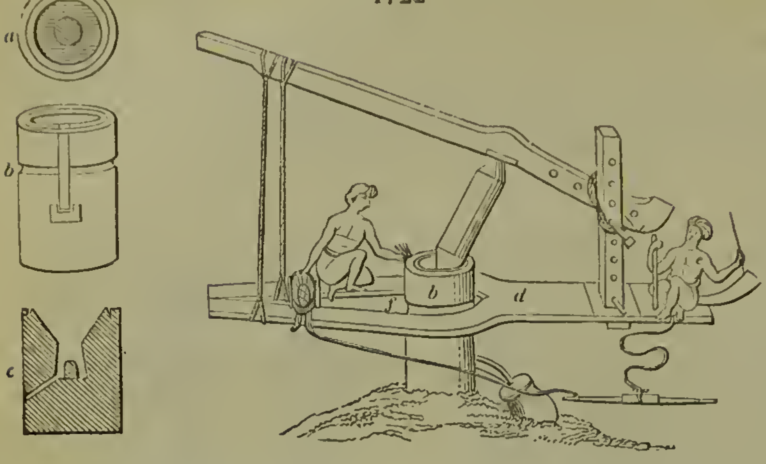


The mill used in Burdwan and near Calcutta is simply two small wooden cylinders, grooved, placed horizontally, close to each other, and turned by two men, one at each end. This simple engine is said completely, but slowly, to express the juice. It is very cheap, the prime cost not being two rupees; and 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-rollers, horizontal and upright, of relatively modern invention in the New World.

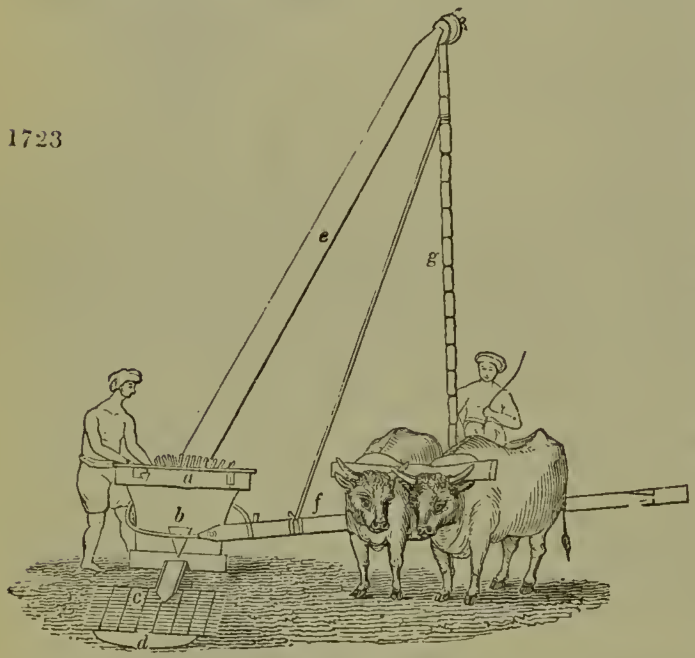
The sugar-mill of Chinapatam, *fig.* 1722, consists of a mortar, lever, pestle, and regulator. The mortar is a tree about 10 feet in length, and 14 inches in diameter: *a* is a plan of its upper end; *b* is an outside view; and *c* is a vertical section. It is sunk perpendicularly into the earth, leaving one end 2 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 16 feet in length, and 6 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 away that have been squeezed.

1722



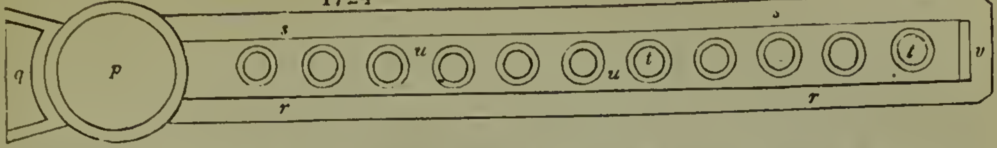
The following describes the primitive rude mill and boiler used in preparing the extract of sugar cane, and which are usually let to the ryots by the day. The mill in Dinajpur, *fig.* 1723, is on the principle of a pestle and mortar. The pestle, however, does not beat the canes, but is rubbed against 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 projecting *a*, may be about 2 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 10 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.

1723



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.* 1724. At one side of this is an

1724



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 twenty-four hours by such a mill, with sixteen men and twenty 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 hogsheads, 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 10 cwt.; the other about 8½. The latter is the segment of a sphere, 9 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 10 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 24 cubits long, and 10 broad; has mud walls 6 cubits high; and is raised about 1 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 20 cubits long by 10 wide; another, about 30 cubits long by 8 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 it 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 quandrangular 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 pots are 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; this 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.

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; a process perfectly analogous to that contemplated in several English pateuts.

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.

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 cauldrons, called clarifiers. On estates which make on an average, during crop time, from 15 to 20 hogsheads of sugar a week, three clarifiers, of 400 gallons' capacity each, are sufficient. With pans of this dimension, the liquor may be drawn off at once by a stopcock or siphon, without disturbing the feculencies after they subside. 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 crystallisation, 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 crystallisers or granulators. These are commonly six in number; each being about 1 foot deep, 7 feet long, and 5 or 6 feet wide. When filled, such a mass is collected as to favour slow cooling, and consequent large-grained crystallisation. 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 due concentration of the syrup in the teache is known by the boiler, by the 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 proportional 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*.

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 aid, 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, tarras, 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 hogsheads, 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 crystallisers into these hogsheads, 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 molasses.

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!

Some years ago a very considerable quantity of sugar was 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. Among more than a hundred samples analysed for the custom-house, Dr. Ure did not perceive 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 to Europe in the state of a rich cane-syrup, or still better of concrete. If the process is carefully performed, the syrup may be transferred at once into the blowing-up cistern, and subjected to the process of refining. Were this means generally adopted, probably 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 hogsheads 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 boiled into a syrup within a week or ten days, it retains no sulphurous odour. A very slight treatment would suffice for the most fermentable cane juice; and it could be easily adopted by the use of suitable apparatus, or still better by the use of bi-sulphite of lime, which is specially prepared for this purpose by Alexander M'Dougall, of Manchester. Thus the acidity 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 skippings. Here it is stirred to ensure uniformity of product, and is then transferred by ladles into conical moulds, made of coarse pottery or of sheet iron, having a small orifice at the apex, which is stopped with a plug of wood wrapped in a leaf of maize. These conical pots stand with the base upwards. As their capacity, when largest, is considerably 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. The clayed sugar of Cuba, which is sun-dried, 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.

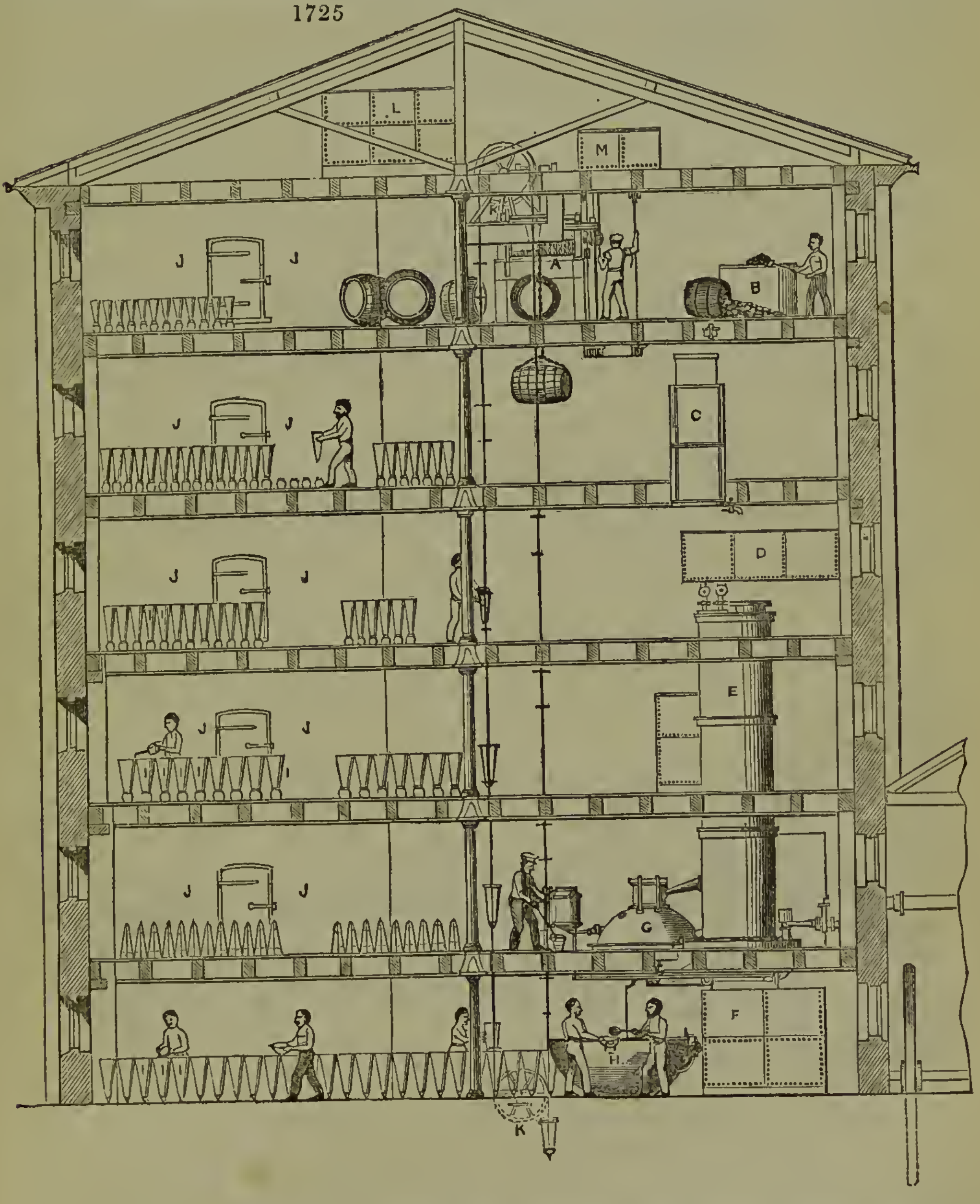
Claying is seldom had recourse to in the British plantations, on account of the increase of labour, and diminution of weight in the produce, for which the improvement in quality yields no adequate compensation. Such, however, was the esteem in which the French consumers held clayed sugar, that it was prepared in 400 plantations of St. Domingo alone.

Sugar Refining. — The raw or Muscovado sugar, as usually imported, is not in a state of sufficient purity for use. The sugar is blended with more or less of fruit and grape sugars, with sand and clay, with albuminous and colouring matter, chiefly caramel. To separate the pure sugar, the plan formerly adopted was to add blood, eggs, and lime-water to a solution of the raw sugar, and after applying heat, to remove the thick scum of coagulated albumen, which also removed a considerable portion of colouring matter. The clear liquid was concentrated, and the semi-crystalline mass being placed in conical moulds, as much of the molasses as would drain by gravitation was allowed to escape from the points of the moulds, and the remainder was expelled by allowing water or a solution of pure sugar to trickle through the mass of crystals. The loaves, being trimmed into shape and dried, were fit for sale.

By this process only a small proportion of the sugar was made into loaf. The method of removing the colouring matter was crude, imperfect, and expensive, and the high temperature requisite for the fermentation of the syrup not only injured its colour, but converted a large proportion of the sugar into the uncrystallisable variety.

These defects were remedied, to a great extent, by the adoption of Howard's vacuum pan, for the concentration of syrups under diminished atmospheric pressure,

1725



and consequently at a low temperature, together with the use of filtering beds of animal charcoal for the removal of colouring matter.

There are three classes of sugar-refineries in this country, the chief productions of which are respectively:—

1st. Loaf sugar.

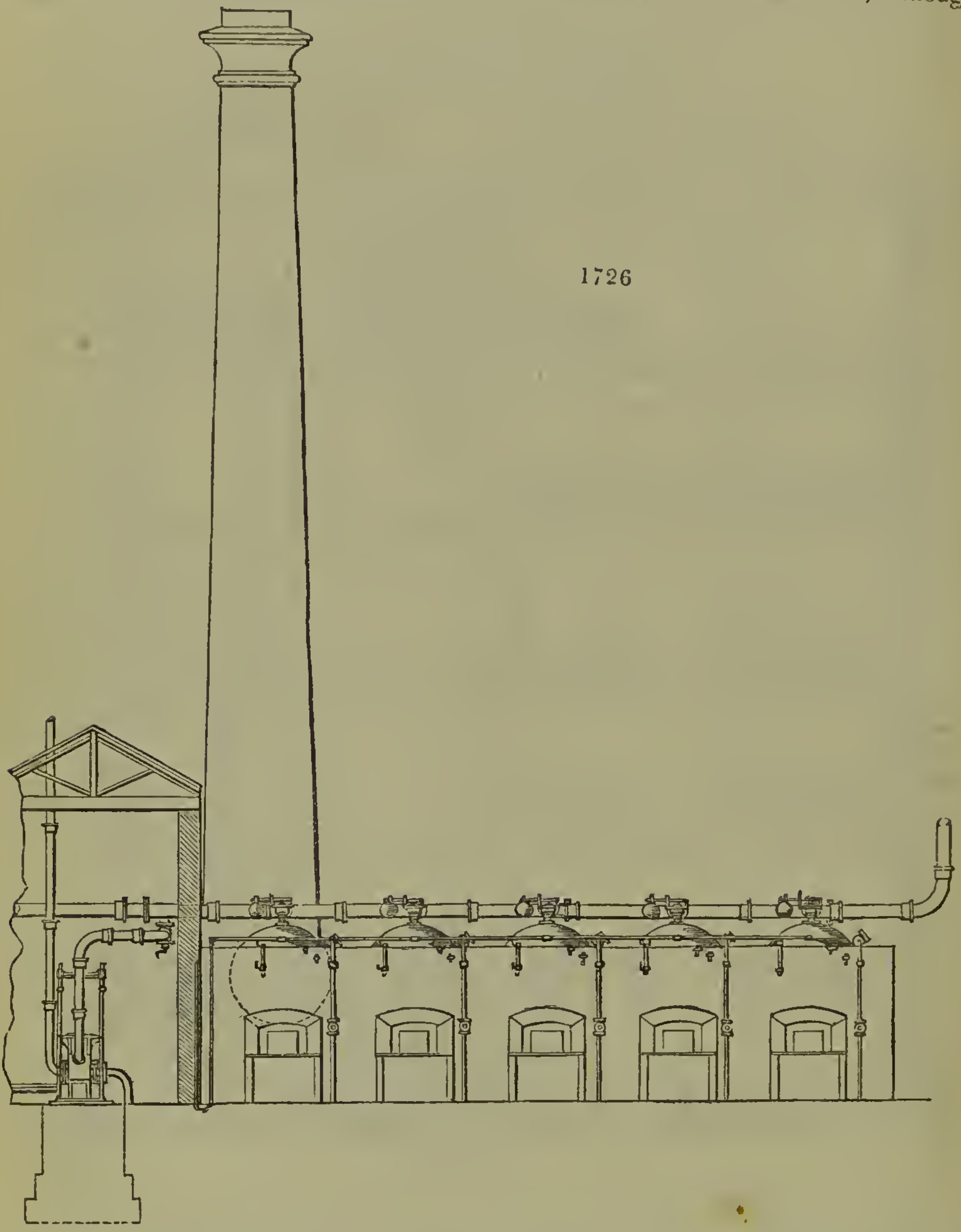
2nd. Crystals (*i. e.* large, well-formed, dry white crystals of sugar).

3rd. Crushed sugar.

In the former two, good West India, Havannah, Mauritius, or Java sugar are almost exclusively used. In the last, all classes of sugar are indiscriminately employed. The manufacture of loaf sugar is chiefly carried on in London; of crystals, in Bristol and Manchester; of crushed sugar, in Liverpool, Greenock, and Glasgow. Besides these places, which are the chief seats of the sugar-refining trades, this branch of industry is carried on more or less at Plymouth, Southampton, Goole, Sheffield, Newton (Lancashire), and Leith. The methods vary a little in different refineries, but the following description refers to the most modern and best conducted which are to be found in this country. The general arrangements of a sugar house are shown in *figs.* 1725 and 1726.

Loaf Sugar. — *Solution.* The raw sugar is emptied from the hogsheads, boxes, or mats, as the case may be, and discharged through a grating in the floor into a copper pan, about 8 feet in diameter. This dissolving pan is sometimes, although

1726



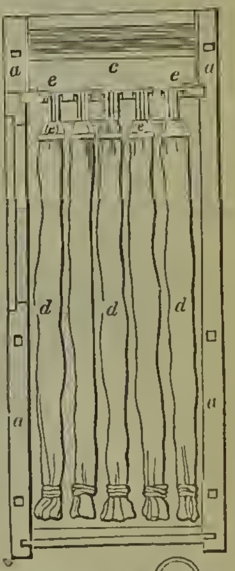
incorrectly, called a defecator, it was formerly called a blow-up, from the practice of blowing steam into it, but the practice and the name are now antiquated. Hot water is added, and the solution is facilitated by the action of an agitator, or stirrer, kept in motion by the steam-engine. The proportions of sugar and water are regulated so that the liquid attains a specific gravity of about 1·250 or 29° Baumé, as a higher density than this would interfere with subsequent processes. A copper coil or casing to the pan, heated by steam, furnishes the means of raising the liquid to a temperature of 165°. The plan of boiling the "liquor" is becoming gradually disused. If the solution is acid, sufficient lime-water is added to make it neutral. The use of blood, which was formerly added at this stage, is in most cases dispensed with;

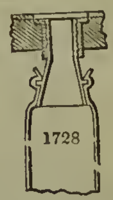
the advantage arising from its use is readily obtained from the employment of an increased amount of animal charcoal in a subsequent process, while the mischief arising from the introduction of nitrogenous matter so prone to decompose is avoided. Some machinery is used for crushing the hard lumps to facilitate solution.

Removal of insoluble matter. The liquor having been brought to the requisite density and temperature, and also being perfectly neutral, is passed through the bag filter.

The apparatus consists of an upright square iron or copper case, *a*, *a*, *fig.* 1727, about 6 or 8 feet high, furnished with doors; beneath is a cistern with a pipe for receiving and carrying off the filtered liquor; and above the case is another cistern *c*. Into the upper cistern the syrup is introduced, and passes thence into the mouths *e*, *e*, of the several filters, *d*, *d*. These consist each of a bag of thick twilled cotton cloth, about 2 feet in diameter, and 6 or 8 feet long, which is inserted into a narrow "sheath," or 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 *e*, which screws tight into a corresponding opening in the bottom of the upper cistern. From 40 to 400 bags are mounted in each filter case. The liquor which first passes is generally turbid, and must be pumped back into the upper cistern, for refiltration. The interior of the case is furnished with a pipe for injecting steam, which is occasionally used for warming the case. *Fig.* 1728, shows one mode of forming the funnel-shaped nozzles of the bags, in which they are fixed by a bayonet catch. *Fig.* 1729 shows the same made fast by means of a screwed cap, which is more secure.

1727





1728

1729

When the bags are fouled from the accumulation of clay and a slimy substance on their inner surfaces, the filter is unpacked, the bags withdrawn from the sheaths, and well washed in hot water. This washing is usually performed with a dash-wheel, or some one of the numerous kinds of washing machines now in use. Perhaps that of Manlove and Alliott, of Nottingham, is in greatest favour. The dirty water, with the addition of a little lime, is smartly boiled, and after some hours being allowed for subsidence, the supernatant, clear, weak solution of sugar is removed and used in the first process (solution), while the muddy residue is placed in canvas bags and subjected to pressure. The residue, technically called scum, is thrown away.

Removal of colour.—The liquor issuing from the bag-filters generally resembles in colour dark sherry wine. To render this colourless it is passed through deep filtering-beds of granulated burnt bones or animal charcoal. When this substance was first introduced, beds of a few inches in depth were considered sufficient, but the quantity of charcoal used per ton of sugar has steadily increased, and filters of no less a depth than 50 feet are now sometimes used.

Cylinders of wrought or cast iron, varying in diameter from 5 to 10 feet, and in height from 10 to 50, having a perforated false bottom, a couple of inches above the true one, are filled with granulated animal charcoal.

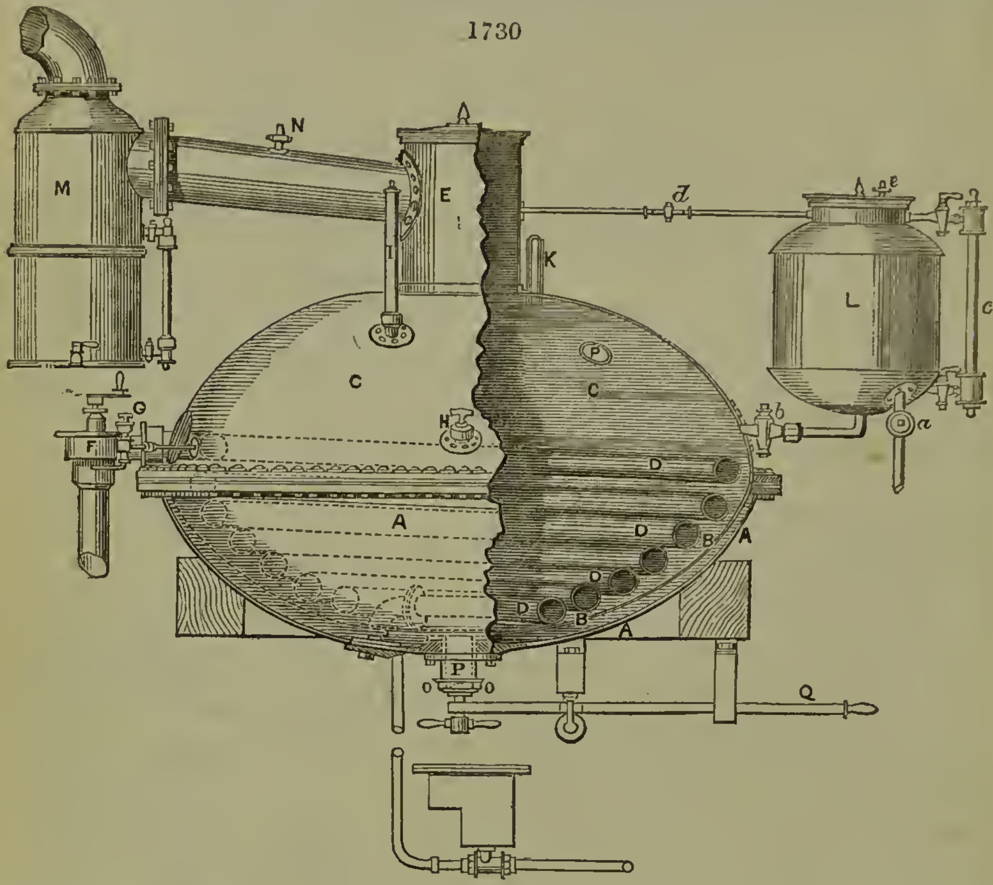
The grain varies from the size of turnip seed to that of peas, some refiners preferring it fine, and others coarse.

Liquor from the bag-filters is run on to the charcoal till the cylinder is perfectly filled, when the exit tap at the bottom is opened, and a stream of dense saccharine fluid, perfectly colourless, issues forth. The amount of sugar which the charcoal will discolour depends upon the age and composition of the charcoal, the degree of perfection with which the previous revivification has been performed, and the quality, colour, and density of the liquor to be operated upon. One ton of charcoal is sometimes used to purify two tons of sugar; and in at least one refinery, where inferior sugar is operated on, two tons of charcoal serve for one ton of sugar. In most provincial refineries about one ton of charcoal is used to one of sugar; but in London, from the dearness of fuel and other causes, a smaller proportion of charcoal is employed. The liquor from the charcoal filter, at first colourless, becomes slightly tinged, and in course of time, varying from 24 hours to 72, the power of the charcoal becomes exhausted, the partially decoloured syrup is passed through a fresh charcoal filter, and the sugar is washed out from the charcoal by means of hot water. The charcoal is ready to be removed for revivification, which process is treated of on page 827.

Concentration.—The next process in sugar-refining is the evaporation of the clarified syrup to the granulating or crystallising point. The more rapidly this is effected, and the less the heat to which it is subjected, 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.

The vacuum-pan, invented by Howard, and patented in the year 1812, is an enclosed copper vessel, heated by steam, passing through one or more copper coils, and a steam jacket. The vapour arising from the boiling solution of sugar is condensed by an injection of cold water, the arrangement of which, and the maintenance

1730

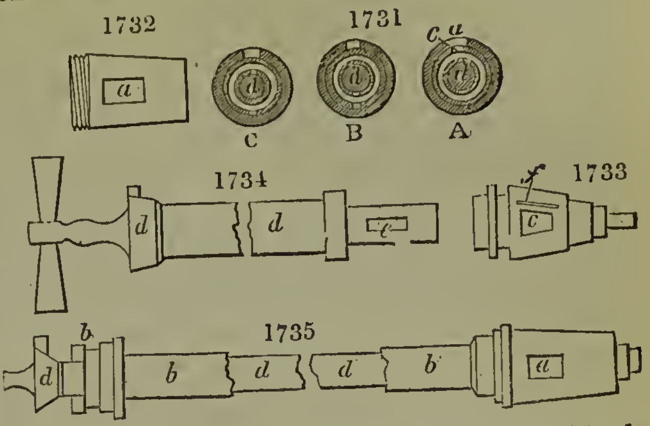


of a vacuum, closely resemble the condenser, injection, and air-pump of an ordinary condensing steam engine.

Fig. 1730, shows the structure of a single vacuum-pan. The horizontal diameter of the copper spheroid C C, is from 7 to 10 feet; the depth of the under hemisphere A, is at least 2 feet from the level of the flange; and the height of the dome-cover is from 3 to 5 feet. The two hemispheres (of which the inferior one is double, or has a steam-jacket), are put together by bolts and screws, to preserve the joints tight against atmospheric pressure.

The steam enters through the valve F, traversing the copper coil D, and filling the steam-jacket, the condensed water issuing from a small pipe below. C represents the dome of the vacuum-pan, the vapour from which passing in the direction of N, allows any particles of sugar carried over by the violence of the ebullition to be deposited in the receiver, M.

The vapour is condensed by jets of cold water issuing from a perforated pipe, and the water, uncondensed vapour, and air, are removed by the action of a powerful air-pump. L is the measure cistern, from which the successive charges are admitted into the pan; I and K represent respectively a thermometer and a barometer. the former being required to indicate the temperature of the boiling syrup, and the latter the diminished atmospheric pressure within the pan. P is the discharge cock, and H, the proof stick, 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. It is shown in detail by figure 1735, which represents 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.* 1732, 1735), or notch, about ½ in. wide. In this external tube, there is another shorter tube *b*, capable of moving round it, through an arca 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.* 1731, A. A 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 holc *e*, which can be placed in communication with the lateral openings in both tubes. Hence it is possiblc, when the plug and the inner tube are brought into the proper position, A, *fig.* 1731, to fill the cavity of the 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, thc plug must be placed in reference to the inner tube, as shown in *fig.* 1731, C, and then 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.

The method of using the vacuum-pan varies with the character of the grain required to be produced. On commencing boiling, the syrup should be run in as quickly as possible, till the whole heating surface is covered, when the steam is turned on, and the evaporation conducted at a temperatnre of from 170° to 180° Fahr. As soon as the syrup begins to granulate, the temperature becomes reduced to 160°; and finally, just before the evaporation is completed, and the sugar ready to be discharged into the heater, it is further reduced, and approaches 145°, being the lowest temperature at which proof sugar boils, 3 inches from a perfect vacuum. When the sugar-boiler ascertains, by withdrawing a sample of the syrup by means of the proof-stick, and examining it against the light between his finger and thumb, that the crystals are in a sufficiently forward state for his purpose, he adds another measure full to that already in the pan, and the same process is repeated till the whole charge has been admitted. After each successive charge the crystals continue increasing in size to the end of the operation, those first formed acting as nuclei, a skip, as it is technically called, or a panful of the concentrated sugar, may be made in from two to four hours from the commencement of the boiling. If a fine grain sugar be required, greater quantities of syrup are admitted at each charge of the measure, and *vice versâ*.

Making of loaf sugar.—The proof sugar at a temperature not exceeding 145° is then let down through a cock or valve in the bottom of the pan into the heater. The sugar liquor consists at this stage of the process of a large number of small crystals floating in a medium of syrup.

The heater is an open copper pan of about the same capacity as the vacuum-pan, and is furnished with a steam-jacket and provided with an agitator,—in fact, it closely resembles the dissolving pan used for the first process. The object to be attained in the heater is to raise thc sugar to a temperature of 180°, which has been found by practice to be the point best adapted for hardening and completing the formation of the crystals, during which process the sugar is constantly stirred.

The sugar is then run out through a cock in the bottom of the heater into a ladle, from whence it is poured into moulds or cones 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 thc concentration of the inferior syrups. Thcse moulds have thc orifices at their tips closed with nails inserted through pieces of cloth or indiarubber, and are set up in rows close to each other, in an apartment adjoining the heaters. 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 100° by means of steam pipes, and placed over gutters to receive the syrup drainings — the plugs being first removed, and a steel wire, called a piercer, being thrust up to clear away any concretion from the tip. The syrup which flows off spontaneously is called green syrup. It is kept separate. In the course of one or two days, when the drainage is nearly complete, some finely clarified syrup, made from a filtered solution of fine raw sugar 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 matter and molasses; whereby, at each successive liquoring, the loaf becomes whiter, from the base to the apex.

To economise the quantity of "fine liquor" used, it is usual to give a first and even a second liquor of an inferior quality before applying the finishing liquor, which is a dense and almost saturated solution of fine sugar absolutely free from colour. 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 are baked thoroughly dry. They are then taken out of the stove, and put up in paper for sale.

In the above description of sugar-refining, nothing is said of the process of claying loaves, because it is now nearly abandoned in all well-appointed sugar-houses.

The drainage of the last portion of the liquor from the moulds is sometimes accelerated by means of a vacuum. Centrifugal action has been also proposed for this purpose, but has not been found to succeed.

The drainings from the moulds which are collected in gutters and run into cisterns are boiled, and form an inferior quality of sugar. The drainings from this last sugar consist of treacle or syrup, which is always obtained as a final product.

Manufacture of crystals. — The use of centrifugal action for the separation of liquids and solids has been adopted in the arts for many years; its application for the separation of syrup and sugar occurred to several individuals, but it was best effected by means of the admirable hydro-extractor, invented and patented by Manlove and Alliott of Nottingham. Various modifications of this machine have been proposed and patented, but it is very doubtful whether anything that has been devised has improved upon the original machine. It would be tedious and unnecessary to detail the list of so-called improvements.

Considerable value, however, has been supposed to attach to the use of a blast of steam to free the meshes of the revolving cylinder from the semi-crystalline syrup. This plan was the subject of a patent granted to the late C. W. Finzel, but the opinion of those who consider that the injurious action of a blast of open steam upon the syrup far outweighs the advantage arising from a machine so easily cleansed, is gaining ground daily.

In the manufacture of "crystals," sometimes called centrifugal sugar, all the earlier processes previous to boiling are conducted as already described.

Concentration. — It is found more convenient to make use of vacuum-pans of large dimensions, and provided with extra heating surface by the introduction of several additional coils. The object sought to be obtained is the formation of large crystals, which is effected as follows: the pan is partially filled with liquor; this is concentrated until minute crystals appear; a further portion of liquor is added — the concentration continued — more liquor and further concentration again and again — until the pan is filled; the object being to keep the *mother-liquor* sufficiently fluid to prevent the formation of a second crop of crystals and yet sufficiently dense to feed the crystals already formed. One half the contents of the pan is discharged into the heater, while the remaining half is retained as a nucleus and the pan charged as before. This process is sometimes repeated several times.

Separation of crystals. — The semi-fluid mass is removed to the centrifugal machines with the least possible delay, and each machine barely attains its maximum speed before the syrup is discharged. To cleanse the surface of the crystals they are washed with liquor, sprinkled in the machine by means of a watering-can, a few pints of liquor being used to each cwt.

By this process the percentage of sugar obtained from the first and each separate crystallisation is considerably less than that obtained in the making of loaf-sugar or the ordinary method of making "crushed," though the *total* product does not vary materially, being rather more than that of the former where the product is stove dried and less than the latter, which is sold damp. The drainage is diluted, filtered through animal charcoal, boiled, and passed through the centrifugal machines, and results in a second quality of sugar, the crystals being smaller. The drainage from this is treated in a similar manner, and a third quality of crystals is the result. A fourth quality of crystals is also sometimes obtained, the drainage from which is again boiled and laid aside in large moulds to crystallise for about a week, when treacle and a low quality of "pieces" is the final result. The drainages are sometimes filtered along with inferior qualities of raw sugar.

The difficulty with which these large and beautiful crystals obtained by this process dissolve is an obstacle to their extensive consumption.

Crushed sugar. — This process closely resembles the manufacture of loaf sugar, but the raw sugar used is generally of an inferior quality. The filtration through the animal charcoal is in consequence not so perfect; the concentration resembles that of loaf sugar, but the use of a heater is dispensed with, and the process of liquoring is also dispensed with where practicable. The first crystallisation is called "crushed," and the second "pieces," the drainage from which goes by the name of "syrup." When this syrup is diluted, filtered through animal charcoal, and concentrated, it is called "golden syrup."

Treatment of molasses.—Foreign and colonial molasses, containing a large proportion of crystallisable sugar, are purchased by refiners. The Muscovado molasses from Cuba, from Porto Rico, Antigua, and Barbadoes, are esteemed the best, but the quality of molasses deteriorates as improvements in the manufacture of sugar are introduced on the plantations. The treatment of molasses formerly was simple; it was merely concentrated and allowed to stand for several weeks in large moulds to drain. The liquid was sold as treacle, and the impure soft, dark sugar, called bastards, found a market amongst the poorer classes, especially in Ireland.

The more recent and better plan, is to dilute the molasses, filter it through animal charcoal, and concentrate to the crystallising point, but without forming crystals. This readily crystallises in the moulds, and in place of the bastards and treacle a bright yellow sugar and a fair quality of syrup are the result. Good molasses yields 40 per cent. sugar, 40 per cent. syrup, the remaining 20 per cent. being water, dirt, and loss.

Palm or Date Sugar.—Many trees of the palm tribe yield a copious supply of sweet juice, which, when boiled down, gives a dark brown deliquescent raw sugar, called in India jaggery. The wild date palm and the gommuto palm yield the largest proportion of this kind of sugar, which is chemically identical with the sugar from the cane, though the crudeness of the manufacture is very injurious to it, and causes a large proportion to assume the uncrystallisable condition. One twenty-fourth of all the cane sugar extracted for useful purposes is obtained from the palm tree.

Beet root Sugar.—The extraction of sugar from beet root, which has become an important manufacture in several countries on the continent, especially in France and Germany, was developed in consequence of the difficulty of obtaining colonial sugar in France during the blockade in the time of Napoleon I. The high price of sugar (5*s.* per lb.) was not the only stimulus to invention, as a prize of a million of francs was offered by the government for the most successful method of manufacturing indigenous sugar. The beet is a biennial plant, native to the south of Europe. There are several varieties of this root, each fitted to its own climate and soil; but the white Silesian beet is most prized where it can be grown, on account of the large amount of sugar in the juice, and the comparative absence of salts; it is less prone to decay when stored previous to use. The average composition of the root of the sugar beet may be stated as follows:—

Sugar - - - - -	$10\frac{1}{2}$ per cent.
Gluten - - - - -	3
Woody fibre, &c. - - -	5
Water - - - - -	$81\frac{1}{2}$
	100

The proportion of sugar varies very much. First, it is greater in some varieties than others; second, it is greater in small beets than in large; third, in dry climates, especially when the climate is dry after the roots have begun to swell; fourth, in light than heavy soils; fifth, in the part above than under ground; sixth, when manure has not been directly applied to the crop. The average proportion of sugar extracted from beet is 6 per cent., though it is stated that $7\frac{1}{2}$ per cent. is obtained in some well conducted manufactories. In France and Belgium the average yield is 14 or 15 tons of beet to the acre, while about Magdeburg they do not exceed 10 to 12 tons, but the latter are richer in sugar.

During the first year of its life the root is developed to its full size, and secretes the whole amount of sugar which, in the natural life of the plant, furnishes the material for the growth and maturity of its upper part. It follows that when the plant is cultivated for its sugar, it is ripe for the sugar manufacturers when its first year's stage of development is complete. The time required for this depends upon that of the sowing, and upon the season. Its criterion is the commencement of death in the leaves. When ripe the beet roots are dug out, the mould gently shaken off, and the heads cut off, together with as much of the root as shows the presence of leaf buds. As the action of light is detrimental even to the exhumed roots, the latter must be covered quickly. If the quantity be small they may be covered with the leaves which have been cut off. It is more usual, however, to pile them in heaps on the ground, to hinder the evaporation of their water, and to protect them from light and frost by covering the heaps with a thin layer of earth. These mounds are sometimes sprinkled with water, which is taken up by the roots, restoring to them the plumpness and crispness which they have lost in a dry season.

Boussingault gave the following analyses of French beets:—

Where grown.	Time of taking from ground, &c.	Per cent. of dry matter.	Water.	Sugar.	Ligneous fibre and albumen.	Pectine?
Botanic school -	Aug. 2.—Roots small - - -	9 5	90·5	5·0	4·5	added to the lig. matter.
	Sept. 1.—A root of 1100 grammes = about $1\frac{1}{2}$ lb. -	7·4	92·6	4·2	2·5	1·0
	Sept. 1.—Root, 460 grammes = about 1 lb. $2\frac{1}{2}$ oz. - -	9·4	90·6	5·0	2·8	1·6
	Sept. 7.—Root, 700 to 800 grammes - - - - - - -	10·0	90·0	7·3	1·9	0·8
	Young root of 0·3 grammes = 4·6 grains - - - - - -	13·7	86·3	5·9	4·4	3·4
Garden of M. Brogniart -	Sept. 26.—Root from 80 to 100 grammes = $3\frac{1}{2}$ oz. - - -	16·1	84·9	10·0	3·3	1·8
	Oct. 9.—Root, 150 grammes = about 5 oz. - - - - - -	14 1	85·9	—	—	—
Vigneux - - -	Sept. 23.—Root, 500 grammes = 1 1-10 lb. - - - - - -	16·9	83·1	11·9	3·2	1·8
	Sept. 23.—Root, 700 grammes — $1\frac{1}{2}$ lb. - - - - - - - -	13·0	87·0	8·6	2·7	1·7
Grenelle - - -	Aug. 7.—Root, 300 grammes = 6-10ths lb. - - - - - -	15·5	84·5	8·9	6·6	to preceding
	Aug. 11.—Root, 600 grammes = $1\frac{1}{3}$ lb. - - - - - - - -	12·6	87·4	8·2	2·8	1·6
	Aug. 30. — Root, 1 kilogramme=2 1-5th lbs. - -	13·1	86·9	8·6	3·1	1·4
	Beet in flower, 200 grammes = about 4-10ths lb. - - -	16·5	83·5	9·8	3·3	3·4
	Beet of two years in seed -	5·5	94·5	0·0	2·5	1·1*
Roville, Meurthe	White beet of Silesia - - -	15·8	84·2	10·6	3·1	2·1
Analysed by M. Braconnet.	Leaves of the beet - - - -	6·4	93·6	1·3	3·6	—†

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.

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. The roots are washed by a rotary movement upon a grating made like an Archimedes' screw, formed round the axis of a squirrel-cage cylinder, which is laid horizontally beneath the surface of water in an oblong trough. It is turned rapidly by means of a toothed wheel and pinion. The roots, after being sufficiently agitated in the water, are tossed out by the rotation at the opposite end of the cylinder.

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 can be obtained from the beet; whilst the pulp procured by the action of a grater produces from 75 to 80 per cent.

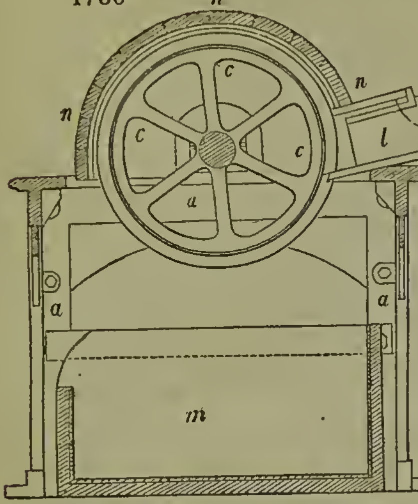
The beet-root rasp is represented in *figs.* 1736, 1737. *a*, *a* is the framework of the machine; *b* the feed-plate, made of cast iron, divided by a ridge into two parts; *c*, the hollow drum; *d*, its shaft, upon either side of whose periphery nuts are screwed

* Add 0·9 of nitre.

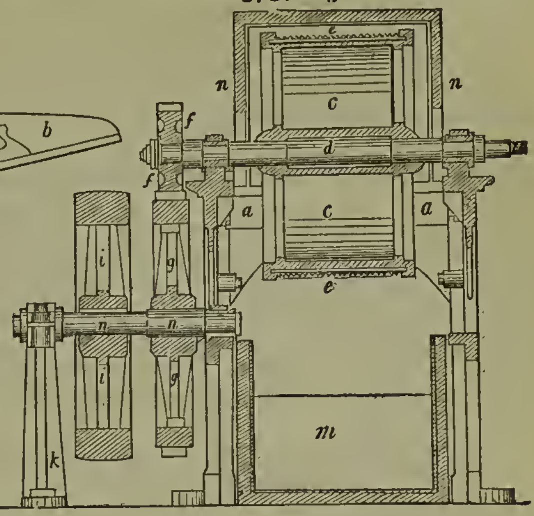
† Add 1·5 nitre; the albumen added to the sugar.

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*

1736



1737



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° Fahr. 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 $5\frac{1}{2}$°, it was ready for the process of defecation. Juice produced in this way is transparent, and requires little lime for its purification; but it is apt to ferment, or to have its granulating power impaired by the watery dilution. A further obstacle to this process is presented by the cost of fuel required for concentrating so weak a solution, and the process has accordingly been abandoned.

By the process of M. Schutzenbach, the manufacture may be carried on during the whole year, instead of during a few winter months. At Waghäusel, near Carlsruhe, this system is adopted. The beets having been washed, are rapidly cut up into small pieces, and subjected to the drying heat of a coke fire for six hours. They lose from 80 to 84 per cent. of their weight; the dried root may be kept without injury for many months, and the sugar is extracted by infusion. At this colossal establishment, which in 1855 employed 3,000 people, and the buildings of which covered 12 acres of land, there were 20 infusing vessels 12 to 14 feet deep, and 7 wide. A cwt. of raw roots cost 7*d*., and the dried root contained 46 to 47 per cent. of sugar; the capital employed was eighty millions of francs.

Whether the juice is extracted from fresh or dried beets the subsequent processes are the same. The juice, having been extracted either by infusion or by submitting the rasped pulp to hydraulic pressure, is placed in a shallow vessel, and mixed with as much milk of lime as renders it strongly alkaline, it is then boiled, generally by means of a copper coil heated by high pressure steam. The excess of lime is removed by passing a stream of carbonic acid gas through the liquid. The gas is generally produced by forcing a stream of air through an enclosed coke fire. The liquid is next filtered through cloth concentrated to a specific gravity of 25° B., filtered through animal charcoal, and treated in all respects similarly to ordinary cane sugar in a refinery. Though the vacuum-pan is employed in most beet-root establishments, there are some manufacturers who continue to evaporate in open vessels.

The large amount of water which has to be removed in the concentration of beet-root syrups involves the use of so much fuel that to economise it an ingenious apparatus has been constructed by M. Cail of Paris. The principle adopted is to use the steam generated from the ebullition of liquid in one vessel for boiling another, the steam from which in like manner boils a third.

Maple Sugar.—The manufacture of sugar from the juice of a species of maple trees, which grow 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 interspersed among other trees. They are supposed to arrive at perfection in 40 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 boiling 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 2 to 3 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 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 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 has 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 crystallised.

In spring, when plentiful, maple sugar sells as low as 3*d* per lb.; in winter it sometimes rises as high as 6*d*.

The total production of maple sugar has been estimated at 45 millions of pounds, or the one hundred and twenty-fifth part of the whole quantity of cane sugar extracted for the use of man. The manufacture of maple sugar diminishes yearly in proportion as the native American forests are cut down.

Potato Sugar.—The manufacture of sugar from starch derived from potatoes, from woody matter, and from rags, can be effected by treating them with sulphuric acid and heat; but the process, interesting though it is, is rarely if ever adopted at present, as the sugar is inferior in quality to that obtained from the cane, and dearer in price.

The process for making sugar from potato starch 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 neutralised 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 pulverised, though it is so deliquescent as to be unfit for sale as sugar.

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.

Good muscovado sugar from Jamaica fuses only when heated to 280°, it turns immediately dark brown, 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 specific gravity of 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.

Animal charcoal. One of the most important considerations for a sugar refiner is to furnish himself amply with bone charcoal of the best quality, and to devote unsparing attention to the process of revivification. The theory of the action of bone charcoal upon solutions of raw sugar and other coloured liquids need not be discussed here. It may, however, be observed, that but little is known upon the subject, and that the behaviour of bone charcoal with respect to metallic oxides and various salts is as remarkable as its action upon colouring matter.

After the *raw liquor* has been passed continuously through a filter of bone charcoal, the decolouring power of the charcoal becomes impaired, and finally lost. This power may be more or less restored by the following means:—

First. Washing with water.
Second. Fermentation.
Third. Washing with weak hydrochloric acid.
Fourth. Long exposure to air and moisture.
Fifth. Heating to redness.

The last plan being the only one which does not materially injure the charcoal, and most completely restores its power, is the course almost invariably adopted; it is however preceded by washing with water.

Various forms of apparatus for reburning charcoal have been proposed and adopted, but the four following methods are the chief at present used.

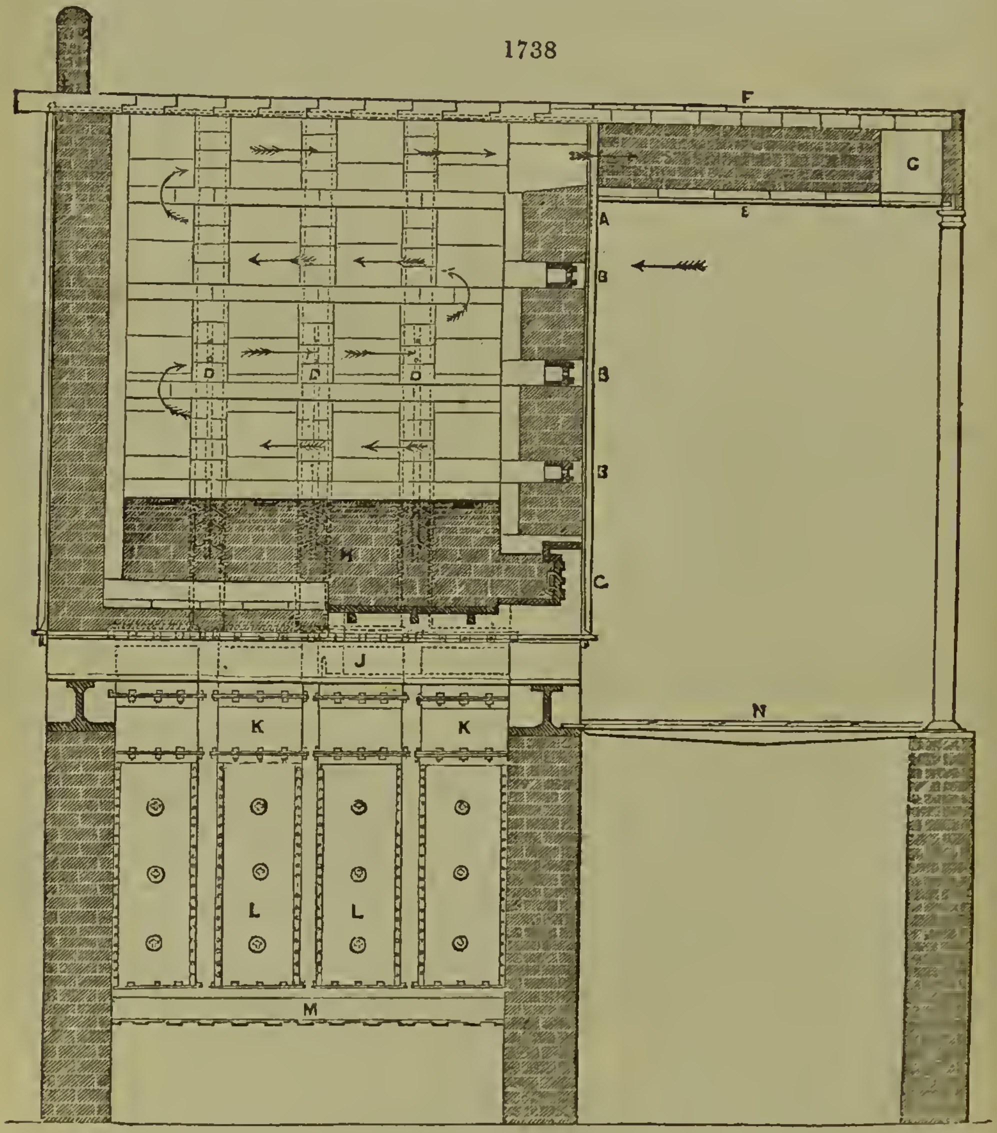
First. Burning in iron pipes.

A furnace about six feet in length, and eighteen inches wide is placed between two rectangular chambers with which it communicates; each chamber contains thirty-two cast-iron pipes of four inches diameter and nine feet in length, whose extremities pass through the top and bottom of each chamber; to the lower end of each pipe, a sheet iron cooler is suspended. When the charcoal kiln is in use, the pipes filled with charcoal are maintained at a dull red heat, and the charcoal is withdrawn from the coolers in measured quantities at such intervals of time as to allow it to be four hours under the action of the heat. The *advantages* of this plan are, cheapness of first cost and simplicity; its disadvantages are first, that the charcoal is unequally burnt, the pipes near the furnace being more heated than those further removed from it; second, the kilns require frequent repairs, some of the pipes being destroyed by the fire; third, the amount of fuel required is large; fourth, the pipes are apt to become choked.

Second. Burning in fire-clay chambers.

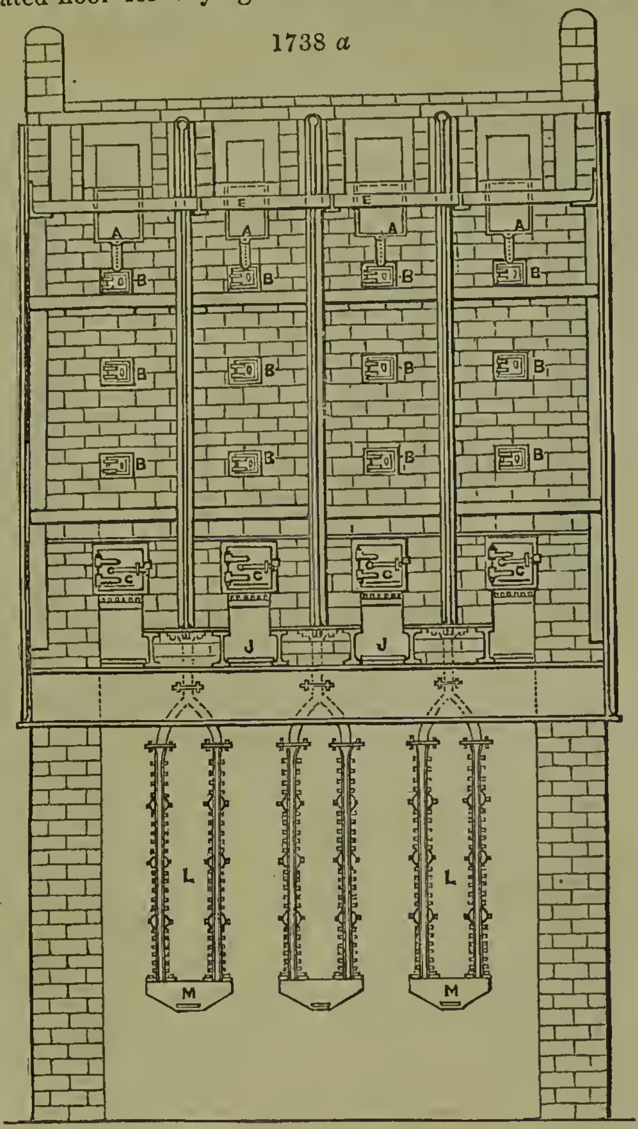
This plan, proposed by Mr. Parker, of London, and improved by Mr. G. F. Chantrell, of Liverpool, is becoming generally adopted. The plan consists in arranging narrow chambers, composed of fire-tiles, and containing charcoal, between small fur-

1738



naces. *Fig.* 1738 shows a section of Mr. Chantrell's kiln through one of the fire places; *figs.* 1738 *a*, 1738 *b*, two front views of the same. C, is the fire door; H, the furnace; the products of combustion issue through apertures in the arched roof of the furnace, and are compelled to take a zigzag course to the flue G, by means of horizontal floors of tiles, each floor being open at alternate ends. B, B, are apertures for cleaning the flues or inspecting the state of the kiln; L, L, the coolers; M, the measuring box or receiver; F, a heated floor for drying the charcoal previous to being reburned; N,

1738 *a*



the firing floor. The advantages of this system are, first, the charcoal is very equally burnt; second, the amount of fuel required is small, not reaching ten per cent. of the charcoal reburned ; third, non-liability to get out of order; the chief disadvantage is the amount of first cost.

Third. Reburning in rotating cylinders.

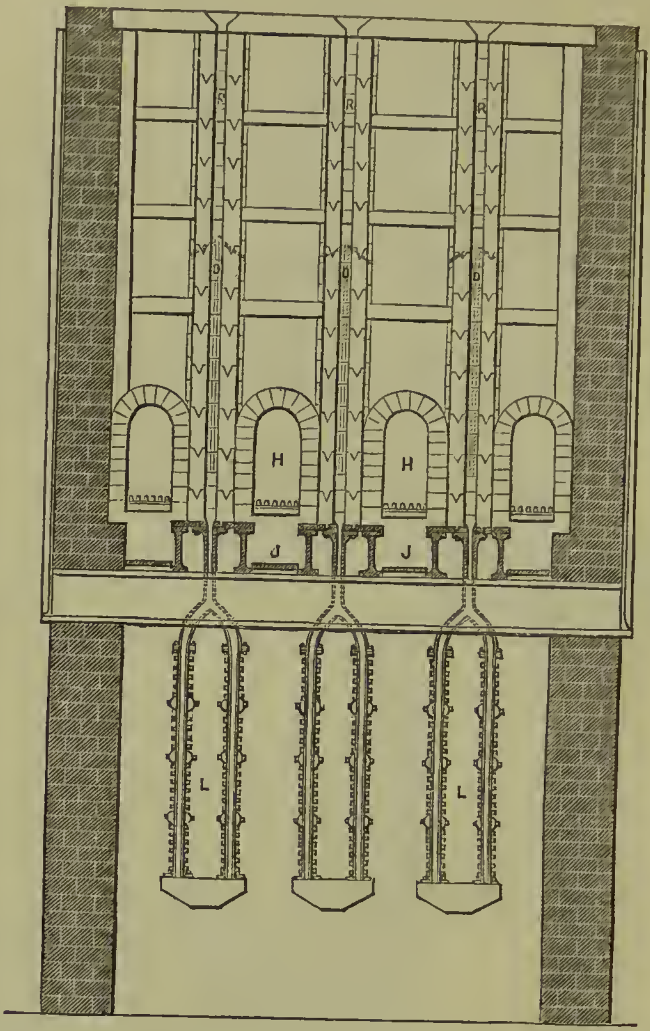
This plan like the former, the subject of a patent, is used at the extensive establishment of Mr. G. Torr, London, the regularity and the excellence of the result being considered by him a sufficient compensation for the costliness of the process.

Fourth. Reburning by means of superheated steam.

This ingenious method, were it not for the expense of the apparatus, and practical difficulties, would supersede the previous methods. The apparatus, is the invention of MM. Laurens and Thomas of Paris. A furnace is constructed, in the flues of which a number of cast-iron tubes connected together and ranged in order, are placed; the products of combustion, after maintaining the pipes at a high temperature, impart heat likewise to the vase-shaped vessel before entering the chimney. A jet of steam being passed through the pipes becomes sufficiently superheated to expel the moisture from the charcoal contained in the receiver, and subsequently to raise it to a temperature of 600° F. This is sufficient to effect destructive distillation of the colouring matter absorbed by the charcoal. The process takes about eight hours; the advantages of this method consist in the steam coming in absolute contact with every single grain of charcoal; the distillates are effectually removed, and there is little or no risk of the charcoal being subjected to too high a temperature; but the plan is expensive and inconvenient; and has not been adopted in England.

To reburn charcoal the best methods are those which most rapidly remove the water, raise the temperature of each grain of charcoal to a uniform temperature of 700° Fahr., and which admit of its being readily cooled without contact with the air.

1738 *b*



The influences of time and temperature, in the reburning process, are very marked; in the best regulated refineries the decolouring power of the charcoal is frequently examined and recorded, and an analysis of the charcoal is made each month.

The following table contains the average results of many analyses made by Dr. Wallace of Glasgow, of several kinds of raw sugar as imported into Greenock and Glasgow, and of the different products of a Greenock sugar house.

	West India.	Beet.	Date.	Lumps.	Pieces.	Bastards.	Green Syrup.	Golden Syrup.	Molasses.	Treacle.
Cane sugar - - - - -	94·4	95·7	95·4	97·3	87·7	68·3	62·7	39·6	48·0	32·5
Fruit sugar - - - - -	2·2	0·3	1·8	0·5	6·0	15·0	8·0	33·0	18·0	37·2
Extractive and colouring matter	0·3	0·4	0·1	- -	0·5	1·2	0·6	2·8	1·5	3·5
Ash - - - - - -	0·2	1·6	0·2	0·2	0·8	1·5	1·0	2·5	1·4	3·4
Insoluble matter - - -	0·1	- -	1·7							
Water - - - - -	2·8	2·0	0·8	2·0	5·0	14·0	27·7	22·7	31·1	23·4
Total - - -	100	100	100	100	100	100	100	100	100	100

The following table shows the consumption per head in the United Kingdom at ten years intervals, and also the amount of revenue annually raised from the tax on sugar.

Years.	Population of United Kgdm.	Consumption of Sugar. Total Tons.	Lbs. per Head.	Prices and Rates of Duty. Gazette Avge. Price. s. d.	Rate of Duty. s. d.	Total per Cwt. s. d.	Duties paid on all Descriptions. £	Per Head. s. d.
1801	16,371,554	159,916	22	59 5	20 0	79 5	3,066,163	3 9
1811	18,548,470	187,092	23	39 8	27 0	66 8	4,652,824	5 0
1821	21,302,392	170,612	18	33 2	27 0	60 2	4,188,997	3 11
1831	24,319,811	203,812	19	23 8	24 0	47 8	4,650,606	3 10
1841	27,021,949	202,899	17	39 8	25 2	64 1	5,114,390	3 9
1851	27,721,921	328,581	26	25 6	{ 13 3 / 12 0 }	{ 38 9 / 37 6 }	3,979,141	2 10
1859	30,000,000	450,000	33	27 0	12 8	39 8	6,000,000	4 0

Imports into the United Kingdom from 1841 *up to the end of* 1859.

	1841.	1842.	1843.	1844.	1845.	1846.
	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.
Sugar raw— Of or from British possessions -	4,057,617	3,868,334	4,028,231	4,129,345	4,779,317	4,617,509
Of or from foreign countries -	261	103	76	98	77,307	602,739
Total of raw sugar - - -	4,057,878	3,868,437	4,028,307	4,129,443	4,856,624	5,220,248
Sugar refined and sugar candy -	22	37	19	6	56	18,408

	1847.	1848.	1849.	1850.	1851.	1852.
	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.
Sugar raw— Of or from British possessions -	4,805,489	4,921,332	5,409,209	5,183,097	4,854,506	6,216,341
Of or from foreign countries -	974,019	1,220,964	496,478	908,395	1,379,041	682,526
Total of raw sugar - - -	5,779,508	6,142,296	5,905,687	6,091,492	6,233,547	6,898,867
Sugar refined and sugar candy -	26,130	46,191	75,137	116,335	338,079	273,991

	1853.	1854.	1855.	1856.	1857.	1858.	1859.
	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.
Sugar raw— Of or from British possessions	5,740,854	5,589,467	4,934,343	5,695,363	5,325,975	5,323,580	5,458,380
Of or from foreign countries	1,531,979	2,439,291	2,319,879	2,065,877	3,064,721	3,775,300	3,552,420
Total of raw sugar -	7,272,833	8,028,758	7,254,222	7,761,240	8,390,696	9,098,880	9,010,800
Sugar refined and sugar candy	214,756	303,649	287,520	187,211	329,122	262,460	386,820

A. F.

SUGAR OF LEAD, properly *Acetate of Lead* (*Acetate de plomb: Sel de Saturne*, Fr.; *Essigsaures Bleioxyd, Bleizucker*, Germ.), is prepared by dissolving pure litharge, with heat, in strong vinegar, made of malt, wood, or wine, till the aeid be saturated. A copper boiler, rendered negatively eleetrical by soldering a strap of lead within it, is the best adapted to this proeess on the great scale. 325 parts of finely ground and sifted oxide of lead require 575 parts of strong acetic aeid, of spec. grav. 7° Baumé, for neutralisation, and afford 960 parts of crystallised 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 siphon, eoncentrated by boiling to the density of 32° B., taking eare that there be always a faint excess of acid, to prevent the possibility of any basic salt being formed, whieh 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 erystallisers. Their edges should be smeared with candle-grease, to prevent the salt creeping over them by *efflorescent vegetation.* The erystals 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 crystallises 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, a specific gravity of 2·345; it effloresces slightly in a dry atmosphere, and when heated above 212° F. it froths up and loses all its water of crystallisation, together with some acetic acid, falling into a powder which passes slowly in the air into carbonate of lead. If heated to 536° F. it is entirely liquid, and at a higher temperature is decomposed, disengaging acetic and carbonic acids, and some acetone; the residue consisting of very finely divided and very combustible metallic lead. The crystals of acetate of lead dissolve in $1\frac{1}{2}$ times their weight of water at 60° F., but in much less of boiling water, and in 8 parts of alcohol. The solution feebly reddens litmus paper, although it imparts a green colour to syrup of violets. The constituents of the salt are, 58·71 oxide of lead, 27·08 acetic acid, and 14·21 water, in 100, or $PbO, C^4H^3O^3 + 3HO$.

Acetate of lead is much used in calico-printing. It is poisonous, and ought to be prepared and handled with attention to this circumstance.

Four subacetates of lead are generally acknowledged to exist, viz.:—

	Oxide of lead.	Acetic acid.
Sesquibasic ditto	$1\frac{1}{2}$	1
Bibasic acetate	2	1
Tribasic ditto	3	1
Hexbasic ditto	6	1

Sesquibasic acetate. $3PbO, 2C^4H^3O^3 + Aq$. This is obtained by heating the neutral acetate in a capsule till the fused mass becomes white and porous; this is then dissolved in water and evaporated, when on cooling pearly lamina separate; they are soluble in water and alcohol, and the solution possesses an alkaline reaction.

Dibasic acetate. This salt, when in solution, is known as *Goulard's extract*, and is formed by boiling together a solution of the neutral acetate and an equivalent quantity of pure litharge (oxide of lead). In the solid state it is crystalline, and consists of $2PbO, C^4H^3O^3 + Aq$.

Tribasic acetate. $3PbO, C^4H^3O^3 + Aq$. This salt is the most stable of the subsalts. It is obtained in the crystalline state, by leaving to itself a cold saturated solution of the neutral acetate, to which one-fifth of its volume of caustic ammonia has been added. It may also be made by digesting 7 parts of pure litharge with a solution containing 6 parts of the crystallised neutral acetate. It forms long silky needles, which are very soluble in water, but insoluble in alcohol. Carbonic acid transmitted through the solution precipitates the excess of oxide of lead, in the state of carbonate; a process long since described by Thénard, for making white lead.

Hexbasic acetate. $6PbO, C^4H^3O^3 + Aq$. This subsalt is obtained by boiling any of the other acetates with an excess of litharge. It is a precipitate, which, when examined by the microscope, presents a crystalline aspect. It is slightly soluble in boiling water, from which, in cooling, white silky needles are deposited. This salt is frequently found in commercial white lead. The solutions of subacetates are rapidly decomposed by the carbonic acid of the atmosphere.

SULPHATE OF ALUMINA AND POTASSA is alum. See Alum.

SULPHATE OF BARYTA is the mineral called Heavy-Spar. See Baryta, Sulphate.

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 crystallise. 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 whitish 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 crystallised 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 SCHEELE'S and SCHWEINFURTH GREEN. In France, as well as in England, 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. See COPPER.

SULPHATE OF IRON, *Green vitriol, Copperas* (*Couperose verte*, Fr.; *Eisen-vitriol, Schwefelsaures Eisenouxydl*, 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 crystallise. The copperas of commerce is made in a much cheaper way, by stratifying the pyrites found in the coal measures (*Vitriolkies* and *Strahlkies* of the Germans), upon a sloping puddled platform of stone, leaving the sulphide 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 crystallising. The other pyrites, which occurs often crystallised, called by the Germans *Schwefelkies* or *Eisenkies*, 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 bisulphide into a bisulphate. Alum schist very commonly contains vitriolkies, and affords, after being roasted and weather-worn, a considerable quantity of copperas, which must be carefully separated by crystallisation 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 neutralise the excess of acid generated from the pyrites, as also to correct the tendency to superoxidisement 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 peroxidisement 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 crystallisation 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 a subpersulphate 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, to which half as much sulphuric acid has been added as it already contained. It forms with galls and log-wood 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.

SULPHATE OF LIME. See GYPSUM.

SULPHATE OF MAGNESIA, *Epsom Salts* (*Sel amer*, Fr.; *Bittersalz*, Germ.). See MAGNESIA, SULPHATE.

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 crystallised. 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. See MERCURY.

SULPHATE OF POTASH. See POTASH.

SULPHATE OF SODA is commonly called Glauber's salt, from the name of the chemist who first prepared it. See SODA.

SULPHATE OF ZINC, called also *White Vitriol*, is commonly prepared in the Harz, by washing the calcined and effloresced sulphide of zinc or blende, on the same principle as green and blue vitriol are obtained from the sulphides of iron and copper. Pure sulphate of zinc may be made most readily by dissolving zinc in dilute sulphuric acid, evaporating and crystallising 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. See Zinc.

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 chloride of barium. They are mostly insoluble in alcohol.

SULPHIDE OF CARBON. See Carbon, Bisulphide.

SULPHITES are a class of salts, consisting of sulphurous acid, combined in equivalent proportions with the oxidised bases.

SULPHOSELS is the name given by Berzelius to a class of salts which are now called sulphides.—H. K. B.

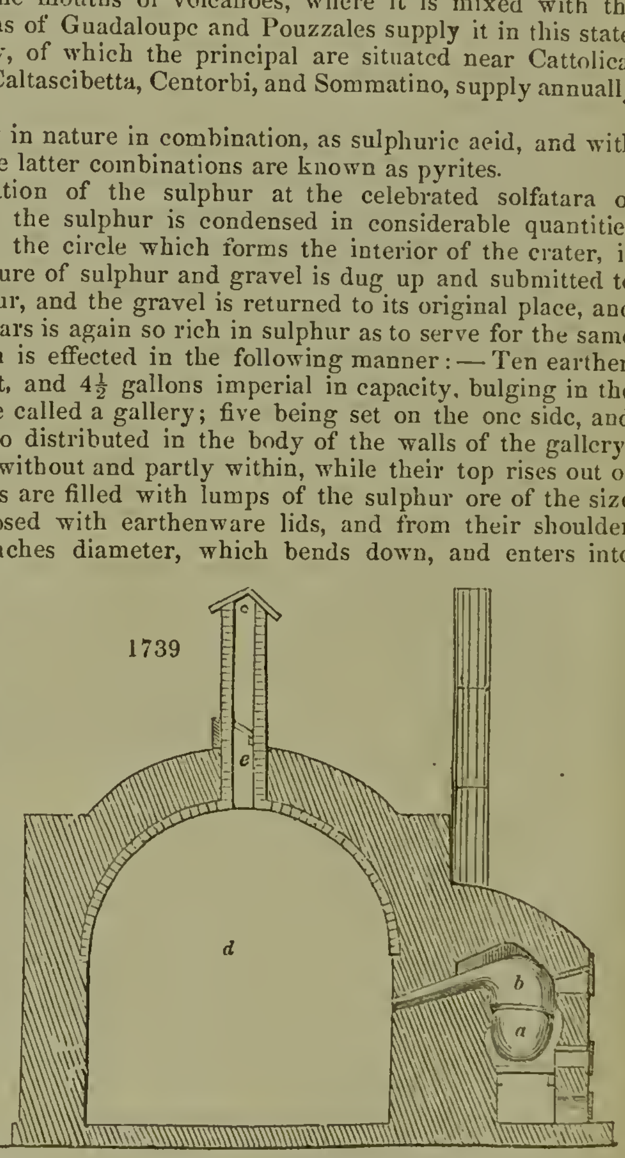
SULPHUR, *Brimstone* (*Saufre*, Fr.; *Schwefel*, Germ.), is an elementary substance of great importance. It is abundantly distributed in nature, either in the free state or in combination with other elements. In the free state it is found in three different forms; 1st, as kidney-shaped lumps disseminated through layers of tertiary and contemporaneous formations; 2nd, in irregular masses in chalky formations, associated with gypsum and rock salt. It is under these circumstances that it is principally found in the mines of Sicily, which supply nearly all the sulphur of commerce in Europe. 3rd, as sublimations around the mouths of volcanoes, where it is mixed with the ashes or gravel. The solfataras of Guadaloupe and Pouzzales supply it in this state.

The sulphur mines of Sicily, of which the principal are situated near Cattolica, Girgenti, Licata, Caltanisetta, Caltascibetta, Centorbi, and Sommatino, supply annually immense quantities of sulphur.

Sulphur is also found largely in nature in combination, as sulphuric acid, and with metals forming sulphides; these latter combinations are known as pyrites.

The process for the separation of the sulphur at the celebrated solfatara of Pouzzales, near Naples, where the sulphur is condensed in considerable quantities amongst the gravel collected in the circle which forms the interior of the crater, is conducted as follows; the mixture of sulphur and gravel is dug up and submitted to distillation to extract the sulphur, and the gravel is returned to its original place, and in the course of about thirty years is again so rich in sulphur as to serve for the same process again. The distillation is effected in the following manner: — 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, volatilises, and runs down in a liquid state into the tubs, where it congeals. When one operation is finished, the pots are re-charged, and the process is repeated.

1739



The sulphur thus obtained is still more or less impure, and in this state can only be used in the manufacture of sulphuric acid; it is therefore subjected to another process of purification, which will now be described: —

Fig. 1739 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 top, 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 cwts. 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.

In some places sulphur is obtained from the metallic sulphides (of iron and copper) which contain a large excess of sulphur.

In Saxony and Bohemia, the sulphides 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 sulphide afford from 100 to 150 parts of sulphur, and a residuum of protosulphide.

Pyrites as a bi-sulphide, 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 sulphide 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.

The great disadvantage in the sulphur prepared from pyrites is, that some of the pyrites contain a large quantity of arsenic, and the sulphur thus obtained from them generally contains sulphide of arsenic, hence the sulphuric acid made from it would contain arsenic, and thus be unfitted 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 in 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 occurs in commerce in two different forms, viz. solid, or in powder; the former is generally in sticks, and is called *lump*, *roll*, or *stick* sulphur; and the latter as *sublimed* or *flowers of sulphur;* and also the kind principally used in medicine, as *precipitated sulphur* or *milk of sulphur.* These different forms are caused by the different modes of preparation; if the sulphur be sublimed into large chambers, which are kept cool during the operation, the product will appear as a powder (*sublimed*, or *flowers of sulphur*); but if the chamber be allowed to get hot, the sulphur melts, and is run off into moulds, and forms the lump sulphur. The washing of the sublimed sulphur is to remove any sulphurous or sulphuric acid, which it generally contains when taken from the chamber. The *precipitated sulphur* is formed by boiling ordinary sulphur with lime and water, the sulphur enters into combination with the lime forming a sulphide of calcium and hyposulphite of lime, which dissolve in the water; to the filtered liquid hydrochloric acid is added, which unites with the lime and precipitates the sulphur. The sulphur thus precipitated is of a pale yellow colour, and when first precipitated will pass through a filter with the water, just as if it were in solution, from the fact of its being so finely divided. Some manufacturers use sulphuric acid instead of hydrochloric acid in this process, and therefore the milk of sulphur found in the shops is generally largely contaminated with sulphate of lime, feels gritty between the teeth, and sparkles when looked at in one direction.

Ordinary sulphur may be crystalline or amorphous; it is capable of crystallising in two different forms, and is hence said to be dimorphous. In acute rhombic octohedrons, belonging to the right prismatic system, which is the principal form assumed by native sulphur, and may be obtained artificially by the spontaneous evaporation of a solution of sulphur in bisulphide of carbon; the second form is that of acute rhombic prisms, belonging to the oblique prismatic system, which is obtained by fusing sulphur in a crucible, and, when partly cooled, breaking the crust which is formed on the top, and pouring out the part which still remains liquid, when the part which has become solid will remain in long crystals. These crystals differ not only in shape, but also in specific gravity; the octohedral crystals having a specific gravity of 2·045, and the prisms a specific gravity of 1·982. 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.

Sulphur also presents another peculiarity. At all ordinary temperatures it is solid, but it melts at 232° Fahr., and at this temperature it is as fluid as water; if the heat be now gradually raised, it will become thicker and thicker until between 430 and 480° Fahr. it is so tenacious that the vessel containing it may be inverted for a moment without losing any of its contents; if while in this state it is cooled suddenly, as by pouring it into cold water, it will remain for many hours perfectly soft and flexible, and may be drawn out into threads; it now presents none of the appearances of sulphur, and is called *amorphous sulphur*. After some time, however, it regains its former properties, becoming brittle and crystalline, and may be restored still more rapidly to its original state by melting and slow cooling. If the temperature be still raised above 480° Fahr., the sulphur between this and the boiling point 792° Fahr., becomes again perfectly liquid. When heated in contact with the air, sulphur ignites and burns with a pale blue flame, generating sulphurous acid gas, which is employed to bleach woollen and silken goods; to disinfect vitiated air, though for this purpose it is greatly inferior to chlorine; 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 has a slight odour, and scarcely any taste. It is a very bad conductor of heat, and a lump of sulphur, even by the heat of the hand, will produce a crackling sound and often break in pieces. It is a bad conductor of electricity, and by friction becomes strongly charged with electricity, which is of the negative kind. Sulphur is insoluble in water and alcohol; but is dissolved by oil of turpentine and the fatty oils, the best solvent of it, however, is bisulphide of carbon. In its chemical relations it is allied to oxygen, &c. It has been known from the most remote ages, and from its kindling at a moderate temperature is employed for readily procuring fire, and lighting by its flame other bodies less combustible. At Paris, the preparation of sulphur matches was once a considerable branch of industry, but they are now principally displaced by the matches which ignite by friction.

Sulphur is also employed for cementing iron bars into stones; 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.

There is another form in which sulphur is sometimes known, and this is what is termed *horse brimstone*, or *black sulphur*. It is the dregs of the subliming pot after the purification of sulphur, and often contains large quantities of arsenic.

The purity of sulphur may be known by its being completely volatilisable, and by being soluble in bisulphide of carbon; any earthy impurities would in either case remain behind. The presence of arsenic may be known by digestion in ammonia, when the sulphide of arsenic would be dissolved, and may be again precipitated as a yellow powder, by the addition of an acid. — H. K. B.

SULPHURATION, is the process by which woollen, silk, and cotton goods are exposed to the vapours of burning sulphur—sulphurous acid gas.

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 pan, 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 soon become respirable. See BLEACHING and STRAW HAT MANUFACTURE.

SULPHURETTED HYDROGEN, *Hydrosulphuric acid.* Sulphur does not unite directly with hydrogen when in the free state, but when the sulphides of those metals which dissolve in dilute acids with liberation of hydrogen, are treated with the same acids, they are dissolved, and the hydrogen, as soon as liberated, unites with the sulphur of the sulphide, and is evolved as sulphuretted hydrogen. Sulphide of iron is the most general substance that is used for this purpose; the action goes on without the application of heat. The following formula represents the decomposition.

$$FeS + HSO^4 = FeSO^4 + HS.$$

This substance does not yield the gas in the pure state, so, when its purity is an object, it is obtained by the action of hydrochloric acid on tersulphide of antimony; in this case the gas is only liberated by the application of heat.

$$SbS^3 + 3HCl = SbCl^3 + 3HS.$$

The sulphide of iron may easily be prepared by projecting into a red-hot crucible a mixture of 2½ parts of sulphur and 4 parts of iron filings, or borings of cast iron, and excluding the air as much as possible; another process is to raise a bar of iron to a white heat, and then rub it with a lump of sulphur, over a vessel of water, the drops of fused sulphide fall into the water.

Sulphuretted hydrogen, at ordinary temperatures, is a colourless gas, possessing a most disgusting odour. It is liberated by many vegetable and animal substances in a state of decay. Its density is 1·171, and it contains 1 part of hydrogen and 16 parts of sulphur by weight. It possesses the properties of an acid, and its solution in water reddens litmus paper.

At a temperature of 50°, and under a pressure of 17 atmospheres, it is condensed to a highly limpid colourless liquid, of specific gravity 0·9, and when cooled to −122 solidifies, and is then a white crystalline translucent substance, heavier than the liquid. In the undiluted state this gas is very suffocating: the best antidote is a little chlorine, which decomposes it immediately, liberating the sulphur:

$$HS + Cl = HCl + S.$$

It is very soluble in water, that liquid dissolving 2½ times its bulk of the gas; the solution quickly becomes milky from the deposition of sulphur, the oxygen of the air uniting with the hydrogen.

$$HS + O = HO + S.$$

The principal use of sulphuretted hydrogen is in the laboratory for the separation of certain metals from their solutions. Being much heavier than air, it can be poured from one vessel to another, and was used successfully by M. Thenard to destroy rats, by pouring into their holes; but I think it would be quite as disagreeable for the time as the rats themselves.—H. K. B.

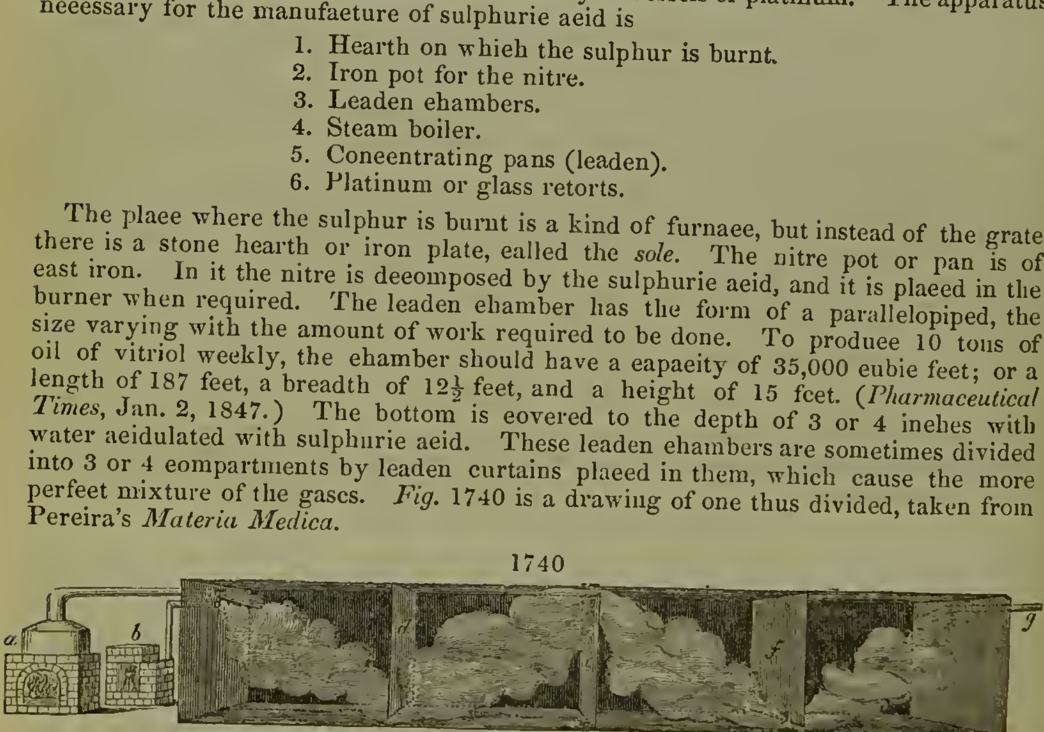
SULPHURIC ACID, *Vitriolic Acid*, or *Oil of Vitriol*. (*Acid sulfurique*, Fr.: *Schwefelsaüre*, Germ.) This important substance now forms an extensive article of manufacture. It appears to have been known several centuries back. It is found in large quantities in the mineral kingdom, combined with bases, in some rivers in the free state, and in such quantity as to render the water acid. It was previously prepared by the distillation of sulphate of iron or green vitriol, from which it received its name of *oil of vitriol* or *vitriolic acid*. This process is even now carried on in some parts of Germany to a certain extent, and the process will be more fully explained under Nordhausen Oil of Vitriol, hereafter. It was afterwards found that it might be produced by the combustion of sulphur, and the ultimate further oxidation of the sulphurous acid, thus obtained, by the means of nitric acid; and from time to time improvements have been made in the process, until it is now almost, perhaps entirely, perfect, and is the process most generally adopted. We shall proceed to describe the process more fully, as it is now carried on.

In the first place the sulphur is burnt on suitable hearths, and the sulphurous acid produced is carried by flues, together with some nitrous and nitric acids, generated in the same furnace from a mixture of nitre and sulphuric acid, into the large leaden chambers, into which steam and air are also admitted; here the different gases react on each other, and the sulphurous acid becomes converted into sulphuric acid, and falls into the dilute sulphuric acid which is placed in the bottom of the chamber, which thereby becomes stronger, and, when of sufficient strength, is drawn off, and concentrated first in leaden vessels, and finally in vessels of platinum. The apparatus necessary for the manufacture of sulphuric acid is

1. Hearth on which the sulphur is burnt.
2. Iron pot for the nitre.
3. Leaden chambers.
4. Steam boiler.
5. Concentrating pans (leaden).
6. Platinum or glass retorts.

The place where the sulphur is burnt is a kind of furnace, but instead of the grate there is a stone hearth or iron plate, called the *sole*. The nitre pot or pan is of cast iron. In it the nitre is decomposed by the sulphuric acid, and it is placed in the burner when required. The leaden chamber has the form of a parallelopiped, the size varying with the amount of work required to be done. To produce 10 tons of oil of vitriol weekly, the chamber should have a capacity of 35,000 cubic feet; or a length of 187 feet, a breadth of 12½ feet, and a height of 15 feet. (*Pharmaceutical Times*, Jan. 2, 1847.) The bottom is covered to the depth of 3 or 4 inches with water acidulated with sulphuric acid. These leaden chambers are sometimes divided into 3 or 4 compartments by leaden curtains placed in them, which cause the more perfect mixture of the gases. *Fig.* 1740 is a drawing of one thus divided, taken from Pereira's *Materia Medica*.

1740



Oil of Vitriol Chamber.

a. Steam boiler.
b. Section of furnace or burner.
d and *f*. Leaden curtains from the roof of the chamber to within six inches of the floor.
e. Leaden curtains rising from the floor to within six inches of the roof.
g. Leaden conduit or vent-tube for the discharge of uncondensible gases. It should communicate with a tall chimney to carry off these gases, and to occasion a slight draught through the chamber.

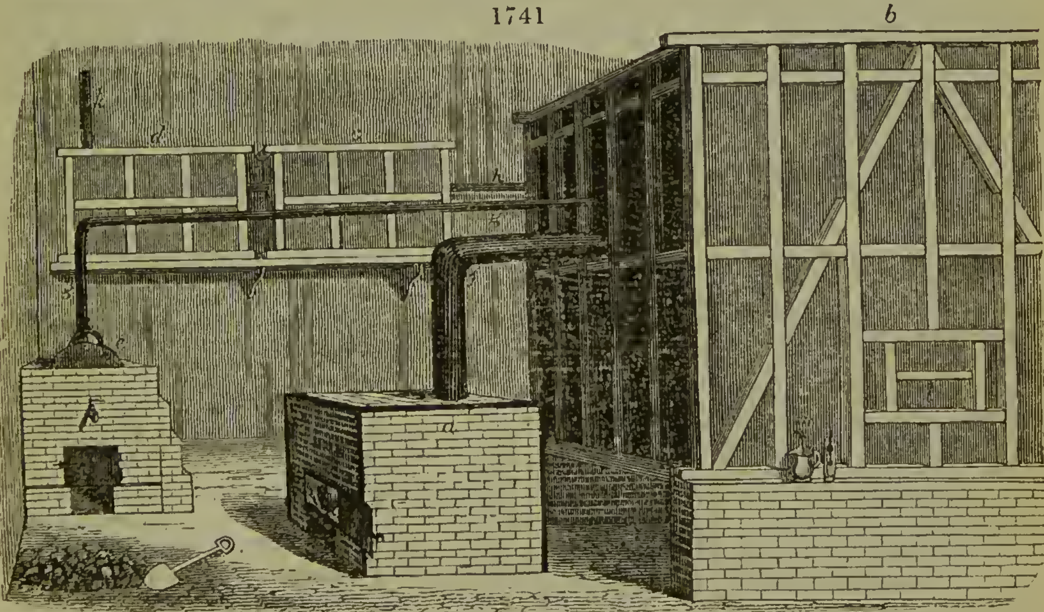
These curtains serve to detain the vapours, and cause them to advance in a gradual manner through the chamber, so that generally the whole of the sulphurous acid is converted into sulphuric acid and deposited in the water at the bottom before it reaches the discharge pipes; but as such is not always the case, there are sometimes smaller chambers, also containing water, appended to the larger, from which they receive the escaping gases before they are allowed to pass out into the air, and thus prevent loss. These smaller chambers are seen in *fig.* 1741 *c, d,* also taken from Pereira's *Materia Medica.*

Another method for preventing this loss 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.

The flue or waste pipe serves to carry off the residual gas, which should contain nothing but the nitrogen of the atmosphere, which has been introduced.

Having now detailed, with sufficient minuteness, the construction of the chamber, we 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 (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

1741



Oil of Vitriol Manufactory.

a. Sulphur burner or furnace.
b. First leaden chamber. In the manufactory from which the above sketch was made this chamber was 70 feet long, 20 feet wide, and 20 feet high; but the size varies considerably in different establishments.
c. Second } smaller leaden chambers.
d. Third }
e. Steam boiler.
f. Flue pipe or chimney of the furnace.
g. Steam pipe.
h. The flue or pipe conveying the residual gas from the first to the second leaden chamber.
i. Pipe conveying the gas, not absorbed in the first and second chamber, into the third.
k. Flue or waste pipe.
l. Manhole, by which the workmen enter the chamber when the process is not going on.
m. Pipe for withdrawing a small portion of sulphuric acid from the chamber, in order to obtain its sp. gr. by the hydrometer.

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 sp. gr. 1·07, which decomposes hyponitric acid into oxygen and binoxide of nitrogen; but not with mere water, which would absorb the hyponitric acid vapours, and withdraw them from their sphere of action. The crystalline compound, described below, is often formed, and is deposited, at low temperatures, 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° Fahr. 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 binoxide of nitrogen. 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 *striæ*.

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, hypo-nitric, sulphurous, and dry sulphuric acids.

Besides the process here described, which is called the *continuous process*, there was another formerly adopted, called the *intermittent* process. This was also carried on in large leaden chambers, but instead of a continuous stream of air, as passes into the chambers, through the furnace by the continuous process, the chambers were opened now and then to introduce fresh atmospheric air. This process is, however, now generally abandoned, on account of the difficulties and delays attending it, though it afforded large products in skilful hands. The following is just an outline of the process: — 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 nitrogen, 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.

For many purposes in the arts the acid, as it is taken from the leaden chambers, is quite strong enough, and is extensively employed under the name of "Chamber Acid."

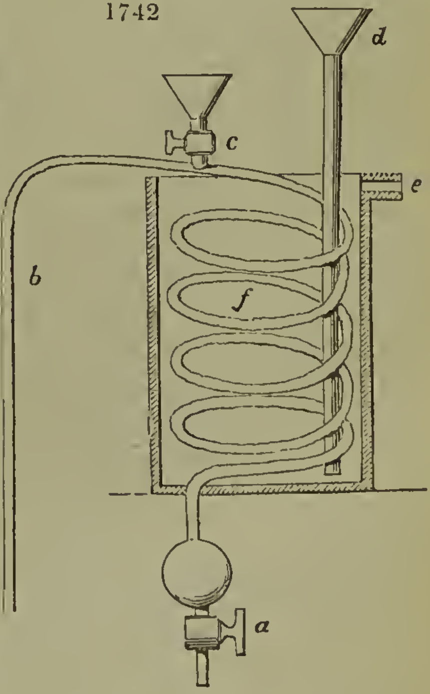
At about the specific gravity of 1·35, in Great Britain, the liquid of the chambers is run off by the siphon above described, into a leaden gutter or spout, which discharges it into a series of rectangular vessels made of large sheets of lead of 12 or 14 lbs. to the square foot, simply folded up at the 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 siphons to replenish the lower pans, in proportion as their aqueous matter is dissipated. The three or four 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. 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 flue gradually ascends from the fireplace 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 siphon, surrounded by another pipe filled with cold water. *Fig.* 1742 shows a 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 siphon 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 twenty-four hours, being at the rate of 420 pounds for 20,000 cubic feet (=nearly 2,000 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 this process results, from the lower concentration of the acid in the chambers, which favours its more rapid production.

1742



The platinum retort admits of from four to six operations in a day, when it is well mounted and managed. It has a platinum capital, 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 carthen pans, supported above the acid on iron stands. But this plan was very laborious and unproductive. It is no longer followed.

Sanitary motives alone induced the makers of soda to condense their waste hydrochloric 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 volatilisation 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 bisulphide 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 volatilised sulphur; but so soon as the bisulphide of iron has been converted into the proto-sulphide, 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 proto-sulphide, 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.

The subsequent processes are the same whether we use sulphur or iron pyrites, the only difference being in the construction of the furnace for generating the sulphurous acid. We shall now, therefore, 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.

The complicated changes which take place in the leaden chambers during the conversion of the sulphurous acid into sulphuric acid, were first traced by M. Clement Desormes. He showed that hyponitric acid and sulphurous acid gases when mixed, react on each other through the intervention of moisture; that there thence resulted a crystalline combination of sulphuric acid, binoxide of nitrogen, 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 binoxide of nitrogen; that this gas re-constituted hyponitric 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 hyponitric acid, and fell down in heavy drops of sulphuric acid, while the binoxide of nitrogen derived from the hypo-nitric 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, binoxide of nitrogen, sulphurous acid, and atmospheric air. The immediate production of red vapours indicated the transformation of the binoxide into hyponitric acid gas; and now the introduction of a very little water caused the proper *reaction*, for opaque vapours arose, 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 hyponitric acid gas, and nitrogen 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.

By a modification of this last process, the manufacture of sulphuric acid from sulphur and nitre may be elegantly illustrated. Take a glass globe with an orifice at its top large enough to take a lead stopper, through which are fixed five glass tubes; one in connection with a flask generating sulphurous acid from copper turnings and sulphuric acid; the second in connection with a gasometer supplying binoxide of nitrogen; the third in connection with a vessel, capable of supplying a tolerable current of steam; the fourth connected to another gasometer supplying atmospheric air; and the fifth which is left open, does not project far into the globe, and serves to carry off the residual nitrogen. By regulating the influx of the different gases and steam, the solid white crystalline compound may be alternately formed and again decomposed. The bottom of the glass globe is formed like a funnel, and the sulphuric acid, when formed, thus runs down the sides into a bottle placed beneath. Some difference of opinion exists about the composition of the crystalline compound thus formed sometimes in leaden chambers. It is probably a compound of sulphuric acid and binoxide of nitrogen $NO^2 + 2SO^3$, but it is not decided if it contains water or not.

Peligot (Ann. Chim. et Phys. 3me sér. xii. 1844) states that the sulphurous acid is oxidised *incessantly* and *exclusively* by nitric acid only, and he accounts for it in this way. The hypo-nitric acid (NO^4) by contact with water is converted into nitric acid, and nitrous acid ($2NO^4 + HO = HNO^6 + NO^3$), and the nitrous acid (NO^3) is again decomposed by more water into nitric acid and binoxide of nitrogen $3NO^3 + HO = HNO^6 + 2NO^2$. The binoxide of nitrogen by contact with atmospheric air is again converted into hypo-nitric acid ($NO^2 + O^2 = NO^4$), which goes through the same changes as before.

There are some points in the manufacture of sulphuric acid which require attention.

1st. If the heat in the sulphur furnace is too high, or when there is not a sufficient supply of air, some sulphur sublimes, and is condensed in the chamber, and at last falls into the sulphuric acid at the bottom of the chamber. By this means, not only is less sulphuric acid produced, but the sulphuric acid, when drawn from the chamber, contains some sulphur in suspension: in this case it must be allowed to stand, so as to deposit the sulphur, which may be collected, washed, dried, and again used. If the sulphur were not removed before concentrating, it would, at the temperature requisite for evaporation, decompose the sulphuric acid with the escape of sulphurous acid gas, and hence much sulphuric acid would be lost. The reaction that would take place is represented by the following equation:—

$$\underbrace{2HSO^4}_{\text{Sulphuric acid.}} + \underbrace{S}_{\text{Sulphur.}} = \underbrace{3SO^2}_{\text{Sulphurous acid gas.}} + \underbrace{2HO.}_{\text{Water.}}$$

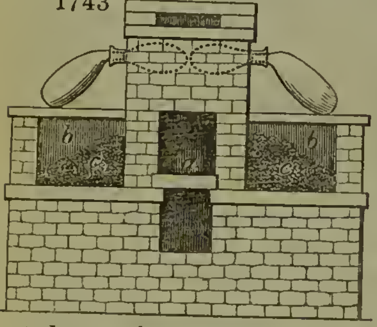
2nd. If there is not a sufficient quantity of steam admitted into the chamber, the solid compound of sulphuric acid and binoxide of nitrogen, above mentioned, would be formed on the sides of the chamber, and thus remove the oxidising agent from action, and hence a large quantity of sulphurous acid would escape by the waste-pipe unchanged.

3rd. A deficiency of nitric acid in the chamber also causes great loss; the sulphurous acid, as in the former case, escaping unoxidised.

The first of these three subjects was counteracted by M. Grovelle, who, taking advantage of an idea put forth by M. Clement Desormes, constructed a furnace for burning the sulphur, so as to have a double current of air. He substituted for the sole of the furnace some parallel bars of iron, on which were placed cast-iron pans or boxes, bound together, but leaving intervals for the entrance of air between each: these were filled with sulphur, which was then ignited, and thus a plentiful supply of air was constantly kept up.

Fuming, or Nordhausen sulphuric acid. At Nordhausen and other parts of Saxony, sulphuric acid continues to be made upon the old plan. This consists in first sub-

1743



jecting sulphate of iron or green vitriol to a gentle heat, by which it is deprived of its water of crystallisation; it is then distilled in earthenware, tubular, or pear-shaped retorts, of which a large number are placed in a gallery furnace. *Fig.* 1743 the fire-place; *a b b*, chamber on each side of the fire-place, for depriving the green vitriol (*c c*) of its water.

To these retorts are adapted earthenware receivers, into which some ordinary sulphuric acid is previously placed, to condense all the anhydrous sulphuric acid which comes over. The heat is raised gradually, and at last the retorts are subjected to an intense heat, which is kept up for several hours.

Some sulphurous acid gas escapes, arising from the decomposition of some of the sulphuric acid of the sulphate by the oxide of iron, and nothing remains in the retorts but sesquioxide of iron.

$$\underbrace{3FeSO^4}_{\text{Green vitriol.}} = \underbrace{Fe^2O^3}_{\text{Oxide of iron.}} + \underbrace{2SO^3}_{\text{Anhydrous sulphuric acid.}} + \underbrace{SO^2}_{\text{Sulphurous acid.}}$$

Anhydrous sulphuric acid. This is most easily obtained by subjecting the Nordhausen sulphuric acid to a gentle heat in a glass retort, to which is adapted a dry receiver placed in ice. White fumes of anhydrous sulphuric acid come over and are condensed in the receiver. Care must be taken to avoid water coming into contact with it, as it unites with it with some violence.

$$\underbrace{HSO^4SO^3}_{\text{Nordhausen sulphuric acid.}} = \underbrace{HSO^4}_{\text{Common sulphuric acid.}} + \underbrace{SO^3}_{\text{Anhydrous sulphuric acid.}}$$

It is best to have a receiver, which can be hermetically sealed as soon as the operation is completed.

Properties of the different Sulphuric Acids.

Anhydrous sulphuric acid. SO^3. This is a white crystalline body, very much resembling asbestos in appearance. Exposed to the air, some of it absorbs moisture, and the rest flies off in white fumes. Dropped into water it produces a hissing noise, just like red-hot iron, and in large quantities causes explosion. It melts at 66° Fahr., and boils at about 120° Fahr. The sp. gr. of the liquid, at 78° Fahr., is 1·97 (*Pereira*), and that of its vapour 3·0 (*Mitscherlich*). It does not present acid properties unless moisture be present.

Nordhausen sulphuric acid. HSO^4, SO^3. This is an oily liquid, generally of a brown colour (from some organic matter), which gives off white fumes of anhydrous sulphuric acid when exposed to the air. Its sp. gr. is about 1·9. It is imported in stoneware bottles, having a stoneware screw for a stopper. It is probably only a solution of anhydrous sulphuric acid in ordinary oil of vitriol, as, after being subjected to a gentle heat, nothing remains but the latter. It often contains several impurities. It is principally used for dissolving indigo, which it does completely without destroying the colour.

Ordinary sulphuric acid, or oil of vitriol. HSO^4. Sp. gr. 1·845. This is, when pure, a colourless, transparent, highly acrid, and most powerfully corrosive liquid. It is a very strong mineral acid, one drop being sufficient to communicate the power of reddening litmus paper to a gallon of water, and produces an ulcer if placed upon the skin. It chars most organic substances. This depends upon its attraction for water, which is so great that, when exposed in an open saucer, it imbibes one-third of its weight from the atmosphere in twenty-four 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° Fahr., the temperature will rise to 300° Fahr.; 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. In this last case the heat, that would otherwise have been given off, has been employed in liquefying the ice. Upon the mixing the acid and water they both suffer condensation, the dilute acid, thus formed, occupying less space than the two separately, and hence the evolution of heat. This affinity for water, which sulphuric acid possesses, is often made use of for evaporating liquids at a low temperature. The liquid is placed in a dish over another dish containing sulphuric acid, and both are placed under the receiver of an air pump. Such is the rapidity with which the evaporation is carried on, that if a small vessel of water be so placed it will speedily be frozen. Sulphuric is decomposed by several substances when boiled with them; such are most organic substances, sulphur, phosphorus, and several of the metals, as mercury, copper, tin, &c.

Sulphuric acid of sp. gr. 1·845, boils at about 620° Fahr., and may be distilled unchanged. This is the best way to obtain it pure. It is a most powerful poison. If swallowed in its concentrated state, even a small quantity, it acts so powerfully on the throat and stomach as to cause intolerable agony and speedy death. Watery diluents mixed with chalk or magnesia are the readiest antidotes.

Ordinary oil of vitriol generally contains some sulphate of lead, which will be precipitated, as a white powder by dilution with water; since so much of it is made from iron pyrites at the present day, it contains arsenic in variable quantities. The best test for sulphuric acid, either free or combined, as soluble salts, is a salt of barium. An extremely small quantity of sulphuric acid, or a soluble salt of it, is thus easily detected by the greyish-white cloud of sulphates of baryta which it occasions in the solution. 100 parts of the concentrated acid are neutralised by 143 parts of dry pure carbonate of potash, and by 110 of dry pure carbonate of soda.

The presence of saline impurities in sulphuric acid may be determined by evaporating a certain quantity to dryness in a platinum capsule. If more than 2 grains of residue remain out of 500 of acid it may be considered impure.

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, hydrochloric, 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 Graham there are three hydrates of sulphuric acid besides the Nordhausen acid, viz.:—

Monohydrate of sulphuric acid, oil of vitriol, of sp. gr. 1·845. HSO^4. This acid is a dense oily, colourless liquid. Boils at 620° Fahr., and freezing at —29° Fahr., yielding sometimes regular six-sided prisms of a tabular form.

Binhydrate of sulphuric acid, sometimes called Eisöl (ice oil), sp. gr. 1·78. $HSO^4 + HO$.

In cold weather acid of this density readily freezes, and produces large, hard crystals, somewhat resembling crystals of carbonate of soda. The melting point of these crystals is 45° Fahr. If the density be either augmented or lessened the freezing point is lowered. The crystals have a sp. gr. of 1·924.

Terhydrate of sulphuric acid. Acid of sp. gr. 1·632. $HSO^4 + 2HO$. This acid is obtained by evaporating a dilute acid *in vacuo* at 212° Fahr. It is in the proportions contained in this hydrate that sulphuric acid and water undergo the greatest condensation when mixed.

The following Table shows the quantity of concentrated and dry sulphuric acid in 100 parts of dilute, at different densities, according to Dr. Ure.

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	0·1584
68	1·5760	55·45	34	1·2490	27·72			
67	1·5648	54·63	33	1·2409	26.91			

H. K. B.

SULPHUROUS ACID. (SO^2.) Sulphur fumigations are mentioned by Homer, but sulphurous acid, of which these were composed, was first accurately examined by Stahl, Schelle, and Priestley, and more recently by Gay-Lussac, and Berzelius.

It escapes from the earth, in the gaseous form, in the vicinity of volcanoes, but is always prepared artificially when required for use, and for this purpose several processes are employed.

1. By heating copper cuttings, or mercury, with concentrated sulphuric acid in a glass flask; sulphate of copper, or persulphate of mercury and sulphurous acid are formed,

$$\underbrace{Cu}_{\text{Copper.}} + \underbrace{2(HSO^4)}_{\text{Sulphuric acid.}} = \underbrace{CuSO^4}_{\text{Sulphate of copper.}} + \underbrace{SO^2}_{\text{Sulphurous acid.}} + \underbrace{2HO.}_{\text{Water.}}$$

this latter is passed through a wash bottle, to remove any trace of sulphuric acid which sometimes comes over, and then through a tube containing chloride of calcium, if the gas be wanted dry; it may then be collected over mercury in the pneumatic trough, or by displacement of air; it cannot be collected over water, owing to its great solubility in that liquid.

2. By heating charcoal, or almost any organic substance, with concentrated sulphuric acid in the same apparatus as above, but in this case the sulphurous acid is contaminated with a large quantity of carbonic acid, which, however, does not interfere with it in many cases, as when employed in the manufacture of alkaline sulphites.

$$\underbrace{C}_{\text{Charcoal.}} + \underbrace{2HSO^4}_{\text{Sulphuric acid.}} = \underbrace{CO^2}_{\text{Carbonic acid.}} + \underbrace{2SO^2}_{\text{Sulphurous acid.}} + \underbrace{2HO.}_{\text{Water.}}$$

3. By the combustion of sulphur or iron pyrites in oxygen gas or in atmospheric air, and this is the process most generally employed on the large scale, as in the manufacture of sulphuric acid. See SULPHURIC ACID.

$$\underbrace{S}_{\text{Sulphur.}} + \underbrace{O^2}_{\text{Oxygen.}} = \underbrace{SO^2.}_{\text{Sulphurous acid.}}$$

Properties. At ordinary temperatures and atmospheric pressure sulphurous acid is a colourless, transparent gas, possessing the disagreeable odour so well known to those who have burnt a sulphur match. It is neither combustible, nor a supporter of combustion, and is always the product obtained by burning sulphur in air. It is a weak acid, and is very soluble in water, that liquid at 60° Fahr. dissolving more than thirty times its volume of the gas; the solution of sulphurous acid thus obtained—bleaches some vegetable colours, as well as the gas itself, viz. those of roses and violets, &c., but in most cases the colours may be restored by treating with a weak acid or alkali. It cannot be respired in the pure state, as it immediately causes spasm of the glottis; but if diluted with air and then breathed, it acts as a local irritant, exciting cough, pain, and a sense of dryness of the mouth and throat. Its sp. gr. is 2·2; 100 cubic inches weighing 68·69 grains. Its solution in water may be kept any time without change, as long as air is excluded, but when air gains access to it, it is gradually converted into sulphuric acid.

One volume of sulphurous acid gas contains one volume of oxygen and $\frac{1}{6}$th of a volume of sulphur vapour, condensed into one volume. When a mixture of sulphurous acid gas and aqueous vapour are passed into a vessel cooled to below 17° Fahr., a crystalline substance is formed which contains about 24·2 parts of acid and 75·8 parts of water.

At 0· Fahr., and under ordinary atmospheric pressure, sulphurous acid condenses to a colourless, limpid liquid, of sp. gr. 1·42 (Faraday), and boils at 14° Fahr. It dissolves bitumen (Pereira). At $-105°$ Fahr. it becomes a crystalline, colourless, transparent body.

The only salt of sulphurous acid which is made at all largely, is the hyposulphite of soda. See SODA HYPO-SULPHITE.

Uses. Sulphurous acid is often used as a bath in some kinds of skin diseases; also in commerce for bleaching straw hats and bonnets, &c., and silks, and for fumigating rooms; for these latter purposes, the sulphur is placed in a vessel in the centre of the room, and ignited, all the apertures of the windows, &c. being previously closed. When thus employed for bleaching, the articles are hung up in the room, which becomes filled with sulphurous acid, and is thus left for a certain time. Its principal use is in the manufacture of sulphuric acid.—H. K. B.

SULPHYDROMETRY, the determination of sulphur, which see.

SUNFLOWER OIL. See OILS.

SUNN consists of the fibre of the *Crotolaria juncea*, a totally different plant from the *Cannabis sativa*, from which hemp is obtained. Sunn is grown in various places of Hindostan. The strongest, whitest, and most durable species is produced at Comercolly.—*McCulloch.*

SUNSTONE. A variety of felspar, of a pale yellowish colour, found in Siberia. It is almost perfectly transparent when viewed in one direction; but by reflected light it appears full of minute golden spangles, owing to the presence of scales of oxide of iron, which are disseminated through the mass.—H. W. B.

SUSSEX MARBLE. Thin bands of shelly limestone, occurring here and there in the Weald Clay, especially in the upper part. This limestone is principally composed of the remains of freshwater snails, a species of *Paludina*, and it has been named Sussex marble in consequence of its great development in that county. Although the stone is not remarkable for any particular beauty of colour, being generally of a uniform bluish or greyish-green tint, the sections of the chambers of the shells give it, when polished, a pleasing appearance, and it has, in consequence, been frequently made use of in former times in the construction of tombs and sepulchral monuments in many of our older churches.—H. W. B.

SWALLOW, ESCULENT (*Hirundo esculenta*). These birds construct the edible nests which form so considerable a part of Chinese commerce. It is the *Larvet* of the Japanese, the *Salangana* of some writers on the Eastern Archipelago. The nests are made of a particular species of sea-weed (see ALGÆ), which the bird macerates and bruises before it employs the material in layers so as to form the whitish gelatinous cup-shaped nests so much prized as restoratives and delicacies by the Chinese.

SWAGES. Tools employed in shaping metals.

SWEEP-WASHER is the person who extracts from the sweepings, potsherds, &c. of refineries of silver and gold, the small residuum of precious metal.

SWORD MANUFACTURE. This is sufficiently described under DAMASKUS BLADES.

SYCAMORE. The wood of the *Acer pseudo-platanus*

SYENITE, or SIENITE, so called from its being obtained by the ancient Egyptians from Syene, in Upper Egypt. It is a granular, aggregated compound rock, consisting of felspar, quartz, and hornblende.

Any granitic rock in which hornblende predominates is termed syenitie. From true granite to the true greenstone the gradations are exceedingly easy.

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 and 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.

T

TABBYING, or WATERING, is the process of giving stuffs a wavy appearance by a peculiar manipulation with the calender. See MOIRE.

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. See 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 crystallised in small six-sided tables. It is splendent, 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 2½ 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-grey 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. See STEATITE.

TALLOW (*Suif*, 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, 68,035*l.*

Under the article FAT the conditions of tallow and its mode of occurrence are fully dealt with.

Ox tallow was alone used formerly, and our great supply was from Russia. Australia now, however, exports to Europe a large quantity of mutton tallow, and America does also a large trade.

The drier the food upon which animals are fed the more solid is the tallow; hence the Russian tallow is the best, the animals being fed for eight months of the year on dry fodder.

In the animal the tallow exists in separate globules, and the object of melting it out is to combine all these into one mass. The *rendering* of tallow, as it is termed, consists in cutting the fat into small pieces, and placing it in a pan over a naked fire. The heat is regulated, and the first action is the bursting of the cells; these pour out their milky contents, which become clear gradually, as the water which it contains is evaporated.

Mechanical power is sometimes applied to aid in the rendering. The fat is placed under a mill-stone working on edge, and thus the cells are torn or crushed, and when this is once effected, the tallow separates with great ease at a moderate temperature. Dorrett employed weak sulphuric acid to act upon the tallow, by mixing this acid with boiling water, and retaining it after the fat has been placed within it, until the separation of the fatty matter is completed. Some admit steam to the melting mass, by which a larger quantity of tallow appears to be obtained. Tallow is generally so impure, that it has to be clarified by the candle maker. This is effected by remelting the tallow, and mixing with it some substances which render insoluble the gelatinous matters, and precipitate the adventitious admixtures. See CANDLES and FAT.

Our *importations* of tallow in 1858 were :—

	Cwts.	Computed real value.
Russia	1,004,563	£2,460,375
Prussia	8,036	21,210
Hamburg	6,021	15,682
Belgium	6,491	16,779
France	22,664	58,659
Turkey Proper	10,087	23,006
United States	14,945	38,635
Uruguay	38,425	97,881
Buenos Ayres	58,856	147,460
British East Indies	9,673	24,762
Australia	46,973	115,710
Other parts	9,055	22,222
	1,235,789	£3,042,381

The duty on tallow imported from British possessions is 1*d.* per cwt.

On that not derived from British possessions 1*s.* 6*d.* per cwt.

TALLOW, PINEY. See OILS.

TAMPING is a term used by miners to express the filling up of the hole which they have bored in a rock, after the gunpowder for blasting has been placed in the bottom of the hole, with sand, the debris of the rock or other matters. This, being beaten hard together, presents nearly as much resistance to the mechanical force of the powder, when exploded, as the rock itself See MINES.

TANGLE. *Laminaria digitata* of Lamoroux. See ALGÆ.

TANNIN, or TANNIC ACID. (*Tannin*, Fr.; *Gertstoff*, Germ.) Under the name *tannin* was formerly understood all those astringent principles which were capable of combining with the skins of animals to form leather, of precipitating gelatine, of forming bluish black precipitates with the persalts of iron, and of yielding nearly insoluble compounds with some of the organic alkalies. But it has of late years been proved that there are several different kinds of tannic acid, most of which possess an acid reaction.

These principles are widely diffused in the vegetable kingdom; most of our forest trees, as the oak, elm, pines, firs, &c.; pear and plum trees contain it in variable quantities.

It is also found in some fruits. Many shrubs, as the sumach and whortleberry, also contain it in large quantities, and on that account are largely used in dyeing and tanning. The roots of the tormentilla and bistort are also powerfully astringent from containing it. Coffee and tea also contain a modification of this principle. The astringent principle in all the above mentioned (except coffee) precipitate the persalts of iron bluish black, or if a free acid be present the solution becomes dark green. The astringent principle of many vegetables precipitate the persalts of iron of a dark green,—such are catechu, kino, &c. Some few plants contain another modification of this astringent principle, which precipitates the persalts of iron of a grey colour,—such are rhatany, the common nettle, &c.

Many of these tannic acids have received names which refer to the plants from which they are obtained. The most important and best known of all these is the *gallo-tannic acid*, or that which is extracted from gall-nuts. There are also *querci-tannic acid*, from the oak; *moritannic acid*, or that from the fustic (*morus tinctoria*), &c.

The only one which need be described here is the *gallo-tannic* acid; it is, in fact, the only one which is perfectly known. It is usually obtained from the gall-nuts, which are excrescences formed on the leaves of a species of oak (*quercus infectoria*), by the puncture of a small insect, by the process first proposed by M. Pelouze, which consists in exhausting the powdered gall-nuts by allowing ordinary ether to percolate through them in a proper apparatus. The ether, which always contains some water, separates in the bottom of the apparatus into two distinct layers, the under one, being the water, containing all the tannic acid, and the upper one the ether, containing the gallic acid and colouring matter. The solution of tannic acid is washed with ether and evaporated gently to dryness, when the gallo-tannic acid is left as a pale buff-coloured amorphous residue.

Some gall-nuts contain as much as 67 per cent. of gallo-tannic acid, and about 2 per cent of gallic acid (Guibourt). Gallo-tannic acid is freely soluble in water, soluble in diluted alcohol, slightly in ether. The tannic acids are all remarkable for the avidity with which they absorb oxygen; the *gallo-tannic* acid becoming *gallic* acid.

A saturated aqueous solution of gallo-tannic acid is precipitated by sulphuric, hydrochloric, phosphoric, and some other acids. When boiled for some time with diluted sulphuric or hydrochloric acid it is converted into sugar and gallic acid (Strecker); the latter crystallises on cooling, while the glucose remains in solution.

$$\underbrace{C^{54}H^{22}O^{34}}_{\text{Gallo-tannic acid.}} + 10HO = \underbrace{3(3HO\ C^{14}H^{3}O^{7})}_{\text{Gallic acid.}} + \underbrace{C^{12}H^{12}O^{12}\ 2aq.}_{\text{Glucose.}}$$

The composition of the gallo-tannates is but imperfectly known, and it is not decided if the acid be dibasic or tribasic. A solution of gallo-tannic acid gives, with persalts of iron, a bluish black precipitate, which is the basis of ordinary black writing ink. The most remarkable compound of gallo-tannic acid is that which it forms with gelatine, which is the basis of leather. See TANNING.

By the reaction of heat gallo-tannic acid is converted into pyrogallic acid, and this distinguishes it from the other species of tannic acid, as they do not yield pyrogallic acid when subjected to the same treatment.

The following formula will show the relation existing between gallo-tannic acid, gallic acid, and pyrogallic acid.

$$\underbrace{C^{54}H^{22}O^{34}}_{\text{Gallo-tannic acid.}} + 10HO = \underbrace{3(3HO^{1}\ C^{14}H^{3}O^{7})}_{\text{Gallic acid.}} + \underbrace{C^{12}H^{12}O^{12},\ 2\ aq.}_{\text{Glucose.}}$$

$$\underbrace{3HO,\ C^{14}H^{3}O^{7}}_{\text{Gallic acid.}} = \underbrace{C^{12}H^{6}O^{6}}_{\text{Pyrogallic acid.}} + 2CO^{2}$$

When powdered nut-galls are made into a paste, with water, and allowed to ferment for some considerable time, with occasional stirring to facilitate the absorption of oxygen, the gallo-tannic acid is almost entirely converted into gallic acid.

$$\left.\begin{array}{lr} \text{1 eq. tannic acid} & C^{54}H^{22}O^{34} \\ \text{24 eq. oxygen} & O^{24} \\ \hline & C^{54}H^{22}O^{58} \end{array}\right\} = \left\{\begin{array}{lr} \text{3 eq. gallic acid} & C^{42}H^{18}O^{30} \\ \text{4 eq. water} & H^{4}\ O^{4} \\ \text{12 eq. carbonic acid} & C^{12}\quad O^{24} \\ \hline & C^{54}H^{22}O^{58} \end{array}\right.$$

The following is the method proposed by Berzelius *for the purification of tannin with sulphuric acid.*

To a hot infusion of nut-galls 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 excess 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 nut-galls, 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 separates 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 decolorising tannin, acting in the same way as powdered charcoal does on some substances.

The following Table shows the quantity of extractive matter and tan in 100 parts of the several substances:—

Substances.	In 480, by Davy.	In about 8 oz., by Biggins.	In 100 parts, by Cadet de Gassincourt.
White inner bark of old oak	72	- -	21
Do. young oak	77		
Do. Spanish chestnut	63	30	
Do. Leicester willow	79		
Coloured or middle bark of oak	19		
Do. Spanish chestnut	14		
Do. Leicester willow	16		
Entire bark of oak	29		
Do. Spanish chestnut	21		
Ditto Leicester willow	33	109	
Do. elm	13	28	
Do. common willow	11	boughs, 31	
Sicilian sumach	78	158	
Malaga sumach	79		
Souchong tea	48		
Green tea	41		
Bombay catechu	261		
Bengal catechu	231		
Nut-galls	127	- -	46
Bark of oak, cut in winter	—	0	
Do. beech	—	31	
Do. elder	—	41	
Do. plum-tree	—	58	
Bark of the trunk of willow	—	52	
Do. sycamore	—	53	16
Bark of birch	—	54	

Substances.	In 480, by Davy.	In about 8 oz., by Biggins.	In 100 parts, by Cadet de Gassincourt.
Bark of cherry-tree	—	59	24
Do. sallow	—	59	
Do. poplar	—	76	
Do. hazel	—	79	
Do. ash	—	82	
Do. trunk of Span. chestnut	—	98	
Do. smooth oak	—	104	
Do. oak, cut in spring	—	108	
Root of tormentil	—	- -	46
Cornus sanguinea of Canada	—	- -	44
Bark of alder	—	- -	36
Do. apricot	—	- -	32
Do. pomegranate	—	- -	32
Do. Cornish cherry-tree	—	- -	19
Do. weeping willow	—	- -	16
Do Bohemian olive	—	- -	14
Do. tan shrub with myrtle leaves	—	- -	13
Do. Virginian sumach	—	- -	10
Do. green oak	—	- -	10
Do. service-tree	—	- -	8
Do. rose chestnut of Amer.	—	- -	8
Do. rose chestnut	—	- -	6
Do. rose chestnut of Carolina	—	- -	6
Do. sumach of Carolina	—	- -	5

H. K. B.

TANNING. (*Tanner*, Fr.; *Gärberei*, Germ.) This is the name given to the process employed for converting the skins of animals into leather, and is strictly a chemical process, it consisting in the combination of the tannic acid of the different tanning materials with the gelatine of the skins.

Many attempts have been made to quicken the tanning process, but the leather so formed is generally of inferior quality and less durable.

There are many astringent vegetable substances that serve for the process of tanning, but experience has shown that *oak bark* and *valonea* will produce the finest leather.

Skins are divided into three classes; hides, kips, and skins. Hides (properly so called) are the skins of the larger animals, as the buffalo, ox, horse, &c.

Kips are the skins of a small species of cattle which are very abundant in the

East Indies and Russia, but by far the greater number are imported from the East Indies. Small ox and cow hides are sometimes called kips.

Skins (so called) are the skins of the sheep, goat, and other small animals; thus no one would speak of a sheep's hide, or an ox skin. Each of these classes of skins require somewhat different processes for tanning, which we shall now proceed to describe.

Sole leather. — English ox, South American, and Australian wet and dry salted ox and cow hides are principally employed in the manufacture of this description of leather.

Dry salted hides are first soaked in water until sufficiently softened for the liming process; the time required varying from a week to a month, according to the time of the year, dryness of the hides, &c.

Wet salted hides and fresh market hides are merely soaked the day before they are limed.

Liming process. — The hides are first placed in milk of lime, which has served for the last liming of previous skins; they are placed horizontally one upon the other, and at the end of a week they are removed to a new milk of lime, in which they remain about ten days; during the whole of this period, which occupies from sixteen to twenty days, they are *drawn*, that is pulled up and down twice or three times a week, according to their age in the lime pit.

Depilation. — This is the next process, and for which the lime treatment prepares the hides. The hide is placed on a convex beam, and the hair is then taken off by means of a concave tool, having two handles, called a "worker," which, moved rapidly up and down over the surface of the hide, rubs off the hair. The *offal* (bellies and shoulders) is then cut off.

The next process is *fleshing*, which consists in the removal of the flesh which is left adhering to the hide after flaying. It is effected on the same convex beam, by the means of a two-handled knife similar in shape to the rubber above described, but having two sharp edges. During these processes the hides are repeatedly washed, and are ready for the tanning process, after being *scudded*, that is the working out of the lime from the pores, by rubbing the rubber rapidly up and down over the hide.

The *tan-pits* were formerly made with boards from 6 to 8 inches apart, having clay puddled between them, or else were built of stone or brick; stone and brick are doubtless the best, since they are far more durable, and also avoid the exudation of the mud from between the boards when the pits become old. A somewhat newer method is to construct them of planks 3 inches thick, placed vertically and fastened by an iron bolt, which runs through each plank from the top to the bottom of the pit. Before describing the tanning process we will just mention the way in which the liquors are made.

A certain quantity of bark, or other tanning material, is thrown into an empty pit or "letch," as it is called, and the strongest liquor which can be spared from the tanning pits is pumped over it and allowed to stand from two days to a week, and is then drawn off for the leather pits, and often the liquor which it replaces is pumped back on the letch in the place of it. When the tan is thus partially exhausted it is cast over into another pit, called the "spender," in which it is usually boiled with fresh water before being thrown away. The spenders are the only letches that are "watered up," the liquors being pumped back in rotation, a weak one on a stronger, and so on.

Tanning process. — Butts (thick skins for sole leather) are first immersed in a weak liquor, and are passed on from time to time into a stronger, as they become more tanned, the strength of which varies from 5° to 65° of the common hydrometer, which stands at 0° in distilled water. Great care must be taken that the hide is not kept too long in the weak liquors, as they will soften it and dissolve a considerable quantity of the gelatine of the hide; in fact, too weak liquors soften the hide nearly as much as the bate of pigeons' dung.

During the first few weeks the butts require to be frequently "handled," that is taken out and put in again, the object of which is to present a fresh portion of the liquid to the hide. There are various methods of effecting this; hitherto the one most in use is the following: — Two men stand at opposite corners of the pit, each with a hook attached to a long handle, and with "rising poles;" with the latter they elevate several hides at a time, and with the former they throw them up separately on the top of the next pit. Latterly many tanners suspend the butts on poles placed across the top of the pits used in the first part of the tanning process, when they require to be handled so often; by this means a great saving of labour is effected, and the leather is better "coloured off," as the liquor surrounds the hide.

The next step is to "lay away" the butts. A layer of butts is formed by strewing some bark or valonia, as the case may be, between the butts alternately; in new tanyards the pits generally hold a hundred butts. At first the layers are renewed once a week, then once in two weeks, and lastly every three or four weeks till the butts are completely tanned. Each time a fresh layer is made the strength of the liquor should be increased, until the maximum strength required is arrived at, and which is regulated to suit the sort of hide being tanned.

The time occupied in tanning ordinary sole leather varies from seven to twelve months, according to the weight of the hide, &c.; buffalo hides require from eighteen to twenty-four months to tan. Bellies are tanned in about three months, being first handled in the liquors for nine or ten weeks, and then laid away in the same manner as the butts, for the remainder of the time. They are chiefly cut up for insole, as they would never make a firm leather. When perfectly tanned they are hung up in drying sheds, with their thickest part always towards the wind, and when of a proper "temper" (dryness), they are "broken down" or rolled, then struck with a "pin," a three-edged sharp knife, which is passed with considerable pressure over the surface of the leather to take out the creases, and if wished to scrape off the *bloom* or deposit from the liquors on the leather; this is done in the north of England, and makes the leather of a redder hue. In the west of England as much bloom as possible is preferred.

The butts are then rolled two or three times more in order to compress the leather and make it firm. When quite dry a little bees'-wax and turpentine is rubbed over the grain to give a polish; after this the leather is ready for sale. Butts are used for sole leather, machinery straps, pumps, and many other purposes.

Upper leather. — Kips are chiefly employed for this purpose, and are imported either dry salted, or brined, but in either case the process is the same.

The first process is to soak them in water; they are then submitted to the action of stocks, similar in construction to fulling stocks, for two hours; this is to soften them all through alike, and to remove the hair, which is very short; they are next put into milk of lime, as described under butts. They are then fleshed in a similar manner to butts, and afterwards immersed in a bate of pigeons', fowls', or dogs' dung for two or three days, which softens them. It is curious that no substitute has yet been found for these substances; one tanner told me it cost him at least 100*l.* a year for pigeons' dung. In India, bullocks' blood is used for the purpose, and answers, but the smell from it is very offensive.

After being "grained" the kips are placed again in the stocks for twenty minutes, and are then ready for tanning.

The usual time allowed for tanning kips is six weeks; they are first placed in the weakest of a set of six pits, and shifted every day, except the two forward ones, which are shifted every alternate day, having a fresh liquor. They are afterwards placed in a warm decoction of *sumach*, principally for the colour which it imparts. When properly tanned they are dried in sheds in the same manner as butts, then oiled with some cheap oil, and again dried, and are then ready for the currier to prepare for the upper leather of boots, &c., &c.

Seal skins are imported in considerable numbers, and are principally used for women's and children's boots and shoes. Many other kinds of skins are used, but the above are the principal ones.

Skins (properly so-called). Sheep and goat skins are prepared for use in various ways, the usual tanning substance being sumach and bark. See Leather.

The *offals* (bellies, &c.) are often tanned at Warrington and other places in the north, by placing them in a barrel, two thirds filled with liquor, which is kept slowly revolving; by this means the skins are constantly being exposed to fresh portions of the liquid, and saves the labour of handling.

There have been several patents for quickening the tanning process, but we shall only mention one or two here.

The following is taken from the Bavarian Journal of Arts and Trades, and is known as Knoderer's tanning process.

It is well known that the absence of atmospheric air greatly facilitates the process of tanning, and in order to effect this the process must be carried on *in vacuo.*

The vessel, in which the tanning substance is kept, has to be made air tight, and at the same time no metal can be used but the expensive one, copper. Iron, as well as zinc, is affected by the tanning substance, and wood can only be used when its pores have been stopped by some varnish which effectually prevents the passage of air into the vessel.

The process is carried on as follows:— When the hides are taken from the wash, all the water contained in them is expelled by a powerful press. They are then placed in a barrel, having a rotatory motion, together with the necessary amount of tanning material, and enough water added to keep the contents of the barrel moist.

The man-hole is now closed, and the air pumped out as completely as possible;

this being done, the stop-cock is closed, and a piece of lead pipe is added to the conducting tube; this lead pipe communicates with a tank which contains tanning fluid of proper strength. If the stop-cock is now opened, the tanning fluid rushes rapidly into the barrel, and when a sufficient quantity has been admitted, the stop-cock is closed, and the barrel is now rotated for an hour, or half an hour, according to the quantity of hides contained in it. After two or three hours' rest, the rotation is again continued to the end of the operation.

The advantages of this process are, first by the air being rarefied the pores of the skins are opened, and thus more rapidly absorb the tanning principle; and the tannic acid is not so rapidly converted into *gallic acid*, which is of no use in tanning.

Secondly, the rotatory motion facilitates the extraction of the tannic acid from the bark, &c. Thus the hides are completely tanned in a much less time than without rotatory motion, as will be seen by the following table, based on actual experiments.

	Time required for tanning, *in vacuo*, without motion.		Time required when motion is employed.	
Calf skins - -	from 6	to 11 days. - -	4	to 7 days.
Horse hides - -	35	40 - -	14	18
Light cow hides -	30	35 - -	12	16
Cow hides (middling)	40	45 - -	18	20
Heavy cow hides -	50	60 - -	22	30
Ox hides (light) -	50	60 - -	20	30
Ox hides (first quality)	70	90 - -	35	40

At the same time a large per centage of bark is saved.

A patent was taken out by E. Welsford, of Bona, Algeria, in 1859. Instead of employing oak bark or the ordinary tanning substances, he uses the leaves of the different trees and shrubs of the family *Terebinthaceæ*, as the *Pistacea terebinthus*, *Pistacea Atlantica*, *Pistacea lentiscus*, &c., abounding on the coast of the Mediterranean and elsewhere. He forms an infusion or decoction of the leaves for tanning.

A machine has been invented by Mr. S. F. Cox, of Bristol, for effecting the various processes of depiling, scudding, striking, smoothing, sticking, and stretching, which are now usually effected by hand. The hide or skin is carried by a cylinder or roller, or by a moving bed or platform which presents it gradually to a revolving spiral bar rib knife or rubber. The spiral consists of a right and left handed screw, so arranged as to rub or scrape the hide, &c. from the centre towards the sides, or it may consist of a single thread of a screw, or several.

The roller or bed which carries the hide or skin is pressed towards the revolving spiral instruments by springs or otherwise, and is gradually advanced by a ratchet, so that the whole of the hide is uniformly and successively exposed to the action of the revolving spiral instruments. A treadle is employed for withdrawing the roller or bed from the revolving spiral to facilitate the adjustment of the hide.

Vegetable Substances used in Tanning.

No two substances will produce the same quality leather, either in texture or colour. Doubtless this is owing to a different variety of tannic acid contained in the materi·., though unfortunately very little is understood about it, the subject not having been much studied. Some things contain a large proportion of tannin but do no not fill up the pores of the hide; gambir, for instance, tans quickly, but does not make a heavy leather.

Oak bark (*Quercus pedunculata*).— This bark is preferred to all other materials for tanning, since it produces the best leather for most purposes. The oak bark of this country is considered superior to that of any other part of Europe. The bark season in England is usually from the middle of April to the end of May. It is essential that the sap should run well before the bark is stripped, as it contains most tannin when the sap begins to run.

English coppice oak bark.— This bark is very similar to timber oak bark, but is lighter and thinner, and contains more tannin, as there is not so much epidermis, (which contains none). It is preferred for tanning light goods. Coppice bark is stripped at the same time of year as the heavier sorts.

Belgium oak bark.— This bark is similar to the English, and is imported, chopped into small pieces, chiefly from Antwerp; it does not sell for so high a price as the English, for it is said not to contain so much tannin.

Chopped bark is simply bark with the rough epidermis scraped off and then chopped into pieces.

Cork-tree bark (*Quercus suber*).—This is the inner bark of the cork tree, the cork growing on the exterior contains no tannin. It is imported from the Island of Sardinia, Tuscany, and the coast of Africa; the Sardinian is the best, and may easily be distinguished by its colour and weight, being of a pinkish hue throughout, and is stouter and heavier than the Tuscan or African. Cork-tree bark contains a great deal of tannin, but deposits little "bloom" on the leather.

There are four species of oak chiefly used for tanning in America. Spanish oak bark is thick, black, and deeply furrowed, and is preferred for coarse leather. In the southern states the Spanish oak grows to the height of 80 feet with a diameter of 4 or 5 feet at the trunk, while in the north it does not exceed the height of 30 feet.

The common red oak, abundant in Canada and in the Northern States, is very generally employed, though inferior in several respects to the other kinds.

The rock chestnut oak abounds in elevated districts. On some of the Alleghany mountains it constitutes nine-tenths of the forest growth; its bark is thick, hard, and deeply furrowed, but only the bark of the small branches and young trees is used in tanning.

Quercitron bark (*Quercus tinctoria*), or black oak, grows through the States; its bark is not very thick, but deeply furrowed, and of a deep brown colour, the leather tanned with it is apt to tinge the stockings yellow. This tree often attains a height of 90 feet, and a diameter of 4 or 5 feet.

There are other varieties used, but it is needless to mention them here.

Valonia, (*Quercus ægilops*).—Valonia is the acorn cup of the *Quercus ægilops*. See LEATHER.

Sumac of commerce is the crushed or ground leaves of *Rhus corriaria*, and is imported from Sicily. In making the usual ground sumac the larger branches or sticks are taken out by hand; the smaller ones do not pulverise, and are taken out by sifting, the stem of the leaves are put under the mill a secoud time. In grinding the calculation is that 333 lbs. of leaves turn out 280 lbs. of fine ground sumac.

There is naturally, or at least unavoidably, from 3 to 4 per cent. of sand or dirt in the leaves as sent to the mills; this can only be taken out before grinding, but if thoroughly done would cost 1*s.* 6*d.* cwt. additional, which the trade will not pay.

Mimosa bark, is the bark of a tree belonging to the order *Fabaceæ*, subdivision *Mimosæ*. It is imported from Australia and Tasmania, but is also abundant in the East Indies. Mimosa bark is difficult to grind, it is also difficult to extract the tannin; it deposits no bloom, and is, therefore, not much esteemed by English tanners, but is used in the East Indies to a large extent.

Gambir, or *terra japonica*.—This astringent substance, sometimes called catechu, is produced by boiling and evaporating the brown hard wood of the acacia catechu in water, until the inspissated juice has acquired a proper consistency; the liquor is then strained, and soon coagulates into a mass.

It is frequently mixed with sand and other impurities, has little smell, but a sweet astringent taste in the mouth, and is gritty if it is perfectly pure; it will totally dissolve in water, and the impurities will fall to the bottom. It is chiefly used in England as in the East Indies (whence it is imported) for tanning kips. It is mixed with valonia and sumac.

Larch bark is used for tanning basils (sheepskins), for bookbinding, &c., principally in Scotland, where the bark is more abundant, though it is also used in England and Ireland.

Birch bark is used for tanning Russia leather; it is also used by the Laplanders.

Hemlock bark (*Abies Canadensis*), is one of the principal barks used in America for tanning; it makes a reddish coloured leather, and not nearly so good as oak bark leather.

There is a large collection of tanning materials in the Museum at the Royal Gardens at Kew, collected by Mr. W. G. Fry of Bristol, to whom we are indebted for the practical part of this paper.—H. K. B.

TANTALUM. This is an exceedingly rare substance; it is found in the minerals *tantalite* and *yttro-tantalite*. It was first discovered by Mr. Hutchett, in a mineral brought from North America, and he called it, on that account, *columbium*.

Ekeberg discovered it in the Swedish minerals, and, considering it a *new* metal, he called it *tantalum*. Dr. Wollaston, in 1809, proved that Hutchett's *columbium* aud Ekeberg's *tantalum* were both the same substance.

It has not yet been applied to any commercial purpose. — H. K. B.

TAP CINDER. Puddling furnace slag. See IRON and SLAG.

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. See the several articles of CARPETS, LACE, TEXTILE FABRICS, WEAVING.

TAPIOCA. (*Manioc* and *Cipipa*, Fr.; *Weisse Sago*, Germ.) Tapioca is cassava meal, which, while moist or damp, has been heated, for the purpose of drying it, on hot plates. By this treatment the starch grains swell, many of them burst, and the whole agglomerates in small irregular masses or lumps. The drying to which it is subjected renders it difficult of solution. In boiling water it swells up, and forms a viscous jelly-like mass. See STARCH.

Tapioca *imported* in 1858, 9010 cwts.

TAR (COAL). A few years since Dr. Ure wrote as follows:—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. 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 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	3	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. By reference to the articles COAL-GAS, DESTRUCTIVE DISTILLATION, NAPHTHA, and others, it will be seen what chemistry has done with *coal-tar*. Every ton of coal distilled for gas yields from 10 to 12 gallons of tar. See TARTAR, WOOD.

TAR, 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. *Stockholm tar*, *Archangel tar*, and *American tar* come into our markets. According to Reichenbach, tar contains the peculiar proximate principles, *paraffine*, *eupion*, *creosote*, *picamar*, *pittacal*, besides pyrogenous resin, or *pyretine*, pyrogenous oil, or *pyroleine*, and vinegar. The resin, oil, and vinegar are called empyreumatic, in common language.

TARE, or VETCH, a plant—*Vicia sativa*—which has been cultivated in this country from the earliest times.

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, and for numerous other similar purposes.

TARSAS. See TRASS.

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 Montpelier, 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, 3½ parts of ground pipe-clay are introduced. The solution being well stirred and then settled, is drawn off into crystallising 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-crystallised, 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 potash, is thus obtained in hard clusters of small colourless crystals, which, examined by a lens, are seen to be transparent four-sided prisms. 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° Fahr. It is insoluble in alcohol. It consists of 24·956 potash, 70·276 tartaric acid, and 4·768 water. See Argol, Potash, Bitartrate.

TARTARIC ACID, (*Acide tartrique*, Fr.; *Weinsteinsäure*, Germ.) This is prepared by adding gradually to a boiling-hot solution of 100 parts of tartar, *bitartrate of potash*, in a large copper boiler, 26 of chalk, *carbonate of lime*, made into a smooth pap with water. A brisk effervescence ensues, from 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 syphon, 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, and elutriation 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. (spec. 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 crystallise. The crystals, being re-dissolved and re-crystallised, become colourless six-sided prisms. 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 supertartrate 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.

From the above description of the process of manufacture 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 be secured in this delicate manufacture.

The composition of tartaric acid, as determined by Berzelius, is carbon, 35·980; hydrogen, 3·807; oxygen, 60·213; or $C^4H^2O^5 + HO$. Liebig regards the equivalent weight as double that assumed, and considers the acid as a bibasic one; according to him, therefore, the formulæ for the crystallised acid is $C^8H^4O^{10} + 2HO$. Fremy has stated that crystallised tartaric acid lost by heating first $\frac{1}{2}HO$, being converted into *tartralic acid*; that it then, by the loss altogether of 1HO, changed into *tartrelic acid*; and that at last, by losing 2HO, it became anhydrous tartaric acid. Various metamorphoses have been stated to occur in tartaric acid upon exposing it to heat. Laurent, Gerhardt, and Pasteur have investigated this matter, and have given the names of *metatartaric acid* and *isotartaric acid* to two of the results. Another acid has been investigated by Arppe, the *pyrotartaric acid*. According to Millon and Reiset, the best mode of preparing it is to distil powdered tartaric acid with powdered pumice-stone. The aqueous is separated from the oily distillate by a wet filter, and evaporated at a gentle heat, till it commences to crystallise. The crystals are digested in nitric acid, then fused to expel the nitric acid, and thus the pure pyrotartaric acid $HO,C^5H^3O^3$ is obtained.

TARTRATES, are bibasic salts composed of tartaric acid and oxidised bases, in equivalent proportions. Some of the tartrates are employed in the arts, bitartrate of potash being used as a mordant in dyeing woollen fabrics. Tartrate of chromium is sometimes used in calico printing, and the tartrate of potash and tin in wool dyeing.

The Stockholm tar is regarded as the best; we have a description of the mode in which it is prepared, by Dr. Clarke, in his *Travels in Scandinavia*.

"The situation most favourable to the process is in a forest near to a marsh or bog, because the roots of the fir, from which tar is principally extracted, are always most productive in such places. A conical cavity is then made in the ground (generally on the side of a bank or sloping hill), and the roots of the fir, together with logs and billets of the same, being neatly trussed in a stack of the same conical shape, are let into the cavity. The whole is then covered with turf to prevent the volatile parts from being dissipated, which, by means of a heavy wooden mallet and wooden stamper, worked separately by two men, is beaten down and rendered as firm as possible about the wood. The stack of billets is then kindled, and a slow combustion of the fir takes place as in working charcoal. During this combustion the tar exudes, and a cast-iron pan being at the bottom of the funnel, with a spout which projects through the side of the bank, barrels are placed beneath this spout to collect the fluid as it comes away. As fast as the barrels are filled they are bunged and ready for immediate exportation.

Wood tar is obtained as a secondary product in the manufacture of acetic acid, in the dry distillation of wood.

Tar *imported*, in 1858, 10,107 lasts.

TAWING, is the process of preparing the white skins of the sheep, doe, &c. See Leather.

TEA (*Thé*, Fr.; *Thee*, Germ.). *Thea*, the tea plant, belongs to the natural order of Lindley *Ternströmiaceæ*. Considerable discussion has taken place with reference to this important substance, some contending that green and black tea are the productions of two different plants, the *Thea viridis* producing the green tea, and the *Thea Bohea* the black tea. There is a third variety, the *Thea Assamensis*, or Assam tea, which appears to resemble both the others. Mr. Fortune appears to have proved that the green and black teas of commerce do not depend upon specific differences, but that in the northern tea districts of China the black and green teas are both obtained from the same species or variety, namely, the *Thea viridis*, while in the Canton tea districts both the varieties of tea are made from the *Thea Bohea*.

The quality of the tea depends much on the season when the leaves are picked, the mode in which it is prepared, as well as on the district in which it grows. Green tea, it is stated, is coloured by the application of an extract of indigo, of Prussian blue, and gypsum, and that the fine odour which renders the "flowery" kinds remarkable is derived from the leaves of *Olea fragrans*, a species of camellia, and other similar plants.

To the black tea belongs the varieties known as *Bohea*, *Congou*, *Campoi*, *Souchong*, *Caper*, and *Pekoe*.

To the green tea, *Twankay*, *Hyson-skin*, *Hyson*, *Imperial*, and *Gunpowder*.

According to Frank, black and green teas are composed as follows: —

	Black.	Green.
Tannin - - - - - -	40·6	34 6
Gum - - - - - - -	6·3	5·9
Woody fibre - - - - - -	44·8	51·3
Glutinous matter - - - -	6·3	5·7
Volatile matter and loss - - -	2·0	2·5
	100·0	100·0

Sir Humphry Davy found more tannin in black than in green tea. This appears contrary to our experience, the astringency of green tea being much greater than that of black tea. Mr. Brande remarks, in the *Quarterly Journal of Science*, "Some years ago I examined the varieties of tea in common use, and found that the quantity of astringent matter precipitable by gelatine is somewhat greater in green than in black tea, though the excess is by no means so great as the comparative flavours of the two would lead us to expect. The entire quantity of soluble matter is also greater in green than in black tea; but the extractive, not precipitable by gelatine, is greater in the latter.

Brande, in his *Manual of Pharmacy*, has given a table from which the following facts are extracted: —

100 parts of Tea.	Soluble in water.	Soluble in alcohol.	Precipitated by jelly.	Insoluble. residue.
Green Hyson — Best -	41	44	31	56
„ Medium -	34	43	26	58
„ Lowest -	31	41	24	57
Black Souchong—Best -	35	36	28	64
„ Medium -	37	35	28	63
„ Lowest -	35	31	23	65

The most remarkable products 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. of 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 sub-acetate of lead.

Dr. Ure 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 $C^8H^5N^2O^2$, 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, Dr. Ure states that he succeeded in obtaining a proportion of theine far more considerable than he at 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 recrystallisation 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 he obtained from 50 grammes of gunpowder tea 1·92 grammes of crystallised theine, which is equal to 3·84 per cent.

But there remains a syrupy liquid which still contains some theine. This he determined by means of a solution of tannin of known strength, which precipitates it alone, and entirely, if the liquid be cold and accurately neutralised with ammonia as the tannin is added.

On adding the fresh quantity of theine, isolated by this reagent, to that obtained as crystals, 100 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. It is 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 4·30 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 30 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.

Dr. Ure found it impossible to separate the whole of this caseine from the tea. He 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, Dr. Ure 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.

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 three 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-cha.

*The Chinese method of making Black Tea in Upper Assam.**—In the first place, the 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 cast-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 burned. 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 smartly 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 on 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

* By C. A. Bruce, superintendent of tea culture.

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 slighest 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.

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 *caffeine*), 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 *caffeine* 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.—See THEINE. Consult *Ure's Dictionary of Chemistry.*

Our Imports of Tea have been as follows:—

	lbs.		lbs.
1844 - - -	53,147,078	1852 - - -	66,360,535
1845 - - -	51,056,979	1853 - - -	70,735,135
1846 - - -	54,767,142	1854 - - -	85,792,032
1847 - - -	55,624,946	1855 - - -	83,259,657
1848 - - -	47,774,755	1856 - - -	86,200,414
1849 - - -	53,459,469	1857 - - -	64,493,989
1850 - - -	50,512,384	1858 - - -	75,432,578
1851 - - -	71,466,421		

TEAK. The produce of the *Tectona grandia;* a native of the mountainous parts of the Malabar coast, and of the western shores of Africa; but the African teak is thought by some to be another genus,

We *imported* in 1858, from Sierra Leone, - - - - - 7,819 loads.
British East Indies, &c. - - - 37,895 ditto.

45,714

TEASEL, or FULLERS' THISTLE. (*Chardon à carder*, Fr.; *Weberdistel*, Germ.; the head of the thistle, *Dipsacus*), is employed to raise the nap of cloth. See WOOLLEN MANUFACTURE.

Teasels—number *imported* in 1858, 14,472,432.

TEEL OIL. See OILS.

TEETH. Dr. Robert Dundas Thomson has published the analyses of teeth by Alexander Nasmyth, Esq. The following Table has been constructed from those analyses:—

	Enamel. Human adult.	Enamel. Elephant.	Ivory. Human adult.	Ivory. Elephant.	Bone. for comparison.
Organic matter	6·160	6·80	26·81	45·65	35·93
Phosphate of lime	89·160	82·55	66·42 }	52·30	51·12
Fluoride of calcium	·260	1·65	0·62 }	—	0·63
Phosphate of magnesia.	—	—	—		—
Carbonate of lime	4·010	7·65	5·63	1·35	9·77
Chloride of sodium } Cloride of potassium }	—	1·05	0·15	0·06	0·59

Teeth imported in 1858.

	Cwts.	Computed real value. £.
Elephant, Sea Cow, Sea Horse, or Sea Morse - -	12,279	410,608

TELEGRAPHS. See ELECTRO-TELEGRAPHY.

TELLURIUM. One of the elementary bodies known to chemists. It is usually classed amongst the metals, but it presents so great an analogy to sulphur and selenium that many are disposed to remove it from the metallic bodies.

Tellurium was originally found in Transylvanian gold ores; and more recently it has been found with bismuth. Tellurium has a silvery lustre, its texture is crystalline and brittle. From its extreme rarity, and consequent cost, it has not yet found any application in the arts.

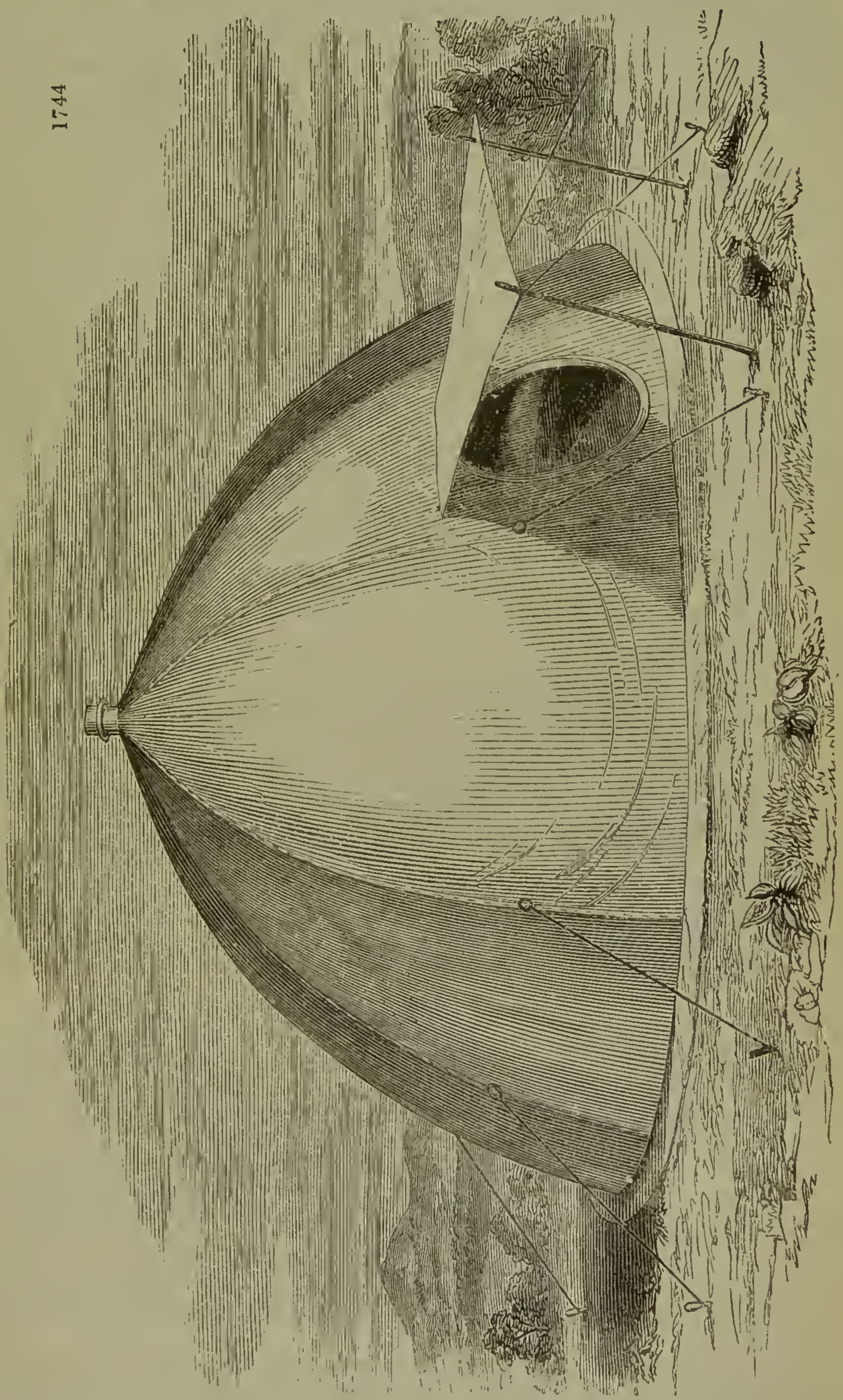
TENT. A portable lodge, consisting of canvas sustained by poles and stretched by cords, used for sheltering men, especially soldiers in camp, from the weather. Tents were commonly used in the earliest periods of man's history. The patriarchal tribes dwelt in tents. Layard describes one of the sculptured stones at Mosul as representing Sennacherib seated on a throne, placed at the entrance of a city. Behind the king was the royal tent supported by ropes, and an inscription, signifying "This is the *tent* of Sennacherib, King of Assyria." This was 700 years before Christ. We learn that Paul was a tent-maker, therefore in those days it was an important calling. The armies of Rome, of the Crusades, and the hosts which have through every age gone forth to the "shock of battles," have ever lodged in tents.

We have no space to enter into the history of tents or describe the varieties which have been used from time to time. A few words on modern tents must suffice:—

The hospital marquee is 29 feet long and 14½ feet wide and 15 feet high. This is supposed to accommodate not less than eighteen or more than twenty-four men. The height of each tent-pole is 13 feet 8 inches; the length of the ridge-pole 13 feet 10 inches; the height of the tent walls from the ground 5 feet 4 inches. The weight of all the material of such a tent is stated by Major Rhodes to be 652 lbs.

Of the *circular single-poled tents* we have two kinds, the new cotton circular tent,

1744

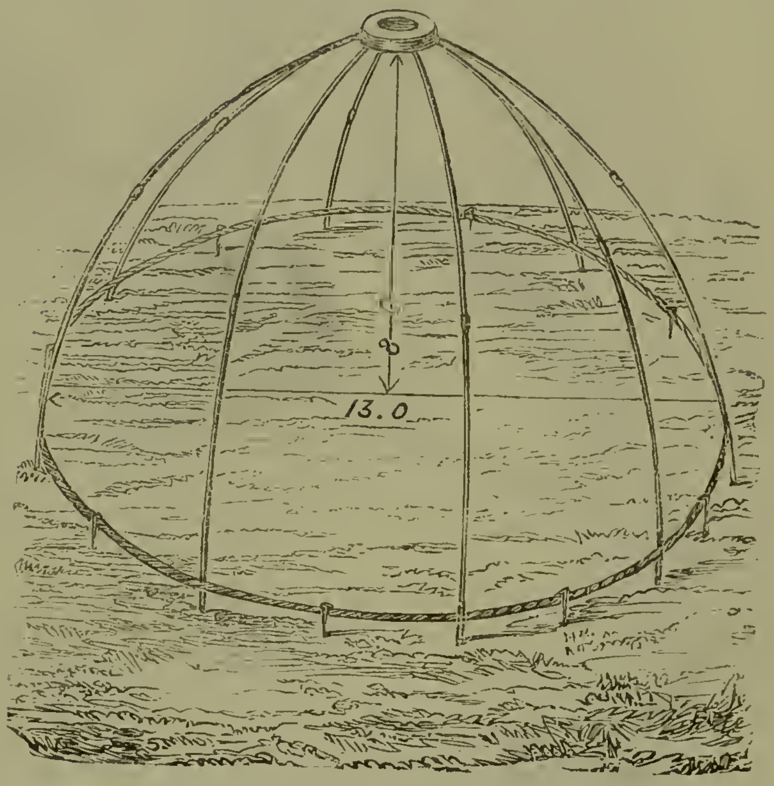


and the new pattern linen circular tent; each tent is provided with a vertical circular wall; that of the cotton tent is 2 feet 6 inches in height, and that of the linen tent is

1 foot. The diameter of each tent is 12 feet 6 inches; the length of the pole about 10 feet. Such a tent accommodates sixteen men.

Major Godfrey Rhodes has introduced a new and improved tent, which has no centre-pole. The frame of the tent is formed of stout ribs of ash, bamboo, or other flexible material. The ends of the ribs are inserted into a wooden head, fitted with iron sockets, and the butts are thrust into the ground, passing through a double twisted rope, having fixed loops at equal distances. The canvas is thrown over this frame-work, and secured within the tent by leather straps to the ground, or circular rope. The present hospital tent, when pitched, covers about 340 square yards. Major Rhodes' hospital tent covers only 63 square yards, and weighs 395 lbs., while it accommodates an equal number of men. The field tent is made up in one package, 5 feet 6 inches long, weighing 100 lbs.; the guard tent into one package 7 feet 6 inches long, weighing 52 lbs. The accompanying cuts, *figs.* 1743, and 1744, show

1745



Major Rhodes' field tent and the frame thereof. The difference, as it regards weight and convenience, in those tents introduced by Major Rhodes, is very great. We regret our space will not admit of more detail; this, however, is somewhat compensated, by the ample detail to be found in a book, *Tents and Tent Life*, published by the patentee.

The ventilation of tents has been admirably effected by Mr. Doyle, to whom we are indebted for the information contained in the following notes on the subject.

The old method of ventilating military tents was very defective. Ventilating openings were made at the top of the tent, but no means were provided for the admission of fresh air. The result was most unsatisfactory, as may be gathered from the following evidence given before the Sebastopol committee: —

"The tents were very close indeed at night. When the tent was closed in wet weather, it was often past bearing. The men became faint from heat and closeness." *

The problem then was to let in fresh air, and produce a draft without inconveniencing the soldiers as they slept.

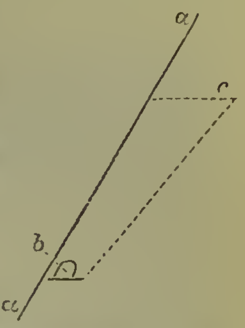
The question attracted Mr. Doyle's notice during the period of the camp at Chobham, and it appearing to him to be one of very great importance, he undertook, with the sanction of Lord Raglan, then Master-General of the Ordnance, to try the following experiment.

He caused two openings to be made in the wall of a tent, about 4 feet from the ground, and introduced the air between the wall and a piece of lining somewhat resembling a carriage pocket, thus: *a a*, the wall of the tent; *b*, the opening to admit air; *c*, the lining.

* Evidence of Sergeant Dawson, Grenadier Guards.

It will be seen that air so introduced would naturally take an upward direction, and that this communicating with the openings at the top of the tent, would probably produce the desired effect.

1746



The following extract from the report on this experiment will show the actual result:—

"The ventilators (Mr. Doyle's) were found of great use in clearing the tent of the fetid atmosphere consequent upon a number of men sleeping in so confined a space. The men state that the heavy smell experienced before the tent was altered is almost banished."

In subsequent experiments the number of the new openings was increased from two to three, and a greater amount of ventilation thus obtained. The result, according to an official letter of thanks received on the subject, was "quite successful." The improvement has been since adopted into the service, and by these very simple means one of the most fruitful causes of sickness among our soldiers in camp finally removed.

TENT, a wine, so called from the Spanish *tinto*—deep coloured—it being of a deep red colour. It comes chiefly from Galicia, or Malaga. See WINE.

TERRA COTTA. This term means literally *baked clay*. It is known in the arts as the name of the ancient vases, amphoræ, pateræ, lamps, statues, and bas-relievi. Monumental vases of terra cotta have been found in the tombs, after the lapse of 2,000 years, in a fine state of preservation. The ancient terra-cotta vases are generally painted black, on a red or buff ground; but on some there are blue, yellow, and other colours. The style of ornamentation is much alike in all — a few narrow lines, or fillets, with dots, meander fretwork, laurel, ivy leaf, and honeysuckle borders, adorning the rim, neck, and staud of the vases, the centre or body being covered with allegorical representations of gods, men, and animals. Terra cottas of the type of the early Greek, commonly called Etruscan vases, are found throughout the ancient Egyptian cities. The art of making the Greek terra cotta seems to have become extinct about 150 years before Christ. The modes in which the Greek works were made have been subjects of much controversy among the learned in art. The body, or substance, appears to a potter, in a commercial point of view, of the lowest grade, as it is common clay, very porous, and coarse-grained. By some authors it is said they were made of clay, mixed with sand only, and by others, with clay mixed with cement. The most probable conclusion is, that some were made of clay only, some of clay and sand, and others (such as those of a ground and monumental character, where it was important that the parts should be kept very true in firing), of clay mixed with potsherds and puzzolano or other detritus of lava. The works are less baked than modern pottery, and it is doubtful if it would stand exposure to the variations of such a climate as England. Among the remains of Greek pottery are gigantic amphoræ of very coarse grain, measuring as much as 8 feet in length by three feet in diameter, and of corresponding thickness. It is said that one of these great vessels was the tub of Diogenes. Vauquelin gives the following analysis of the Greek terra-cotta vases:—

Silica	53
Alumina	15
Lime	8
Oxide of iron, &c.	24
	100

The Roman terra cottas are of an entirely different character to those just described, and consist chiefly of cinerary urns, lamps, and pateræ; and these appear to have been moulded; the ornament is either incised or embossed, and odd fantastic shapes prevail.

Terra-cotta works of an architectural character are constantly met with in the buildings erected in Italy between the 12th and 17th centuries. The clay sketches and models of Michael Angelo, and other great sculptors, were rendered in terra cottas. Bramante employed terra cotta in decoration.

The merit of reviving in England the manufacture of terra cotta belongs to Josiah Wedgewood, who in 1770 established large works in Staffordshire. About 1790 a pottery was established at Lambeth for the manufacture of decorative works; and terra cotta was made for many years by a lady of the name of Coade, and afterwards by Coade and Sealey. The chief materials used by them were the Dorset and Devonshire clays, with fine sand, flint, and potsherds. The chief portion of the old coats of arms above the shop fronts of London were made of this terra cotta. Between 30 and 40 years ago, Mr. Babb, the sculptor, had a manufactory for terra cotta. The frieze of the Opera, in the Haymarket, is an example of his work.

To explain the mode of executing any work in terra cotta, it is best to describe the proper meaning of the words modelling, moulding, and casting.

A model is an original work made by the sculptor in clay, and worked out by the fingers and small tools made of bone and steel, varying from about 6 to 10 inches in length. This original work of the artist is allowed to dry, and then the moulding operation commences. This process is effected by mixing plaster of Paris with water to the consistency of thick cream; this is spread over the model, and when it has set it is removed in sections, which, when again carefully united, form the mould, in which either clay or metal can be cast, and receive the form of the original work. For terra-cotta work, unless many copies of the original are wanted, moulds are not employed.

When only one or two copies of a work are required, the original models are built up in a cellular manner, they are then dried and removed to a kiln and baked, being a perfectly original work.

When moulding is performed for terra-cotta works, sheets of clay are beaten on a bench to the consistency of glazier's putty, and pressed by the hand into the mould; according to the magnitude of the work and the weight it may have to sustain, the thickness of the clay is determined and arranged, and here consists a part of the art it would be impossible to describe, and which requires years of experience in such works to produce great works and fire them with certainty of success. At the Crystal Palace, Sydenham, are several large works manufactured by Mr. J. M. Blashfield, who has extensive terra-cotta works at Stamford. The figure of Australia, modelled by John Bele, nine feet in height, and burnt in one piece; the colossal Tritons modelled by the same artist, and other works, are examples. After the moulded article has become sufficiently dry, it is conveyed to a kiln. A slow fire is first made, and quickened until the heat is sufficient to blend and partially vitrify the material of which the mass is composed; when sufficiently baked, the kiln is allowed to cool, and the terra cotta is withdrawn.

TERRA DI SIENNA is a brown ferruginous ochre, employed in painting, obtained from Italy. It is a hydrous sesquioxide of iron combined with traces of arsenic; from which we may infer it is derived mainly from the decomposition of arsenical pyrites. It is calcined before being used as a pigment, and is then known as burnt sienna. Raw sienna is not much employed; it contains water, which the calcined does not.

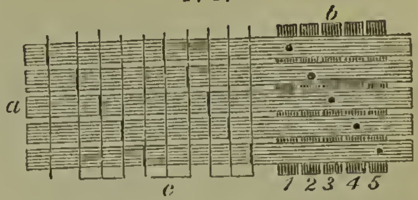
TERRA JAPONICA. See ACACIA, CATECHU.

Terra Japonica and Cutch *imported* in 1858, almost all from the British East Indies, 11,205 tons. Computed real value, 204,240*l.*

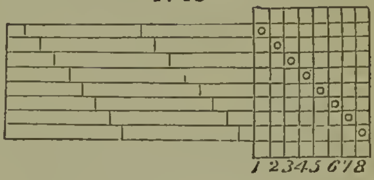
TESTS are chemical reagents of any kind, which indicate, by special characters, the composition of the body to which they are applied. Chemistry is based on the application of tests. See *Ure's Chemical Dictionary.*

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.* 1747, 1748, &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.* 1747 and 1748 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.* 1747, 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 connection 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 connection is carried directly from under the leaf to the treddle. To direct a weaver which of these connections 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 connections 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.* 1747 and 1748 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 ornamented 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 ciphers 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 1756; 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.

1747



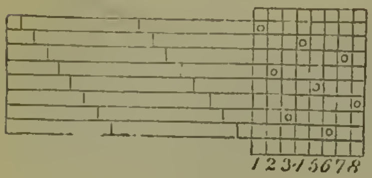
1748



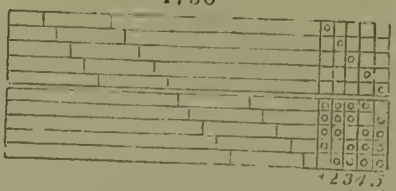
Some explanation of the various kinds of fanciful cloths represented by these plans may serve further to illustrate this subject, which is, perhaps, the most important of any connected with the manufacture of cloth, and will also enable a person who thoroughly studies them, readily to acquire a competent knowledge of the other varieties in weaving, which are boundless. *Figs.* 1747 and 1748 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.* 1748. 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. 1749 and 1750 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 ciphers

1749

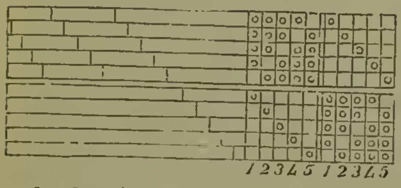


1750

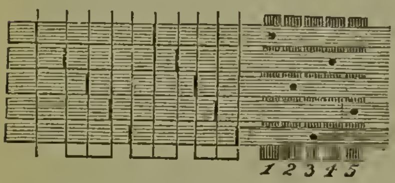


which mark the raising cords, and comparing them with those of the broken tweel of five leaves. *Fig.* 1751 represents the draught and cording of striped dimity of a tweel of five leaves. This is the most simple species of fanciful tweeling. It consists of ten leaves, or double the number of the common 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 versâ*. 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.* 1748. 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.* 1752.

1751



1752



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.* 1752, 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:—

1753

4		1		4		1		1		4		1	
	4		4		1		1		1		4		4

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. 1754 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.* 1747 *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.

1754

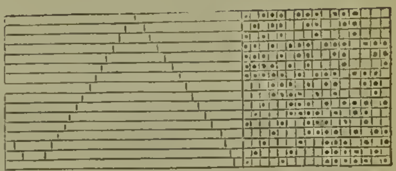


Fig. 1755 represents the draught of the diaper mounting, and the cording of the front leaves which are moved by treddles. From the plan, it will appear that five threads are included in every mail of the harness, and that these are drawn in single threads through the front leaves. The cording forms an 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 × are placed.

1755

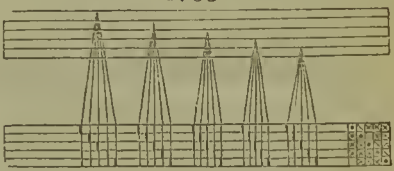
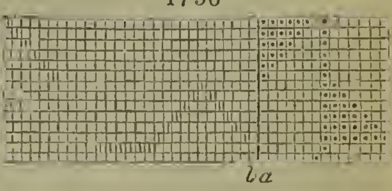


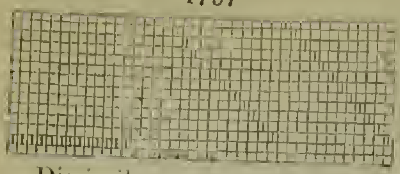
Fig. 1756 is the draught and cording of a spot whose two sides are similar, but reversed. That upon the plan forms a diamond, similar to the one drawn upon the design paper in the diagram, but smaller in size. The draught here is reversed, as in the dimity plan, and the treading is also to be reversed, 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 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.

1756



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-treddles 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.

1757



Dissimilar spots are those whose sides are quite different from each other. The draught only of these is represented by *fig.* 1757. The cording depends entirely upon the figure.

Fig. 1758 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 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 thickness of the cloth is double of that diameter. Denser cloth would not be sufficiently pliant or flexible.

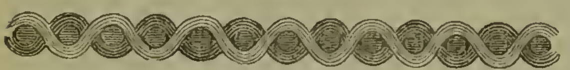
1758

1759

Fig. 1759 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.

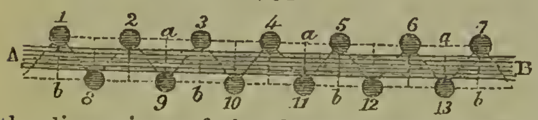
Fig. 1760 may be supposed a plain fabric of that description which approaches the most nearly to any idea we can form of the most dense or close contact of which yarn can be made susceptible. Here the warp is supposed to be so tightly stretched in the loom as to retain entirely the parallel state, without any curvature, and the whole flexure is therefore given to the woof. This mode of 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.

1760



In *fig.* 1761 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 A, B, 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 *b*, 2 *b*, &c., for those above, and in that of 8 *a*, 9 *a*, &c., for those below; but the contraction for A, B, by its deviation from a straight to a curved line, in consequence of the compression of the warp threads 1 *b*, 2 *b*, &c., and 1 *a*, 2 *a*, &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 A, B, if A is supposed to be placed at the middle of the cloth, equidistant from the two extremities, or *selvages* as they are called by weavers, the thread at 1 may be supposed to move really in the direction 1 *b*, and all the others to approach to it in the directions represented, whilst those to the right would approach in the same ratio, but the line of approxima-

1761

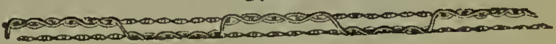


tion would be inverted. *Fig.* 1762 represents that common fabric used for lawns, muslins, and the middle kind of goods, the excellence of which neither consists in the greatest strength, nor in the greatest transparency. It is entirely a medium between *fig.* 1759 and *fig.* 1760.

1762

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.* 1763. See CARPETS.

1763



Of the simplest kind of tweeled fabric, a section is given in *fig.* 1764.

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.* 1761, we shall readily discover the very different way in which the tweeled fabric is affected.

1764

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.* 1765. In this figure, we have, as before, four threads, and one alternately intersected; but here the four threads marked 1 and 2 are under the woof, while those marked 3 and 4 are above.

1765

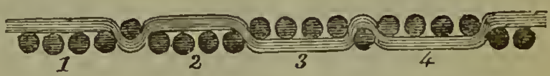


Fig. 1766 represents that kind of tweeled work which produces an ornamental effect, and adds even to the strength of a fabric, in so far as accumulation of matter can be considered in that light. The figure represents a piece of velvet cut in section, and of that kind which, being woven upon a tweeled 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.

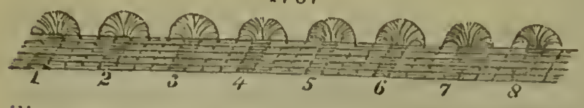
1766

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. 1767, 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.

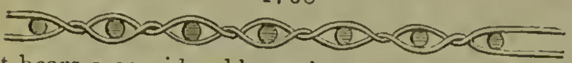
1767



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. 1768 represents common gauze, or *linau*, 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 versâ*, 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 weft 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.

1768



1769

Fig. 1769 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. 1770 is a superficial representation of the most simple kind of ornamental network 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.

1770

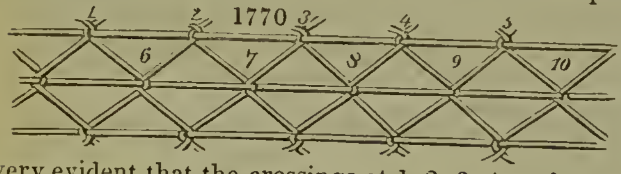
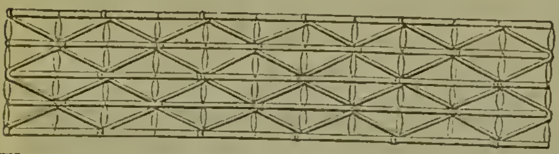


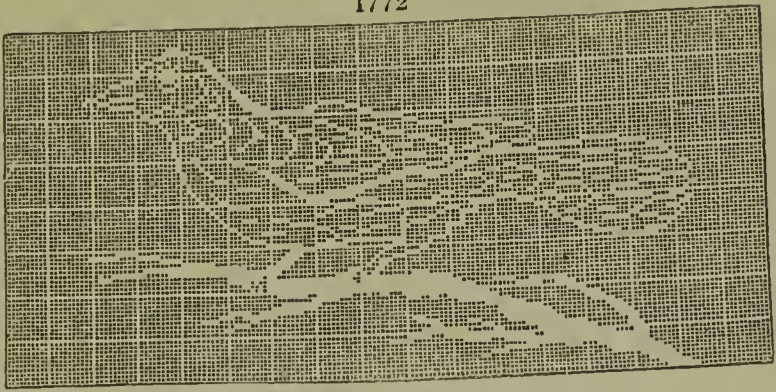
Fig. 1771 represents, superficially, what is called the mail-net, and is merely a combination of common gauze and the whip-net in the same fabric. The gauze here being in the same direction as the dotted line in the former figure, the whole fabric is evidently a continued succession of right-angled triangles, of which the woof forms the basis, the gauze part the perpendiculars, and the whip part the hypothenuses. The contraction here being very different, it is necessary that the gauze and whip parts should be stretched upon separate beams.

1771



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.* 1772, 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 con-

1772

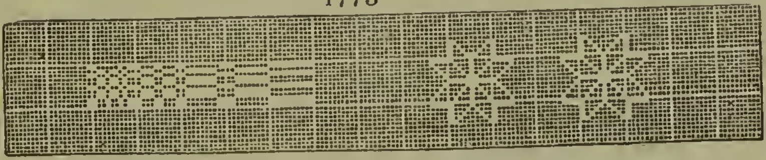


siderably bolder than the others. This number in the design is 135 spaces. Counting again, from the stem of the branch to the upper part of the bird's head, he will find 76 spaces. Between these spaces, therefore, the whole superficial measure of the pattern is contained. By the measure of the paper, this may be easily tried with a pair of compasses, and will be found to be nearly $6\frac{5}{10}$ inches in length, by $3\frac{3}{16}$ 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.

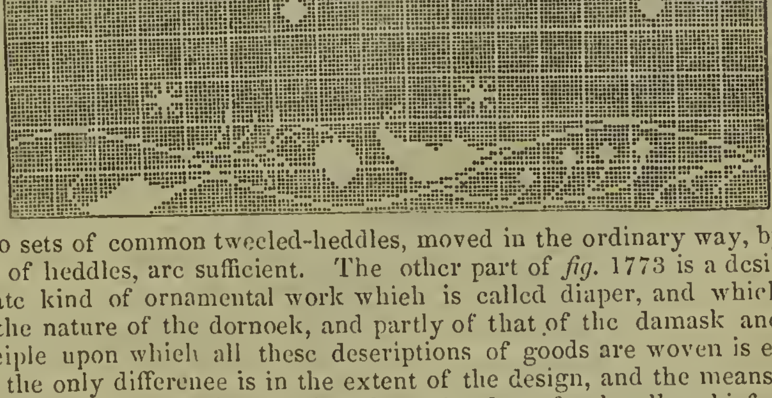
Fig. 1773 is a representation of the most simple species of table linen, which is

1773



merely 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

1774



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.* 1773 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 extent of the design, and the means by which it is executed. *Fig.* 1774 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 plan of transforming cotton and flax into fibres of a fine silky texture, while their strength and substance are increased, excited much interest a few years since. He subjected 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 produced 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, "soured," 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.

THALLOGENS. See Exogenous.

THEBAINE. $C^{38}H^{21}NO^{6}$. One of the numerous alkaloids contained in opium.

THEINE. Syn. *Caffeine.* $C^{16}H^{10}N^{4}O^{4}+2$ aq. A feeble base contained in tea, coffee, and, in fact, in most of the plants used in the manner of tea; such as Paraguay and Guarana tea. The following are the percentages in the various teas and coffees, with the names of the observers:—

Teas	Hyson	2·5 to 3·4	Peligot.
	Gunpowder	2·2 to 4·1	"
	Paraguay	0·13	Stenhouse.
Coffees	Martinique	·36	Rabiquel and Boutron.
	Mocha	·21	"
	Cayenne	·20	"

THENARD'S BLUE, or COBALT BLUE, is prepared by digesting the oxide of cobalt with nitric acid, evaporating the nitrate of cobalt formed, almost to dryness, diluting it with water, and filtering, to separate some arseniate of iron, which usually prec pitates. The clear liquor is to be poured into a solution of phosphate of soda, when 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. It is extracted by boiling with water, filtering, precipitating with acetate of lead, seperating 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 recrystallisation. It is little soluble in water or alcohol.

THERMOMETER. An instrument used, as its name signifies, as a measure of heat. A description of this valuable instrument belongs to physics. The principle upon which it is constructed depends upon the expansion of some fluid or solid by heat. In all bodies the rate of expansion is uniform for equal increments of heat; therefore we may adopt any body as our heat measurer, if we determine by previous experiments the rate of expansion to which it is subject, and construct a fixed scale. Usually either mercury or spirits of wine are employed.

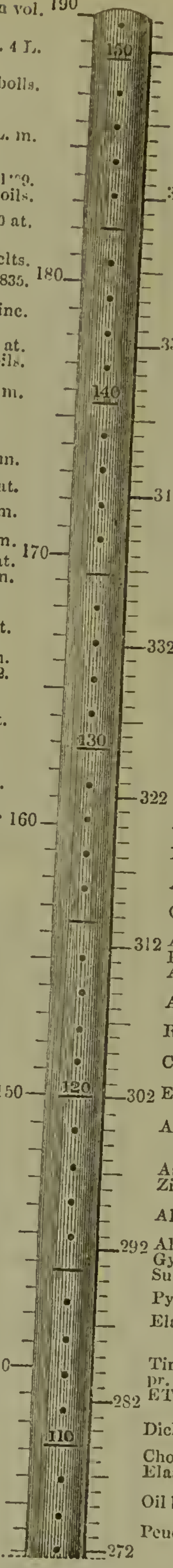
Thermometrical Table, by Dr. Alfred S. Taylor, F.R.S.—The accompanying thermometrical table of Dr. A. Taylor has been copied from a thermometer in his possession, graduated on the scales of Fahrenheit, Reaumur, and Celsius, or the Centigrade. It has been designed to obviate the necessity for those perplexing 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.

THERMOMETER.



CENTIGRADE.

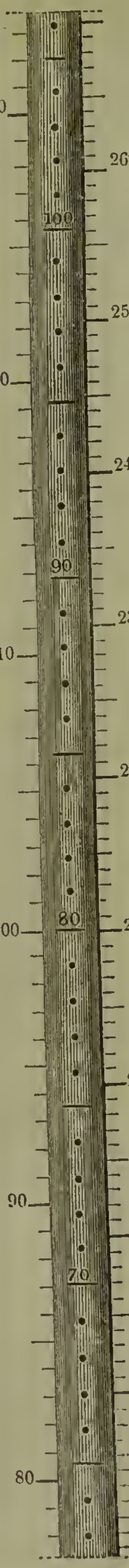
190 Chlor. Cyanogen vol.
Tin and lead, p. æ. m.; also Alloy 18 T. 4 L. (Plumbers' solder).
Sat. sol. Chloride zinc boils.
Alloy 4 T. 1 L. m.
Oxalic ether, b. 1·09.
Sulphuric acid, 1·67 boils.
pr. steam, 10 at.
Paranaphthaline, m., alloy 12 T. 4 L. melts.
180 Oil of oranges, b. 0·835.
Starch converted to dextrine.
pr. steam, 9 at.
Elast. Turp., v. 53·8. Sulphuric acid 1·65 boils.
Alloy 10 T. 4 L. m.
Alloy 9 T. 4 L. m.
pr. steam, 8 at.
Alloy 8 T. 4 L. m.
Alloy 7 T. 4 L. m.
170 pr. steam, 7·5 at.
Alloy 1 B. 2 T. m.
pr. steam, 7 at.
Alloy 8 B. 28 L. 24 T. m.
Oil elemi, b. 0·852.
pr. steam, 6·5 at.
Elast., A. V. 137. 28.
pr. steam, 6 at. Fusible. Alloy 8 B. 32 L. 36 T. m.
160 Alloy 8 B. 32 L. 34 T. m.
Elast. A. V. 131·57.
Fulminating silver explodes.
pr. steam, 5·5 at.
Elast. A. V. 125·85.
Elast. Turp. v. 33·5.
pr. steam, 5 at.
Elast. A. V. 120·03.
Elast. Turp. v. 30. Sat. nit. lime boils.
Sulphur burns feebly.
Elast. A. V. 114·15.
150 Terbromide Silicon, b.
...huric acid, and 1 pt. water mixed; pr. steam, 4·5 at.
Mastich resin, m.
Alloy 8 B. 16 L. 18 T. m.
Elast. A. V. 108·31; Temp. of certain factories.
Nicotine distils.
pr. steam, 4 at.
Elast. A. V. 102·45.
Fulminating gold explodes.
Alloy 8 B. 16 L. 14 T. m.
pr. steam, 3·5 at.
140 Chlor. cyanogen, m.; S. G. 1·32.
Grape sugar to Caramel.
Elast. A. V. 90·99.
Sat. nit. ammonia boils.
pr. steam, 3 at.
Pimelic acid, m.; Elast. A. V. 79·91.

REAUMUR.

FAHRENHEIT.

pr. steam, 12 at.
372 Zinc pulverisable.
Arsenious acid vol.; Saliculous acid b.
Phenic or carbolic acid boils.
Dichlor. carbon, b. d. v. 4·7.
pr. steam, 11 at.
Fulminating mercury explodes.
Alloy 15 T. 4 L. m.
362 Alloy 14 T. 4 L. m.
Elast. Turp. V. 60·8.
Alloy 13 T. 4 L. m. Aniline boils.
Paranaphthalin or anthracene m.
Arsenic vol.; sugar melts; hydruret of benzule m.
Succinic acid melts.
Gun cotton explodes.
352 Alloy 8 B. 32 L. 24 T. m.; Citrilene b. 0·88.
Alloys 5 T. 4 L., and 11 T. 4 L. m.
Sulphuret solid; iodine boils, d. v. 8·69.
Malic acid m.
Alloy 8 B. 32 L. 26 T. m.
Oil of lemons boils, 0·818.
Oil of Cascarilla b. 0·938. Sulphide Nitrogen explodes.
Alloy 8 B. 30 L. 24 T. m.
312 Caoutchoucine boils.
Elast. Turp. V. 47·3.
Kakodyl b.
Sat. acet. potash boils; cupion b.
Alloy 6 T. 4 L. m.
332 Alloy 8 B, 32 L. 28 T. m.
Oxalic acid vol.; elast. turp. V. 42·1
Alloy 8 B. 32 L. 30 T. m.
Alloy 8 B. 32 L. 40 T. m.
322 Alloy 8 B. 32 L. 38 T. m.
Naphtha boils; alloy 8 B. 26 L. 24 T. m., also 8 B. 32 L. 32 T
Prussian blue decomposed.
Alloy 8 B. 16 L. 24 T. m.
Oil of turpentine boils 0·86; dens. V. 4·7.
312 Alloy 8 B. 16 L. 22 T. m.
Kinic acid m.
Alloy 8 B. 20 L. 24 T. m.; oil juniper b.
Alloy 8 B. 22 L. 24 T. m.
Rect. petroleum b.
Carb. pot. sat. boils. {Alloys 8 B. 16 L. 10 T. and 8 B. 16 L. 20 T. m.
302 ETHERIFICATION ends; latent heat; ether vap.
Alloy 8 B. 16 L. 8 T. m.; camphilene b. 86.; sugar of milk m.
Asphaltum melts; camphor melts, d. v. 5·31.
Zinc malleable.
Alloy 8 B. 16 L. 12 T. m.
292 Alloy 8 B. 16 L. 16 T. m.
Gypsum converted to plaster.
Sulphuric acid, 1·52 b.
Pyroxanthin m.
Elast. A. V. 96·64.
Tin and bismuth, p. æ. melt; succ. acid vol.
pr. steam locomotive boilers.
282 ETHERIFICATION begins.
Dichloride sulphur b.
Cholesterine melts.
Elast. A. V. 85·47.
Oil black mustard b.; maleic acid m.
Peucyl b. 0·86.
272

CENTIGRADE. REAUMUR. FAHRENHEIT.



CENTIGRADE.

Chloride benzoic, m.
130 Phloridzine solid. Alloy, 8 B. 10 L. 8 T. m.
Camphoric acid v.
pr. steam, 2·5 at.
Elast. A. V. 69·72.
Sebacic acid m; Elast. alch. v. 155·2.
Sat. mur. ammonia boils.
Sat. acet. soda boils.
Pyromeconic acid m.
Elast. A. V. 60·05.
pr. steam, 2. at.
120 Cinnamic acid m.; caoutchouc melts.
Alloy 5 B. 1 L. 4 T. m.
Sat. nit. soda boils.
Sat. chlor. stroutium boils.
Elast. A. V. 51 34.
Syrup boils 86 per cent.; chlor. calcium sat. boils.
Sat. nit. potash 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. 43·24.
110 Elaene b.; Elast. alch. v. 94·1.
Phloridzine m.
Elast. A. V. 39·59.
Alloy, 8 B. 8 L. 3 T. m.
Oxalhydric acid, b. 1·375.
Water of the Dead Sea boils.
...t. carb. soda, chlor. of barium, and chlorate potash boil.
Salicine m.; nitric acid, 1·16 b.
Sat. chlor., calcium, boracic acid b.
Mur. acid, 1·136 b.
Syrup boils 52 per cent. sugar.
Chlor. aluminum boils; water boils, bar. 31 213·76.
Glauber salt sat. boils.
100 c. i. 1 pt. ice; 4 sulphuric acid; pr. steam, 1 at.
100 air at 32°=137·5.]
Elast. A. V.=30 S. G. 625.] Water boils bar. 29 in.
Chloride uitrogen. 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. 23·64.
W. B. MEXICO.
7471 ft. el.
90 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. 1·24.
W. B. source of Oxus, CENTRAL ASIA.
(15,600 ft. elev.)
Elast. A. V. 15·15.
Geyser Springs, Iceland.
Elast. A. V. 14·2.
80 Heat of fluid. bees wax.
Elast. alch. vap. 30 in. S. G. 0·813.

FAHRENHEIT.

Syrup sat. boils.
Corrosive sublimate volatilized.
Chloride of arsenic b.
Elast. A. V. 74·79.
Margaritic acid; castor oil m.
Elast. alch. V. 166·1.
Syrup boils 89 per cent. sugar.
262 Sat tartrate potass boils.
Sat. nitrate potass boils; heat borne by Sir J. Banks and D... [Blagden
Hydriodic acid boils 1·7; also hydrobrom. acid, 1·5.
Elast. A. V. 64·82.; pimaric acid m.
Sat. acetate soda boils.
Alloy 8 B. 8 L. 6 T. m.
252 Nitric acid 1·42 boils.
Elast. alch. V. 132·3.; dichl. carbon v.
Benzoine melts; Hyd. acet. acid boils (Turner).
Elast. A. V. 55·54.
Heavy muriatic ether b.
Elast. alch, V. 118·2.
242 Alloy 8 B. 8 L. 6 T. m.
Quinia m.
Sulphuric acid 1·30 b.; pyrogallic acid m.
Veratrine and benzamide m.
Accumulated temp. of air, EDINBURGH.
Acet. acid 1·063 boils; nit. acid 1·30 b.
Sat. mur. ammonia boils.
Syrup boils 84 per cent. sugar.
232 Sulphur melts, d. v. 6·65; benzoine m.
Benzoic acid melts, d. v. 4·27.
Salicine m.
Zinc malleable; heat borne by Delaroche.
Sat. chlor. sod. boils.
Sat. chlor. pot. boils.
Sat. nit. strontia boils.
Sat. phos. soda boils.
222 Muriatic acid 1·047 b.; Elast. A. V. 36·25.
Accumulated temp. of air, GENEVA.
Asphaltum soft; iodine melts; elast. ether V. 240.
Phosphorus distils.
Elast. A. V. 33·09 inches mercury; grape sugar m.
Osmic acid volatilized. Sulphocyanic acid b.
Sylvic acid m.
Water boils 1054 ft. dep.; selenium melts; water boils, bar...
Water boils, 328 dep.; W. B. DEAD SEA and SEA of T... [R...
212 Water boils bar. 30.
Water boils 531 ft. elevation.
Water boils 1064 ft. elevation; osmic acid melts.
Water boils 1600 ft. clevation; Reikiavik spr.
Water boils 2138 ft. elevation.
Water boils 2678 ft. elevation; alloy 8 B. 6 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 5415 ft. elevation.
Fusible metal, 8 B. 5 L. 3 T. m.; chloral b. d. v. 5.
Elast. alch. vaps. 53.
W. B. St. Gothard, 6807 ft. elevation.
W. B. Mt. William, AUSTRALIA, 8200 ft. el.
Water boils at Quito, 9341 ft. el.
Sodium melts; Trinchera springs S. AMERICA.
192 Water boils summit of Etna, 10,955 ft. elev.
Elast. ether vap. 124·8; alch. vap. 43·2.
Alcohol b. 0·967, 25 per cent.
Nitric acid 1·522 boils; alcohol b. 0·958, 30 pr. c.
Ozockerite m.
182 Water boils Mont Blanc summit, 15,630 ft. el.
San Germano bath, NAPLES.
Starch dissolves; alch. b. 0·870, 71 per cent.
AIX LA CHAPELLE, spr. max. t.
Latent heat, petroleum vap., also oil turp.
Benzole, benzine, or phene b.
Alcohol boils, 0·835, 85 per cent.
Thermal spr., I. LUCON.
Alcohol boils, 0·794, also 0·812, 94 per cent. to 100.
172 Naphthaline melts.

CENTIGRADE. REAUMUR. FAHRENHEIT.

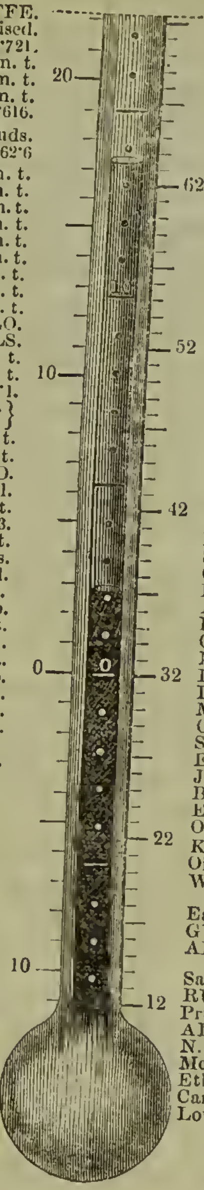
CENTIGRADE.

Pitch melts.
Vapour bath, FINLAND, max. t.
Perchlor. carbon vap. 1·55.
Helenine m.
Elast. A. V. 9·16; ether vap. 80·3.
Starch converted to sugar.
70 —
Baden Baden Springs, max. t.
CALPEE, INDIES, max. t.
BAGNERES DE LUCHON, spr.
Elast. A. V. 7·42., S. G. 0·17; ether, vap. 67·6.
Albumen opaline.
Elast. A. V. 6·87.
Heat of fluidity Spermaceti.
Heat of fluidity sulphur.
Vapour bath, RUSSIA.
Chloroform, b. d. v. 4·2.
Nitric acid (1·5) 58 pts. water, 12 pts. from 60°. 60 —
Mariana springs, S. AMERICA.
Elast. ether, vap. 51·9.
BARBARY max. t.
Abietic acid m.
Ammonia 0·936 b.
Elast. A. V. 4·2.
OASIS OF MOORZOUK, max. t.
FEZZAN, AFRICA, max. t.
Terchlor. silicon, b.
BAGNERES DE BIGORRE, spr.
Amalgam 8 B. 5 L. 3 T. and 3 mercury m. 50 —
Concent. sulphuric acid evaporates.
Palmitic acid m.
Hamman Ali springs, BARBARY.
PAMPAS, SOUTH AMERICA.
CENTRAL AFRICA, s. t.; BASSORA, max. t.
PONDICHERRY max. t.
Chloronaphthalese m.
ILOE, EGYPT, CAPE OF GOOD HOPE, max. t.
Myrtle wax m.
SENEGAL, s. t.
BAREGE, spr.
MADRAS, CAIRO, max. t.
40 —
Ournartok spring, GREENLAND.
Amylene b. GUADALOUPE, max. t.
PARIS 1793, EQUATOR, max. t.
Eupion b 0·65.
UANAXUATO MINES, 1700 ft. deep. 7034 ft. el..
MEXICAN MINES, max. t.
STRASBURG, VIENNA, max. t. *Man, min. t.
TEXAS, s. t.
MARTINIQUE, max. t.
STOCKHOLM, max. t.
Consol mines, CORNWALL, 1740 ft.
COPENHAGEN, WARSAW, max. t.
EAUX BONNES, Pyrenees.
max. t. of SURINAM.
ROCHAT, spr.
CAIRO, s. t.
IS. MALTA, EGYPT, m. s. t.
ychelles, max. t. PONDICHERRY, m. t. 30 —
Schlangenbad Spa.
CUMANA, m. t.
BRAZILS, m. t.; BARBARY m. s. t.
CEYLON, SENEGAL, BATAVIA, m. t.
MADRAS m. t.
, MANILLA, BENARES, HAVANNAH, m. t.
m. t.; ITALY, m. s. t. Date tree, VERA CRUZ.
tesian well (200 ft.), BRAZILS, JAMAICA, m. t.
RIO JANEIRO, m. t.
CANTON, MACAO, m. t.
BAGDAD, m. t.
Aldehyde, b ; CARACCAS, CAIRO, m. t.

FAHRENHEIT.

172 Ethylic alcohol b.
Elast. ether vap. 92·8, alch. b. 92 per cent. 0·817.
Elast. A. V. 11·5.
Phosphorus burns violently; acetic ether b.
Oil of cedar melts, Carlsbad Spa.
Elast. A. V. 10·4.
162 Heat of fluidity lead.
Albumen coagul.; acetic ether boils; Pisciarelli springs, [NAPLES.
Kochbrunnen, Wisbaden.
Stearic acid melts.
Elast. A. V. 8·4.
STEAM BOATS ENGINE ROOM, W. INDIES.
HECLA, EARTH AT SUMMIT.
152 Thermal spr., TAJURAH AND SHOA.
White wax melts; Pyrox. spirit boils.
Wiesbaden Spa; hydriod. ether b., S. G. 1·92.
Plombieres spr.
Ambergris m. Peroxide Chlor. explodes.
Ischia springs, NAPLES; Leuker spr. 5000 ft. el.
Aix-la-Chapelle Spa.
142 Chloroform boils.
Yellow wax melts.
Ammonia 0·94 boils; pyroxylic sp. b. 0·832; elast. A. V. 5·71.
Muriatic acid 1·19 boils.
UPPER EGYPT, in a tent; Arles spr.
Elast. A. V. 5·11.
Margaric acid melts.
Formic ether b., S. G. 915.
132 Acetone boils (pyroacetic spirit).
Oleene boils.
Potassium melts; vapour bath ends.
Berger in vapour bath 12 min.
Jorullo springs, S. AMERICA; MYNPOOREE, max. t.
Sands at S. Fernando, S. AMERICA, air 101°.
Stearic and oleic acids (mixed) melt, BELBEIS, EGYPT.
Mutton suet melts; Cauterets spr.
Katakekaumene spr.
122 Styracine m.
Stearine and cetine melt; myristic acid m.; elast. A. V. 3·33.
Bisulphide carbon b.
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. fowl; Cross bath at Bath.
*Birds, 108°, 111°.
Cold blooded animals die.
Temp. for incubation; elast ether vap. 30 inches.
*Sheep and pig, owl; phosphorus melts.
*Ape, dog, goat; artificial incubation.
102 *Animals, man, max. t.; ox, infant child.
*Squirrel, rat, cat, jackal, panther.
*Bat, hare, tiger, horse, elephant; elast. A. V. 1·86.
Warm bath ends, vapour bath commences.
*Temp. man, kite (birds).
Blood heat, hedgehog, dormouse.
{Tepid bath ends, warm bath begins.
{Ether boils 0·724; dens. V. 2·58.
Oil of roses melts; cocoic acid m.
92 PUTREFACTION rapid. Old palm oil m.
VALENCIANA MINE, MEXICO; Grenelle well, 1,794 ft.
Elast. A. V. 1·36; Poldice mine.
Tallow melts.
ACETOUS FERMENTATION.
PETERSBURG, max. t.; oil nutmegs m.
Kaisareyeh, ASIA MINOR, 4,200 ft. el.
Tepid bath begins, Cacao butter m. [1428 ft.
*Tortoise, Cornish mines, Buxton Spa, DALCOATH MINE
*Serpents, SEA EQUATOR, 83 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. [El. A. V. 1.
Frog, shark, flying-fish, scorpion (Tropics).
Insects, silk worms hatched, germination.
Bristol Spa, temp., wasp.
MEXICAN MINES, 1,650 ft. deep.: SYDNEY, s. t.
Glow worm, cricket; PRUSSIAN MINES, 880 ft.
Artesian well, GRENELLE, 1,300 ft. deep.
72 MONKWEARMOUTH MINE, 1,500 ft. deep.

CENTIGRADE. REAUMUR. FAHRENHEIT.



Centigrade side:

SANTA CRUZ, TENERIFFE.
Hypon. ether b.; iodine vaporised.
Aldehyd boils; Elast. A. V. 0·721.
Cotton tree; ALGIERS, m. t.
Gipps' 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. 62·6
TOULON, m. t.
Elast. A. V. 0·52.; ROME, NICE, m. t.
ILLE, I. (max. t.) NISMES, GENOA, LUCCA, m. t.
PERPIGNAN, MONTPELIER, m. t.
Waterford mines, 774 ft. dep. MARSEILLES, m. t.
ON, BOLOGNA, BORDEAUX, AIX, VENICE, m. t.
LYONS, VERONA, MILAN, m. t.
PAU m. t. LOWER 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.
t mines CRACOW, 730 ft.; Muriatic acid, 40 at. Liq.
Sulphur. hyd. 17 at; ammonia, 6·5 at
EDINBURGH, BERLIN, 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. 0·263.
CHRISTIANIA, DRONTHEIM, m. t.
Hybernation of animals.
PETERSBURG, m. t.; Etna sum. 10,955 ft. el.
KASAN, m. t.
POLAR SEAS 360 ft. deep.
BERGEN, PADUA, COLUMBIA, r. w. t.
V. m. t.; oils freeze. ALTEN, NORWAY, m. t.
acid liq. 36 at.), N.CAPE LAPLAND, LABRADOR.
Elast. A. V. 0·2 inches, S. G. 005.
CUMBERLAND, HO. N. A. m. t.
Earth, YAKUTSK, 350 to 382 ft. dep.
CHIMBORAZO, 18,500 ft. el.
MONT BLANC, 15,630 ft.
HIMALAYAS, 18,000 ft. el.
IRKUTSK, m. t.
SIBERIA, m. t.
Earth YAKUTSK, 77 ft. dep.
AIR m. t. POLAR SEA.
VA ZEMBLA, m. t., PORT ENTERPRIZE, w. t.
Anhyd. sulphurous acid boils.
Oil of turpentine freezes.

natural temperature at YAKUTSK in Siberia,
−72=84° below this scale.

CENTIGRADE TO FAHRENHEIT.

ove Ice. 1·8+32 — Between Ice and Zero. 32 (C×1·8) — Below Zero. C×1·8−32

Fahrenheit side:

Water boils in vacuo, *crab.
VINOUS FERMENTATION, butyrine melts, CAIRO W
DURHAM COAL MINES, 900 ft. [210 ft.
Cocoa nut oil liquid, Matlock bath, Grotto del Cane.
CORDILLERAS, ANDES, m. t. 5,000 ft. el.
Matlock springs, CUMBERLAND COAL MINES, 600 ft.
SAXON MINES, 1,246 ft.; Bakewell springs.
{MADEIRA, m. w. t.; air centre of Atl. waters of the Scan
{NAPLES, m. t. Temp. for sick rooms.
DEEP MINES, EUROPE; sea bank of Aguillas.
PARAMATTA, N. S. W. m. t.; ALGIERS, w. t.; sea Az
Fluoric acid boils, anhyd. chlorine liqfd. 4 at.
Acetic acid cryst.; Puy de Dome, 3,600 ft.
CAIRO w. t., MINES OF BRITTANY 500 ft., BERGEN
*Trout, MEDITERRANEAN SEA 2,000 ft. deep.
Vaucluse fountain, 360 ft. el.
Artesian well VIENNA, 200 ft.; Hanwell, 290 ft.
Camphor floats, elast. A. V. 0·44.
PIC DU MIDI, 9,560 ft.; JERSEY, m. t.
Oil of aniseed solid, muriatic ether boils.
CLERMONT, m. t.; Columbia r. m. t. [begins.
ITALY, m. w. t.; VIENNA, m. t. 50·5; PUTREFACTION
Liq. ammon. boils, Sat. at. 32; STRASBURG, m. t.
WARSAW, BERNE, m. t. [PRAGUE, GENEVA, m
TENERIFFE PEAK, 12,072 ft. el.
ZURICH, GOTTINGEN, LABRADOR s. t.
Sulphurous acid liqfd. 2 at.; protox. nit. 50 at.; Cyanogen, 30
SEA EQUATOR, 2,400 ft. deep.
DEEP SEA, common 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; CARPATH. MOUNTAINS; mercury eva
CAPE HORN SURFACE OF SEA. max. density of water.
EDINBURGH, w. t. ENGLAND, m. w. t. 37 8. [w
Alcohol boils in vacuo; NOVA ZEMBLA s. t., SHETLAN
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, sc. ad. 3rd., hydr. freezes.
POLAR SEA, 2,300 ft. deep; earth YAKUTSK, 382 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.
Elaiu freezes, HECLA (Air) at summit, 5,110 ft. el.
Oil bergamot freezes.
Kakodyl solid.
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 below zero (calc.).
Mercury freezes. } 40° below zero, m. w. t. at NOVA
Ether boils in vacuo. } ZEMBLA AND YAKUTSK.
Carbonic acid freezes 148° below zero.
Lowest artificial cold 187° below zero.

FAHRENHEIT TO CENTIGRADE.

Above Ice. $\frac{F-32}{1·8}$ — Between Ice and Zero. $\frac{32-F}{1·8}$ — Below Zero. $\frac{F+32}{1·8}$

ABBREVIATIONS.

lts. m. t. mean temperature. w. winter. s. summer. at. atmosphere. b. boils. v. volatilised. liq. liquid. iquefied. Ad. acid. max. maximum. min. minimum. Sol. solution. W. B. water boils. el. elevation. In ice to fusible alloys. B. bismuth. T. tin. L. lead. pr. pressure. dep. depression. I. Island. Vapr. Vapour. Elasticity. Fluid. Fluidity. Alch. Alcohol. Turp. Turpentine. dens. density. In regard to places mean temp. ied where *not* expressly stated. r. river. spr. spring. fr. freezes. A. V. Aqueous vapour. d. v. density of vapour. pecific gravity. The Elasticity of Vapours is given in inches of Mercury.

TEMPERATURES ABOVE THE SCALE.

l Cadmium m. 442°. Tempered steel (straw colour) 460°. Sulphc. ad. 1·78 b. 467°. Bismuth m. 476°. Tempered steel) 500°. Fixed oils b. 530°. Tempered steel (red and purple) 550°. The same (blue) 600°. Lead m. 612°. Sulphc. b. 648°. Mercury b. 662°. Zinc m. 680°. Gunpowder explodes 700°. Antimony m. 810°. Red heat 980°. Flint . 1000°. Heat of common fire 1141°. Brass m. 1869°. Silver m. 1873°. Copper m. 1996°. Gold m. 2016°. Cast 6°. Pure iron and platina m. 3280°. Wind furnace white heat 3300°.

It will be seen that the table here published ranges from 12° to 374° Fahr., from — 11° to + 190 Centigrade, and from — 9° to + 152 Réaumur.

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.

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 to 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 the principal solids and liquids in chemistry, from 12° to 374° Fahr., from — 11° to + 190° Cent. and from — 9 to + 152° 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 their 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.

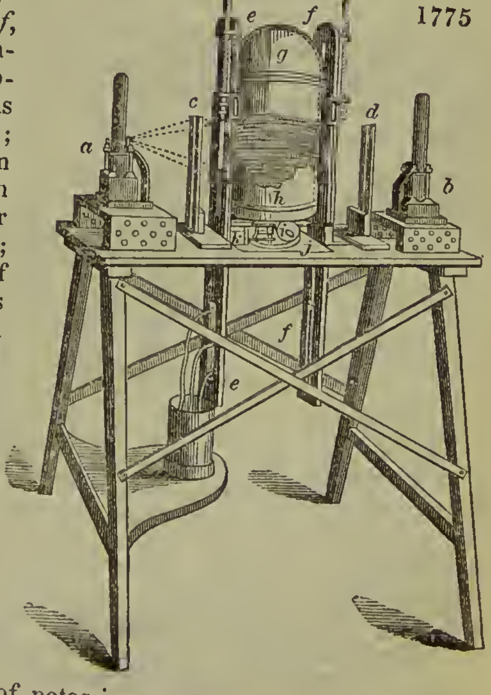
As the value of a table of this kind, depends less on the compiler than on the observers on whom he relies, I feel bound to state that I am chiefly indebted to the following authorities: — for Climatology and Physical Geography: to Humboldt, Bonpland, Saussure, Boussingault, Rose, Ermann, Baer, Von Wrangell, Breislak, Phipps, Scoresby, Franklin, Parry, Back, Ross, Pachtusoff, 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.

Thermometer. Self-registering by photography. The first person who in this country proposed to apply photography, and actually did apply it, as a means of registering the movements of the mercury in the thermometer and barometer, and also for registering the variations in the magnetic intensity, was Mr. Thomas B. Jordan, at that time secretary to the Royal Cornwall Polytechnic Society. The results of this gentleman's methods, and the description of his plans, will be found in the *Sixth Annual Report of the Royal Cornwall Polytechnic Society for* 1838.

Mr. Ronalds, of the Kew Observatory, also devised an arrangement for employing photography as the means of registering meteorological inventions, and subsequently Mr. Brook perfected the following method: — 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.* 1775, 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.

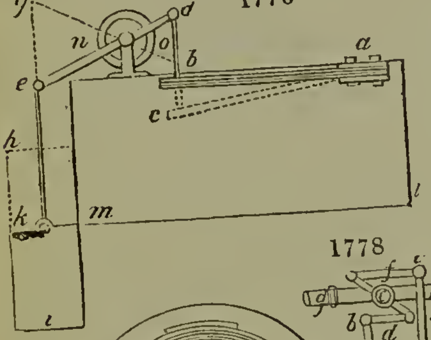
1775



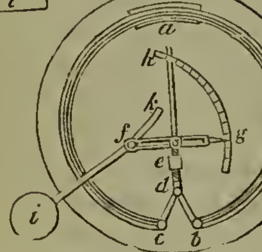
The paper is prepared so as to render it extremely sensitive to light, being first washed with a solution of isinglass, bromide of potassium and iodide of potassium, in the proportion of 1, 3, and 2, respectively; and when required for use, it is washed with an aqueous solution of nitrate of silver which 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.

THERMOSTAT, is the name of an apparatus for regulating temperature, in vaporisation, distillations, heating baths or hothouses, and ventilating apartments, &c.; for which Dr. Ure obtained a patent in the year 1831. It operates upon the physical principle, that when two thin metallic bars of different expansibilities are riveted 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, riveted 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:—

1776



1778



1777

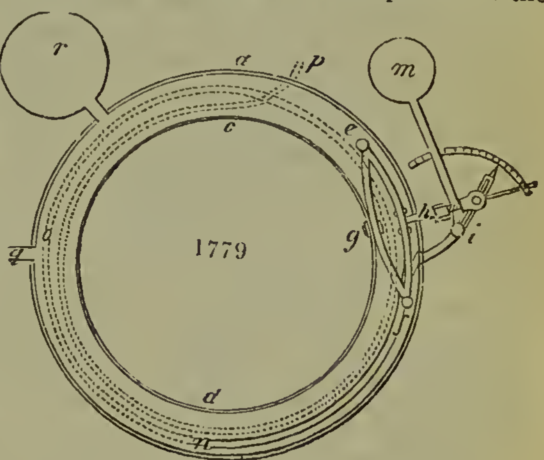
Fig. 1776, *a*, *b*, is a single thermostatic bar, consisting of two or more bars or rulers of differently expansible solids (of which, in certain cases, wood may be one): these bars or rulers are firmly riveted or soldered together, face to face. One end of the compound bar is fixed by bolts at *a*, 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 equipoised slide-damper *k i*, which is suspended by a link from the end *e*, of the lever *e 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. 1777, *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 k*, the pipe to admit cold water; *l*, the over-flow pipe, at which the excess of hot water runs off.

Fig. 1778 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.

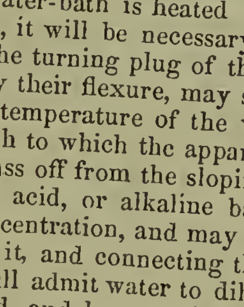
Suppose that for certain purposes in pharmacy, dyeing, or any other chemical art, a water-bath is required to be maintained steadily at a temperature of 150° Fahr.; let the combined thermostatic bars, hinged togther at *e*, *f*, *fig*. 1779, be placed in the bath, between the outer and inner vessels *a*, *b*, *c*, *d*, being bolted fast to the inner vessel at *g*; and have their sliding-rod *k*, 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 *q*. An oil bath may be regulated on the same plan; the hot oil overflowing from *q*, 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 the 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.



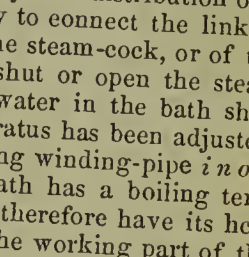
1779

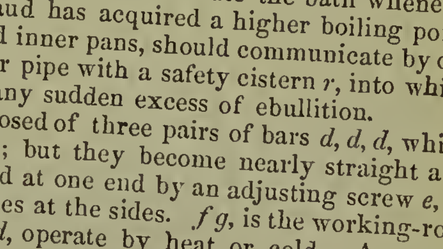
Fig. 1782 is a thermostatic apparatus, composed of three pairs of bars *d*, *d*, *d*, which are represented in a state of flexure by heat; but they become nearly straight and parallel when cold. *a b c* is a guide-rod, fixed at one end by an adjusting screw *e*, in the strong frame *f c*, having deep 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 forwards 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.

1780



1781





1782

Fig. 1783 represents a chimney furnished with a *pyrostat*, *a b c*, acting by the links *b*, *d*, *c*, *c*, on a damper *f h g*. The more expansible metal is in the present example 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. 1781 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.

1783

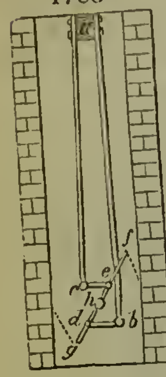


Fig. 1780 represents another arrangement of my thermostatic apparatus applied to a circular turning register, like the preceding, for ventilating apartments. Two pairs of compound bars are applied so as to act in concert, by means of the links *a c*, *b c*, on the opposite ends of a short lever, which 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 e*, 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 flexture of the compound bars will open the apertures.

THIALDINE. $C^{12}H^{13}NS^{4}$. A curious alkaloid, formed by the action of sulphuretted hydrogen on aldehyde ammonia.

THIEVES' VINEGAR. (*Le Vinaigre des quatre Voleurs*, Fr.) See Aromatic Vinegar.

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 MM. 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 size of the intended 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 mandril. 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.

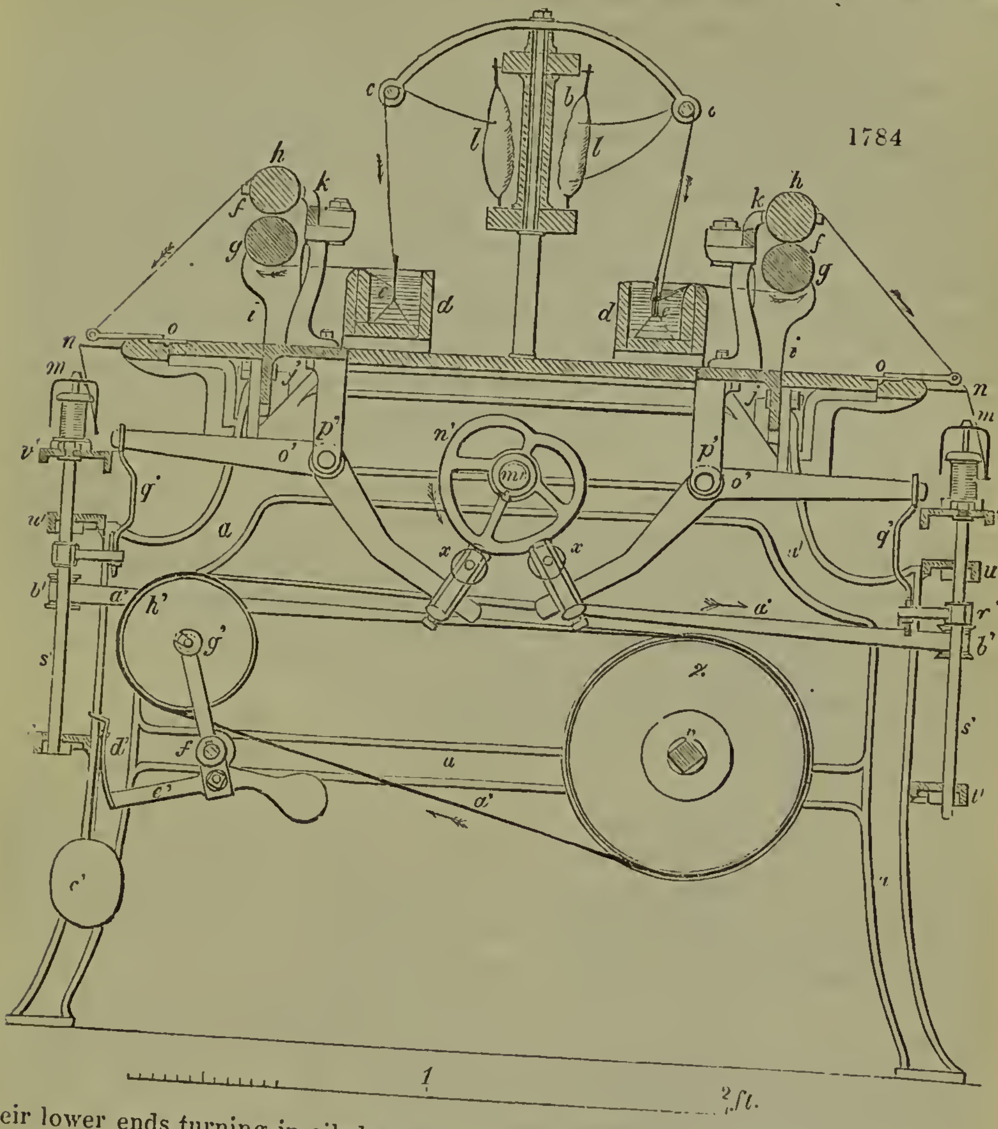
Thimbles are made in this country by means of moulds in the stamping machine. See Stamping of Metals.

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 alkalies, in all twelve 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.

THORINUM or THORIUM. A rare metal found in the mineral *thorite*, which contains about 57 per cent. of thorina, the oxide of this metal.

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.* 1784 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,

1784



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 boxwood; the former extends from end to end of the frame, in lengths comprehending eighteen 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 e*, 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*, *s'*; 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 b' 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 n'. As this eccentric revolves, it gives a reciprocating motion to the levers o', o', 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', u', along with the cast-iron step v', which bears the bottom washer of the bobbins. The periphery of the heart-wheel u', 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.

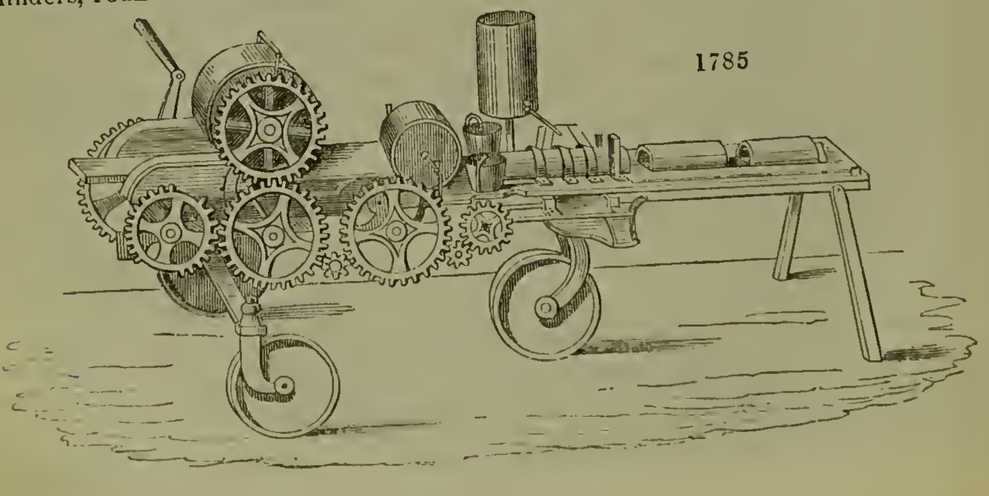
TILES and TESSERÆ. Tile manufacture is a very comprehensive term, embracing the following varieties: —

Paving bricks or tiles.
Plain tiles.
Ridge tiles.
Oven tiles.
Pan tiles.
Circulars.
Foot tiles.
Hip tiles.
Drain tiles, &c.

The clay used for making tiles is purer and stronger than that used for making bricks. When the clay is too strong, that is, too adhesive, it is mixed with sand before passing it through the pug-mill. As a usual practice the clay is *weathered*; this is effected by spreading it out in layers of about two inches in thickness during the winter, and each layer is allowed the benefit of at least one night's frost before the succeeding layer is put over it. This *weathering* is sometimes effected by exposing the layers to sunshine, which is said to answer equally well with frost. What this weathering does is by no means clear: it is said "to open the pores of the clay." We believe that what really takes place is, that under the influences to which it is exposed, the particles break up into smaller particles, and that we have the clay in a more finely comminuted state. The next process is that of *tempering*. After the clay has been allowed to "mellow, or ripen," in pits, under water, it is passed through the pug-mill and well kneaded or tempered. It is then *slung*, that is, cut into slices with a string: during which process the stones fall out, or are removed by the hand; it is then ready for the operation of moulding. This may be performed by hand, or by any one of the many machines which have been devised.

Fig. 1785 shows Mr. Hunt's machine for making tiles. It consists of two iron cylinders, round which webs or bands of cloth revolve, whereby the clay is pressed

1785



into a slab of uniform thickness, without adhering to the cylinders. It is then carried over a covered wheel, curved on the rim, which gives the tile the semi-cylindrical or other required form; after which the tiles are polished and finished by passing through three iron moulds of a horse-shoe form, as shown in the centre of the cut, while they are at the same time moistened from a water cylinder placed above them. The tiles are next cut off to such lengths as are wanted, and carried away by an endless web, whence they are transferred by boys to the drying shelves.

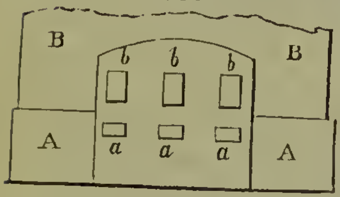
Flat tiles, for sole pieces to draining tiles, are formed in nearly the same manner, being divided into two portions while passing through the moulds: the quantity of clay used for one draining tile being as much as for two soles.

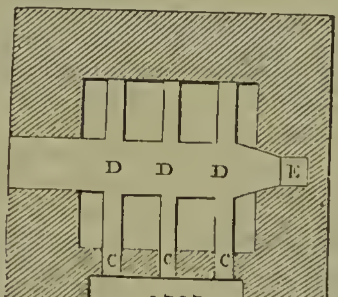
By hand, the work is divided between a moulder and a rough moulder. The latter, a boy, takes a piece of clay and squares it up, that is, beats it up into a slab nearly the shape of the mould, and about 4 inches thick, from which he cuts off a thin slice the size of a tile, and passes it to the moulder. The moulder sands his stock-board, and, regulating the thickness of the tile by four pegs, on which the mould is placed, he puts the piece of clay with which he is supplied into the mould; he then smooths the surface with his very wet hands, removes the superfluous clay, and moulds it into a curved shape. They are then placed to dry, with the convex side uppermost; when half-dry the tiles are taken out one by one, placed on the *thwacking* frame, and beaten with the thwacker to produce the required shape; when dry they are kilned.

The following plan of a furnace, or kiln, for burning tiles has been found very convenient: —

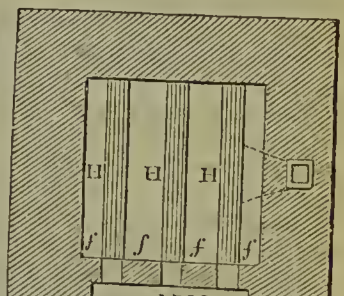
Fig. 1786, front view, A A, B B, the solid walls of the furnace; *a a a*, openings to the ash-pit, and the draught hole; *b b b*, openings for the supply of fuel, furnished with a sheet-iron door. *Fig.* 1787, plan of the ash-pits and air channels C C C. The

1786





1787



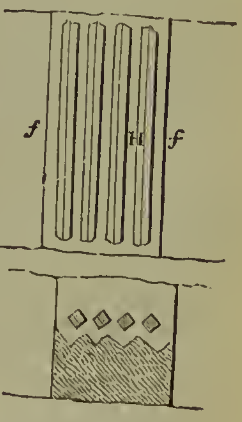
1788

principal branch of the ash-pit D D D, is also the opening for taking out the tiles, after removing the grate; E, the smoke flue. *Fig.* 1788, plan of the kiln seen from above. The grates, H H H. The tiles to be fired are arranged upon the spaces *f f f f.*

Fig. 1789 is the plan and section of one of the grates upon a much larger scale than in the preceding figures.

The Roman tesseræ, of which many very fine examples have been discovered in this country, were, often, natural stones (sometimes coloured artificially), but generally of baked clay. The beauty of many of these has led to the production of modern imitations, which have been gradually improved, until, in the final result, they far exceed any work of the Romans.

1789



About half a century since Mr. C. Wyatt obtained a patent for a mode of imitating tesselated pavements, by in-laying stone with coloured cements. Terra cotta, inlaid with coloured cements, has also been employed, but with no very marked success.

Mr. Blashfield produced imitations of those pavements, by colouring cements with the metallic oxides: these stood exceedingly well when under cover, but they did not endure the winter frosts, &c. Bitumen, coloured with metallic oxyds, was also employed by Mr. Blashfield. In 1839 Mr. Singer, of Vauxhall, introduced a mode of forming tesseræ from thin layers of clay. These were cut into the required forms, dried and baked. In 1840 Mr. Prosser, of Birmingham, discovered that if the material of porcelain (china clay) be reduced to a dry powder, and in that state be compressed between steel dies, the powder is condensed into about a fourth of its bulk, and is converted into a compact solid substance of extraordinary hardness and density.

This process was first applied to the manufacture of buttons, but was eventually taken up by Mr. Minton, and in conjunction with Mr. Blashfield, Messrs. Wyatt, Parker, and Co., was carried to a high degree of perfection for making tesseræ.

The new process, invented by Mr. Prosser, avoided the difficulty altogether of using wet clay.

This change in the order of the potter's operations, although very simple in idea (and a sufficiently obvious result of reflection on the difficulties attending the usual course of procedure), has nevertheless required a long series of careful experiments to find out the means of rendering it available in practice.

The power which the hand of the potter has exercised over his clay has been proverbial from time immemorial, but it is limited to clay in its moist or plastic state; and clay in its powdered state is an untractable material, requiring very exact and powerful machinery to be substituted for the hand of the potter; in order, by great pressure, to obtain the requisite cohesion of the particles of clay.

In the new process, the clay, or earthy material, after being prepared in the usual manner, and brought to the plastic state, as above described (except that no kneading or tempering is requisite), is formed into lumps, which are dried until the water is evaporated from the clay.

The lumps of dried clay are then broken into pieces, small enough to be ground by a suitable mill into a state of powder, which is afterwards sifted, in order to separate all coarse grains and obtain a fine powder, which it is desirable should consist of particles of uniform size as nearly as can be obtained. The powder, so prepared, is the state in which the clay is ready for being moulded into the form of the intended article by the new process.

The machine and mould used for moulding articles of a small size, in powdered clay, is represented in the annexed drawing, wherein *fig.* 1790 is a lateral elevation of the whole machine.

A A is the wooden bench or table whereon the whole is fixed, that bench being sustained on legs standing on the floor. B D E is the frame, formed in one piece of cast iron; the base, B, standing on the bench, and being fixed thereto by screw bolts; the upright standard, D, rising from the base, and sustaining at its upper end the boss, E, wherein the nut or box, *a*, is fixed for the reception of the vertical screw, F. The screw, F, works through the box, *a*, and has a handle, G, *g*, *h*, applied on the upper end of the screw; the handle is bended downwards at *g*, to bring the actual handle, *h*, to a suitable height for the person who works that machine to grasp the handle, *h*, in his right hand, and, by pulling the handle, *h*, toward him, the screw, F, is turned round in its box, *a*, and descends. The lower end of the screw, F, is connected with a square vertical slider, H, which is fitted into a socket, I, fixed to the upright part, D, of the frame, and the slider, H, is thereby confined to move up or down, with an exactly vertical motion, when it is actuated by the screw, without deviation from the vertical.

Thus far the machine is an ordinary screw press, such as is commonly used for cutting and compressing metals for various purposes. The tools with which the press is furnished for the purpose of this new process consist of a hollow mould, *e e*, formed of steel, the exterior cavity of the mould being the exact size of the article which is to be moulded. The mould, *e e*, is firmly fixed on the base, B, of the frame, so as to be exactly beneath the lower end of the piston *a*, or plug, *f*, which is fastened to the lower end of the square slider, H, and the plug, *f*, is adapted to descend into the hollow of the mould, *e e*, when the slider, H, is forced downwards by action of the screw, F, the plug *f* being very exactly fitted to the interior of the mould, *e e*.

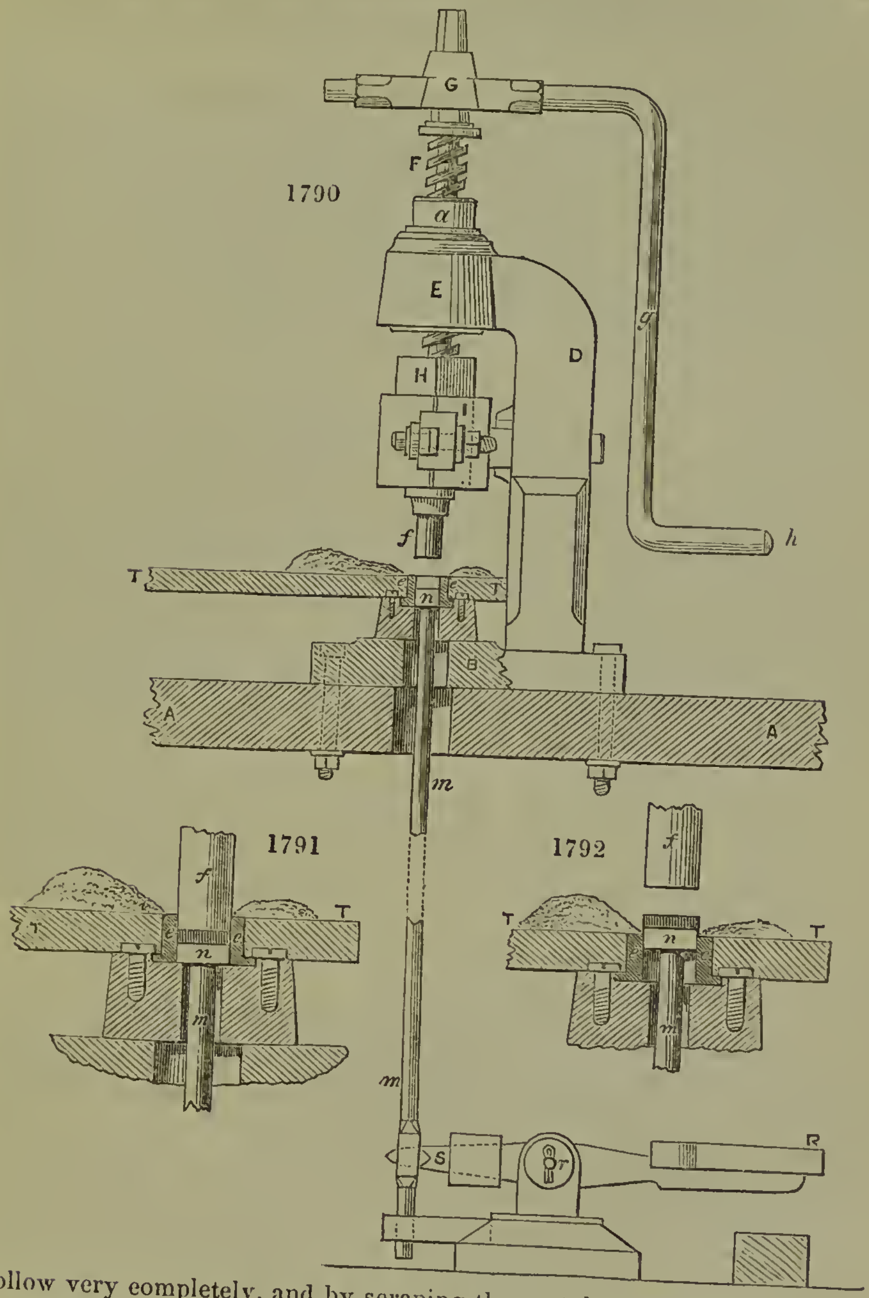
The bottom of the mould, *e e*, is a movable piece, *n*, which is exactly fitted into the interior of the mould, but which lies at rest in the bottom of the mould, *e e*, during the operation of moulding the article therein; but afterwards the movable bottom, *n*, can be raised up by pressing one foot upon one end, R, of a pedal lever, R S, the fulcrum of which is a centre pin, *r*, supported in a standard resting upon the floor, and the end, S, of the lever operates on an upright rod, *m*, which is attached at its upper end to the movable bottom, *n*, of the mould, *e e*.

A small horizontal table, T T, is fixed round the mould, *e e*, and on that table a quantity of powdered clay is laid in a lump in readiness for filling the mould.

The two detached figures, marked figures 1791 and 1792, are sections of the mould *e e*, and the plug, *f*, on a larger scale than figure 1790, in order to exhibit their action more completely.

The operation is extremely simple; the operator, holding the handle, *h*, with his right hand, puts it back from him, so as to turn back the screw, F, and raise the slider, H, and the plug, *f*, quite out of the mould, *e e*, and clear above the orifice of the mould, as shown in figure 1790.

Then with a spatula of bone, held in the left hand, a small quantity of the powder is moved laterally from the heap, along the surface of the table, T, T, towards the mould *e e*, and gathered into the hollow of the mould with a quiet motion, so as to fill



that hollow very completely, and by scraping the spatula evenly across over the top of the mould *e e*, the superfluous powder will be removed, leaving the hollow cavity of the mould exactly filled with the powder in a loose state, and neither more nor less than filled.

Then the handle, *h*, being drawn forwards with a gentle movement of the right hand, it turns the screw, F, so as to bring the slider, H, and the plug, *f*, which thereby descends into the mould, *e e*, upon the loose powder wherewith the mould has been filled, and begins to press down that powder, which must be done with a gentle motion without any jerk, in order to allow the air that is contained in the loose powder to make its escape; but the pressure, after having been commenced gradually, is continued and augmented to a great force, by pulling the handle strongly at the last, so as to compress the earthy material down upon the bottom, *n*, of the mould, into about one-third the space it had occupied when it was in the state of loose powder. The section, *fig.* 1791, shows this state of the mould *e e*, and the plug *f*, and the compressed material.

Then the handle, *h*, is put backwards again, so as to turn back the screw, F, and raise up the slider, H, and the plug, *f*, until the latter is drawn up out of the mould *e e*, and clear above the orifice of the mould, as in *fig.* 1790, and immediately afterwards by pressure of one foot on the pedal, R, of the pedal lever, R, S, and by action of the upright rod, *m*, the movable bottom, *n*, of the mould is raised upwards in the mould *e e*, so as to elevate the compressed material which is resting upon the bottom, *n*, and carry the same upwards, quite out of the mould *e e*, and above the orifice of the mould, as is shown in *fig.* 1792, and then the compressed material can be removed by the finger and thumb.

The compressed material which is so withdrawn is a solid body, retaining the exact shape and size of the interior cavity of the mould, and possessing sufficient coherence to enable it to endure as much handling as is requisite for putting a number of them into an earthenware case or pan, called a sagger, in which they are to be enclosed, according to the usual practice of potters, in preparation for putting them into the potter's kiln for firing; the sagger protects the articles from discoloration by smoke, and from partial action of the flame, which, if a number of small articles were exposed thereto without being so enclosed, might operate more strongly upon some than upon others of those articles; but by means of the saggers the heat is caused to operate with clearness, uniformity, and certainty upon a number of small articles at once.

After the firing is over, the articles being removed from the saggers, are in the state of what is termed biscuit, and are ready for use, unless they are required to be glazed, in which case they may be dipped into a semi-liquid composition of siliceous and other matters, ground in water to the consistency of cream, and the surface of the articles which are so dipped becomes covered with a thin coating of the glazed composition, and then the articles are again put into saggers, and subjected to a second operation of firing in another kiln, the heat whereof vitrifies the composition and gives a glassy surface to the articles, all which is the usual course of making glazed earthenware or porcelain; but for articles formed by the new process, a suitable glazing composition is more usually applied within the saggers, into which the articles are put for the first firing, and the glazing is performed at the same time with the first burning, without any other burning being required. Or, in other cases, the composition of earthy materials which is chosen for the articles may be such as will become partially vitrified by the heat to which they are exposed in the kiln, and thereby external glazing is rendered unnecessary.

The great contraction which must take place in drying articles which have been moulded from clay in the moist state is altogether prevented, and consequently all uncertainty in the extent of that contraction is avoided. Tiles, tesseræ, and other articles are now made by this machine; and very beautiful pavements are constructed, excelling the finest works of the Romans in form, in colour, and in all the mechanical conditions.

Number of tiles *exported* in 1858, 784,768; declared real value, £6489.

TILTING OF STEEL. See Steel.

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, called the creaking of tin, as if sandy particles were intermixed. 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 grey oxide, 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. It is probably mentioned in the books of Moses; and the ships of Tarshish appear to have brought this metal from islands eastward of the Persian Gulf. The Phœnicians carried on a lucrative trade in it with Spain and Cornwall.

The earliest navigators appear to have taken tin from the east and from the west to supply the wants of Egypt and of Greece. That the Phœnicians, with whom, in those days, the maritime trade of the world rested, collected tin from our own islands is certain; at the same time it is highly probable that the Indian islands were another source from which they obtained this metal in considerable quantities.

"Kassiteros," says Humboldt, "is the ancient Indian Sanscrit word Kastire; *Zinn* in German, *Den* in Icelandic, *Tin* in English, and *Tenn* in Swedish, is in the Malay and Javanese language *Timah*, a similarity of sound which reminds us of that of the old German word *Glessum* (the name given to transparent amber) to the modern 'glas,' glass. The names of articles of commerce pass from nation to nation, and become adopted into the most different languages. Through the intercourse which the Phœnicians, by means of their factories in the Persian Gulf, maintained with the east coast of India, the Sanscrit word *Kastira* became known to the Greeks, even before Albion and the British Cassiterides had been visited."

The Cassiterides, or Tin Islands, have been supposed to be, by some, the Islands of Scilly. This idea has been far too hastily adopted, seeing that the Scilly Islands produce no tin. In all probability this name was given by the Phœnicians to the whole of the western promontory of Cornwall, the only part of this country with which they were acquainted, the name being without doubt derived from the *Kassiteros* of the East.

There are only two ores of tin; the peroxide, tin-stone, or Cassiterite, and tin pyrites, sulphide of tin, or stannine, 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, grey, 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 granite, gneiss, clay slate, chlorite and mica slate; also in beds and veins, in large irregular masses; and in pebbles, in the beds of ancient torrents: these occasionally take a ligneous aspect, and are termed *wood-tin*.

This ore has been found in but a few countries in a workable quantity. Its principal localities are, Cornwall, Bohemia, and Saxony, in Europe; and Malacca, Banca, and Billitan, in Asia. The tin mines of the Malay peninsula lie between the 10th and 6th degrees of south latitude. 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 Galicia 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 found in the alluvial deposits. Small groups of black twin crystals have been discovered in the albite rock of Chesterfield in Massachusetts.

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 Tol-pedden-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, and other similar islands on the coast.

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 was the yellow sulphide of copper. A great 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 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 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.

The Cornish ores occur—1, in small strata or veins, or in masses; 2, in congeries of small veins; 3, in large veins; and 4, disseminated in alluvial deposits, as described.

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. In the mine of Bottalack a *tin-floor* has been found in the killas (a 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 connection between the *floor* and the great vein.

2. Stockwerks, as the Germans term the disseminated masses, 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. Austell*. The works are carried on in the open air, in a friable granite, containing felspar — *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-grey 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.

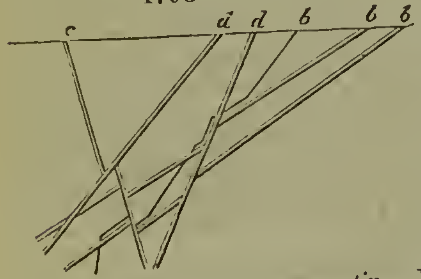
Stanniferous masses are much more frequent in the elvan (porphyry); of which the mine of Trewidden is a remarkable example. It was worked among flattened masses of *elvan*, separated by strata of *killas*, which dip to the east-north-east at a considerable angle. The tin ore occurred in small veins, varying in thickness from half an inch to 8 or 9 inches, which were irregular, and so much interrupted that it was 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. Austell; and 3. In the neighbourhood of Dartmoor in Devonshire.

The first group is by far the richest and the best explored. The formation most abundant in tin mines is principally granitic; 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 or more different systems. Their direction is, however, nearly the same, but some of them dip towards the north, and others towards the south. It was formerly thought by the Cornish miners that tin occurred in the upper portions of the mineral lodes only, and mines were abandoned, as we have already stated, when in sinking the miners came to the "yellows"— copper pyrites, which were said "to have cut out the tin." Within the last few years, however, tin has been found at very great depths below the surface and beneath the copper. Dolcoath mine is a very remarkable example of this. This mine was first worked as a tin mine for a very long period; then as a copper mine for half a century; and then, upon persevering in depth, the lode was found to become more and more rich in tin, which is now worked to great advantage.

At Trevaunance mine 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.* 1793, *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.

1793

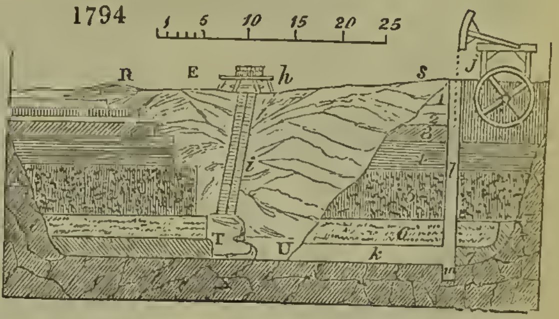


4. *Alluvial tin ore, stream tin.*—Peroxide of tin occurs disseminated both in the *alluvium* which covers the gentle slopes of the hills adjoining the rich tin mines, and also in the alluvium which fills the valleys that wind round their base; and in these deposits the tin-stone has been so abundant that for centuries the whole of the tin of Cornwall was derived from them; and it is still so to some extent. The most important explorations of *alluvial tin ore* are grouped in the environs of St. Just and St. Austell, where they are called *stream-works*, because water is the principal agent employed to separate the metallic oxide from the sand and gravel.

The most extensive and productive stream-works were formerly those of Pentewan, near St. Austell.

Fig. 1794 represents a vertical section of the Pentewan deposit, taken from the stream-work *Happy Union*. A vast excavation, R, T, U, *s*, has been hollowed out in the open air, in quest of the alluvial tin ore T, which occurs here at an unusual depth, below the level of the strata R, *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 occurred, in rounded particles, a coarse quartzose sand, and the tin-stone, commonly in small grains and crystals. Beneath the bed T, is the clay slate called *killas* (A, X, Y), which supports all the deposits of more recent formation.

1794



The system of mining employed in stream-works 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 *h*, a horse-gin, for alternately raising and lowering the two baskets of extraction on the pathway *i*.

Mine tin—as distinguished from *Stream tin*, the former being worked by the miner out of the lode,—requires peculiar care in its mechanical preparation or dressing, on account of the presence of foreign metals, from which, as we have stated, 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, by care, so as to be cleaned of almost every matter not chemically combined.

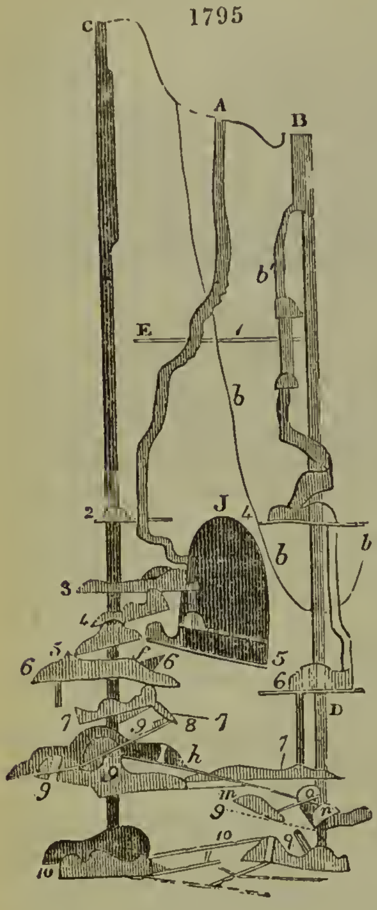
3. As the peroxide of tin is not affected by a moderate heat, it may be exposed to calcination; whereby the specific gravity of the associated sulphides and arsenides is so diminished as to facilitate their separation.

Tin ore, therefore, 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 and other parts is fully described in the article ORE DRESSING, which see. See also METALLURGY for a description of the roasting processes.

The tin ores of Cornwall and Devonshire are all smelted within the counties where they are mined: the vessels which bring the fuel from Wales, for smelting these ores, return to Swansea and Neath loaded with copper ores.

The tin mine of Altenberg, in Saxony (*fig.* 1795, which is a vertical projection in a plane passing from west to east), is remarkable for an 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*, sulphide of molybdenum, and bismuth, having gangues of fluor spar, mica, and felspar. The ore occupies the heart of the quartz, 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 *b*, *b*, *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 B. The parts excavated are shaded black in the figure. There are two masses of ore, one under the shaft B, 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; B 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 B the ladders are placed in an accessory shaft *b′*; under D a shaft is sunk for pumping out the water, by means of an hydraulic wheel at D; E 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 D 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 D.

1795



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 (Leipsic) 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.

The smelting-works belong in general to individuals 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 serves the smelter's purpose, as it affords him a similar result to what he would get on the large 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.

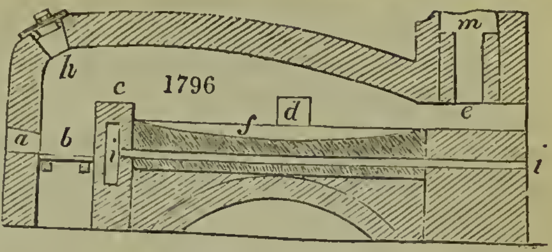
The smelting of tin ores has been effected by two different methods: —

In the first, a mixture of the ore with anthracite was exposed to heat on the hearth of a reverberatory furnace fired with coal.

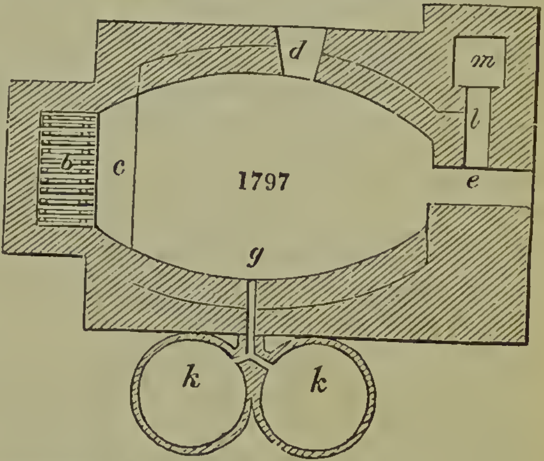
In the second, the tin ore was fused in a blast furnace, called a blowing-house, supplied with wood charcoal. This method is not now practised in England.

In the *smelting-houses*, where the tin is worked in reverberatories, two kinds of furnaces are employed; the reduction and the refining furnaces.

Figs. 1796 and 1797 represent the furnaces for smelting tin at Truro, in Cornwall; the former being a longitudinal section, the latter a ground plan. *a* is the fire-door, 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.



1796

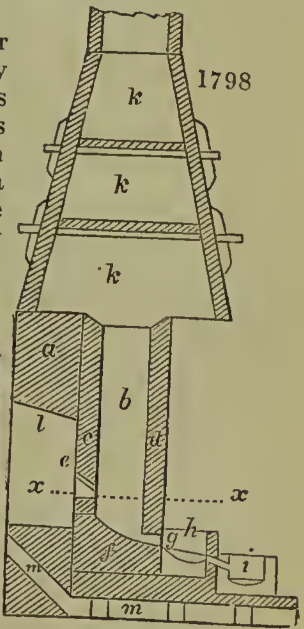


1797

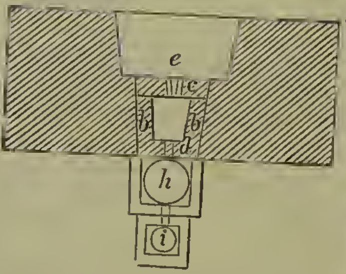
Fig. 1798 represents in a vertical section through the tuyère, and *fig.* 1799, in a horizontal section, in the dotted line *x*, *x*, of *fig.* 1798, the furnace employed for smelting tin at the Erzegebirge mines in Saxony. *a*, are the furnace pillars, of gneiss; *b*, *b*, are shrouding or casing walls; *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.



1798



1799

Formerly in Cornwall nearly all the tin was smelted in blast furnaces; these works were called *blowing-houses.* The smelting furnaces were 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, was deposited. This chamber was not placed vertically over the furnace; but the lower portion of the chimney had an oblique direction from it. The furnace was 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, were 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 was the hemispherical basin of reception, set partly beneath the interior space of the furnace, and partly without. Near the corner of the building there was a second basin of reception, larger than the first, which could discharge itself into the former by a sloping gutter. Near this basin there was another, for the refining operation. These were all made either of brick or cast iron. These blast furnaces are now entirely superseded in this country by the reverberatory furnace.

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; deoxidisation 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 *culm*; 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 draught from sweeping any of it away at the commencement. From 20 to 25 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 scoriæ, and to ascertain if the operation be in sufficient forwardness. When the reduction seems to be finished, the scoriæ 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 scoriæ 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 globules. These scoriæ are in small quantity. The stamp slag contains fully 5 per cent. of metallic tin.

As soon as the scoriæ 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 scoriæ 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 sulphides and arsenides that have escaped decomposition, a little unreduced oxide of tin, and also some earthy matters which have not passed off with the scoriæ.

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.* 1796, 1797). 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 five or six 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 hundredweight. 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 scoriæ B 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 scoriæ C are smelted without any preparation; but those marked B 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 little use can be made of it. About 3½ tons of coal are consumed in producing 2 of tin.

To test the quality of tin, dissolve a certain weight of it with heat in hydrochloric 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 grey 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 peroxidised 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 flocks, if iron is present; and on evaporating the supernatant liquid to dryness, the copper will be obtained.

For the purification of tin from tungsten, see TUNGSTEN.

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.

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.	Years.	Tons.
1750 - -	1,600	1800 - -	1,500
1760 - -	1,800	1810 - -	1,400
1770 - -	2,000	1820 - -	1,700
1780 - -	1,800	1830 - -	3,500
1790 - -	2,000	1840 - -	5,000

The produce of the Cornish and Devonshire mines in recent years has been as follows:—

1848 -	10,176 tons of tin ore.			
1849 -	10,719	do.		
1850 -	10,383	do.		
1851 -	9,455	do.		
1852 -	9,674	do.		
1853 -	8,866	do.	producing	6,000 tons of tin.
1854 -	8,747	do.	,,	5,947 do.
1855 -	8,949	do.	,,	5,998 do.
1856 -	9,350	do.	,,	6,177 do.
1857 -	9,783	do.	,,	6,582 do.
1858 -	10,618	do.	,,	6,920 do.

Tin of British produce *exported* in 1858 : —

	Cwts.	Declared real value. £
Unwrought - - - - -	46,542	270,698
Tin plates, entered at value - - - -		1,351,151
Tin and pewter wares, at value - - -		38,707

Tin — Our *imports* in 1858 were: —

Tin ore and regulus - - -	628 tons.
Tin in blocks, ingots, bars, or slabs	59,115 ,,

TINCAL. Crude borax.

TINCTORIAL MATTER. The colouring matter employed in dyeing. See Dyeing; Madder; Turkey Red, &c.

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. See Mordant.

Mordant A, as commonly made by the dyers, is composed of 8 parts of nitric acid, 1 part of common salt or sal-ammoniac, and 1 of granulated tin. This preparation is very uncertain.

Mordant B.— 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 2 drams Fr., 144 grs., 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 1 ounce of granulated tin of Cornwall, observing not to put in a fresh piece till the preceding be dissolved.

Mordant E, by Scheffer.— Dissolve 1 part of tin in 4 of a nitro-muriatic acid, prepared with nitric acid diluted with its own weight of water, and one thirty-second of sal-ammoniac.

Mordant F, by Poerner.— Mix 1 pound of nitric acid with 1 pound of water, and dissolve in it an ounce and a half of sal-ammoniac. Stir it well, and add, by very slow degrees, 2 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 1 dram (72 grs.) 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 PLATES. Some of the earliest historical records refer to the tin mines of Britain, and to the intelligence and skill of the miners who worked them. The works of Herodotus (450 years B.C.), and later of Diodorus Siculus and Pliny, prove the great importance of the tin mines of this country, more than 2000 years past. Since that time they have been constantly worked, and so far from being exhausted, the tin mines of Cornwall seem now to be only beginning to open out, and to prove that the store of ore that district contains is practically inexhaustible.

The Government official returns, for the year 1858, made under the able superintendence of Mr. Robert Hunt, show that 10,618 tons of tin ore were raised in Great Britain. This quantity is greater than that of any preceding year; and as many of the deep mines in Cornwall are changing from copper into tin ore, increased supplies will be obtained to meet any demand. About four-fifths of all the tin ore to supply the world is raised in Great Britain. The same race of men who worked the mines more than 2000 years since, still work them and preserve their customs and nationality.

The art of coating copper with tin seems to have been known at an early period. Pliny refers to this, and from his description it is probable the vessels to be covered were dipped into melted tin, and the "*vasa stannea*" of the Romans were copper vessels covered with tin. The difficulty of coating iron with tin was, however, much greater; and the processes of hammering the iron into sheets sufficiently thin, and cleaning the surface, which latter work had often to be done by filing, were serious hindrances to the extensive use of the invention.

The art of tinning iron appears to have been first practised in Bohemia, and about the year 1620 to have been introduced into Saxony.

Beckmann states that, "in the year 1670, a company sent to Saxony, at their expense, an ingenious man named Andrew Yarrenton, in order to learn the process of tinning. Having acquired the necessary knowledge, he returned to England with some German workmen, and manufactured tin plate which met with general approbation. Before the company could carry on business on an extensive scale, a man of some distinction, having made himself acquainted with Yarrenton's process, obtained a patent for this art, and the first undertakers were obliged to give up their enterprise, which had cost them a great deal of money, and yet no use whatever was made of the patent which had been obtained." About the year 1720 works for the manufacture of tin plates were established at Pontypool, and these seem to be the earliest of such works in England which were permanently successful.

In 1728, John Payne invented a process for rolling iron. This seems to have at once led to the use of the flat or sheet rolls for the manufacture of iron for tin plates; but it is very remarkable that no further progress was made in this discovery of rolling iron until 1783, when Henry Cort invented the grooved rolls. This discovery was not appreciated for some years. Mr. Reynolds, of Ketley, erected Cort's rolls in 1785. In 1790 Henry Cort was engaged by Mr. Richard Crawshay to erect the mills at Cyfarthfa, and, soon after, this important improvement in the iron manufacture was generally adopted. The writer proposes to give in this paper a short résumé, first, of the process for cleaning and tinning the iron plate, and after, of the methods of preparing the iron for this purpose.

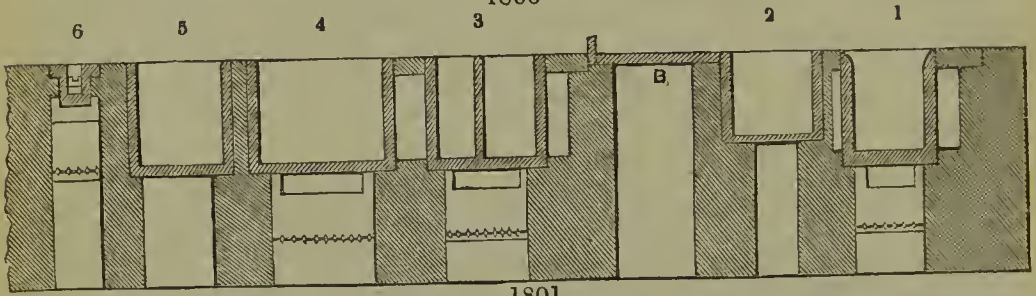
The affinity of iron for tin is much greater than is generally supposed. The point at which the metals cohere is no doubt an *actual alloy*; and advantage is taken of this by the manufacturers of articles for domestic use, made in iron—as bridle bits, common stirrups, small nails, &c. When the iron, whether wrought or cast, *is perfectly clean and free from rust*, and brought in contact with melted tin, at a high temperature, an alloy seems to be at once formed, protecting the iron from oxidisation whilst the tin lasts. Many plans are used for tinning iron articles, of small size, by the manufacturers. One of the common methods of the manufacturers of bridle bits and small ware, in South Staffordshire, is to clean the surface of the articles to be tinned, by steeping them for sufficient time in a mixture of sulphuric and hydrochloric acids, diluted with water, then washing them well with water, but taking great care they do not rust, at once placing them in a partially closed stone-ware vessel (such as a common bottle), which contains a mixture of tin and hydrochlorate of ammonia. This vessel is then placed on a smith's hearth, duly heated, and frequently agitated to secure the complete distribution of the tin over the iron. The articles, when thus tinned, are thrown into water to wash away all remains of the sal-ammoniac; and lastly, cleaned in hot bran, or sawdust, to improve the appearance for sale.

The plans of cleaning and preparing the iron for tinning have undergone many changes in the past century. About 1720 the plan of cleaning was to scour the plates with sand and water, and file off the rough parts, then cover with resin, and dip them in the melted tin. About 1747 the plates were, after being cold rolled, soaked for a week in the lees of bran, which had been allowed to stand in water about ten days, to become, by fermentation, sufficiently acid, and then scoured with sand and water. In 1760 the plates were pickled in dilute hydrochloric acid before annealing, and cleaned with dilute sulphuric acid after being taken out of the bran lees. An improvement of great importance in this process was made about 1745; the inventor seems to have been Mr. Mosely, who carried on tin plate works in South Staffordshire. This invention was the use of the grease pot, and in this department little, if any, improvement has since been made. The plan was introduced into South Wales in 1747 by Mr. John Jenkins, and his descendants are still amongst the principal manufacturers in the trade. The process of cleaning and tinning at some of the best works now is as follows: when the sheet iron leaves the plate mill, and after separating the plates, and sprinkling between each plate a little sawdust, the effect of which is to keep them separate, they are then immersed, or as technically termed "pickled," in dilute sulphuric acid, and after this placed in the annealing pot, and left in the furnace about 24 hours; on coming out, the plates are passed through the cold rolls; after passing the cold rolls, the plates seem to have too much the character of steel, and are not sufficiently ductile: to remedy this they are again annealed at a low heat, washed in dilute sulphuric acid, to remove any scale of oxide of iron, and scoured with sand and water; the plates in this state require to be perfectly clean and bright, and may be left for months immersed in pure water without rust or injury; but a few minutes' exposure to the air rusts them. With great care to have them perfectly clean, they are taken to the stow, *fig.* 1800, being a section through the line K K of the plan *fig.* 1801. Taken from right to left,

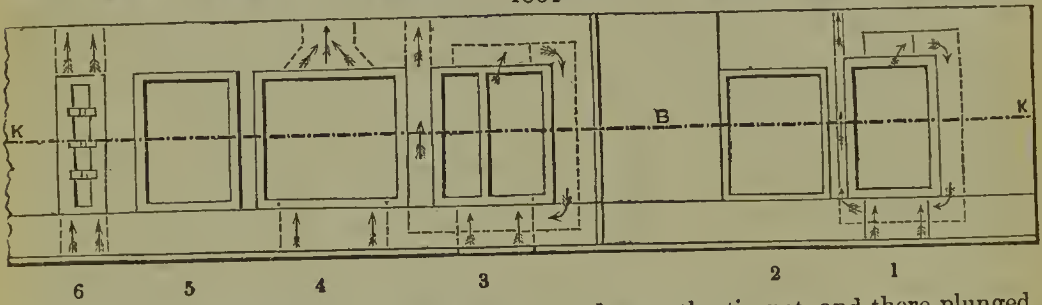
1 represents the Tinman's pan.
2 „ the Tin pot.
3 „ the Washing or dipping pot.
4 represents the Grease pot.
5 „ the Cold pot.
6 „ the List pot.

The tinman's pan is full of melted grease: in this the plates are immersed, and left there until all aqueous moisture upon them is evaporated, and they are completely

1800



1801

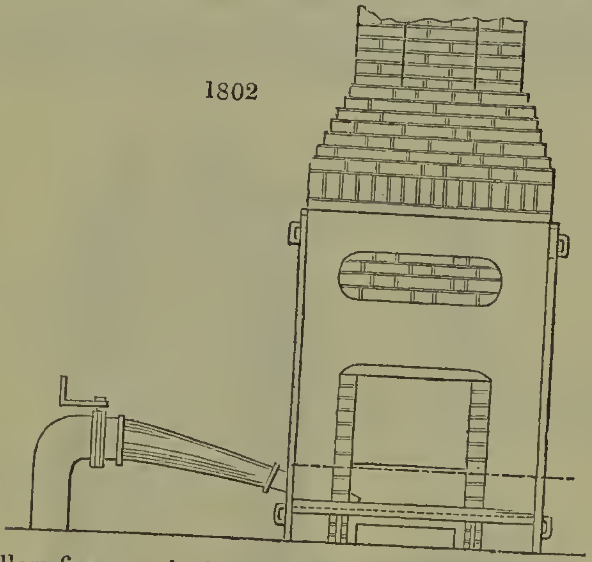


covered with the grease; from this they are taken to the tin pot, and there plunged into a bath of melted tin, which is covered with grease; but as in this first dipping the alloy is imperfect, and the surface not uniformly covered, the plates are removed to the dipping or wash pot; this contains a bath of melted tin covered with grease, and is divided into two compartments. In the larger compartments the plates are plunged, and left sufficiently long to make the alloy complete, and to separate any superfluous tin which may have adhered to the surface; the workman takes the plate and places it on the table marked B on the plan and wipes it on both sides with a brush of hemp; then to take away the marks of the brush, and give a polish to the surface, he dips it in the second compartment of the wash pot. This last always contains the purest tin, and as it becomes alloyed with the iron it is removed on to the first compartment, and after to the tin pot. The plate is now removed to the grease pot (No. 4): this is filled with melted grease, and requires very skilful management as to the temperature it is to be kept at. The true object is to allow any superfluous tin to run off, and to prevent the alloy on the surface of the iron plate cooling quicker than the iron. If this were neglected the face of the plate would be cracked. The plate is removed to the cold pot (No. 5): this is filled with tallow, heated to a comparatively low temperature. The use of the grease pots, Nos. 4 and 5, is the process adopted in practice for annealing the alloyed plates. The list pot (No. 6) is used for the purpose of removing a small wire of tin, which adheres to the lower edge of the plate in all the foregoing processes. It is a small cast-iron bath, kept at a sufficiently high temperature, and covered with tin about one-fourth of an inch deep. In this the edges of the plates are dipped, and left until the wire of tin is melted, and then detached by a quick blow on the plate with a stick. The plates are now carefully cleaned with bran to free them from grease. Lastly, they are taken to the sorting room, where every plate is separately examined and classed, and packed in boxes for market as hereafter described.

The tests of quality for tin plates are—ductility, strength, and colour. To obtain these, the iron must be of the best quality, and the manufacture must be conducted with proportionate skill. This necessity will explain to some extent the cause why nearly all the improvements in working iron during the past century have been either originated or first adopted by the tin-plate makers, and a sketch of the processes used at different times, in working iron for tin plates, will be, in fact, a history of the trade.

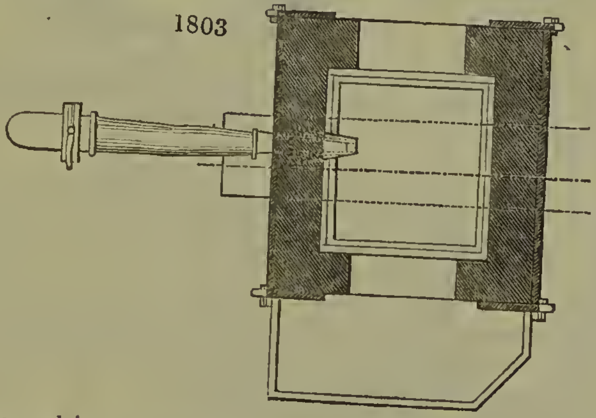
The process of preparing the best or charcoal iron seems to have undergone but little change from 1720 to 1807. The finery, the chafery, and the hammer, were the modes of bringing the iron from the pig to the state of finished bars. The finery was of the exact form of the *figs.* 1802, 1803, 1804, but less in size than those now used.

1802



The chafery or hollow fire was, in fact, the same as the present smiths' forge fire, but on a larger scale; and the "*hollow*" or chamber, in which the bloom was heated, was

1803



made by coking the coal in the centre with the blast, and taking care not to disturb the mass of coal above, which was used to reverberate the heat produced. Both the finery and chafery were worked by blast.

The hammers were of two descriptions: the forge hammer, a heavy mass for shaping the blooms, and the tilt hammer, much lighter and driven quicker, for shaping the bars.

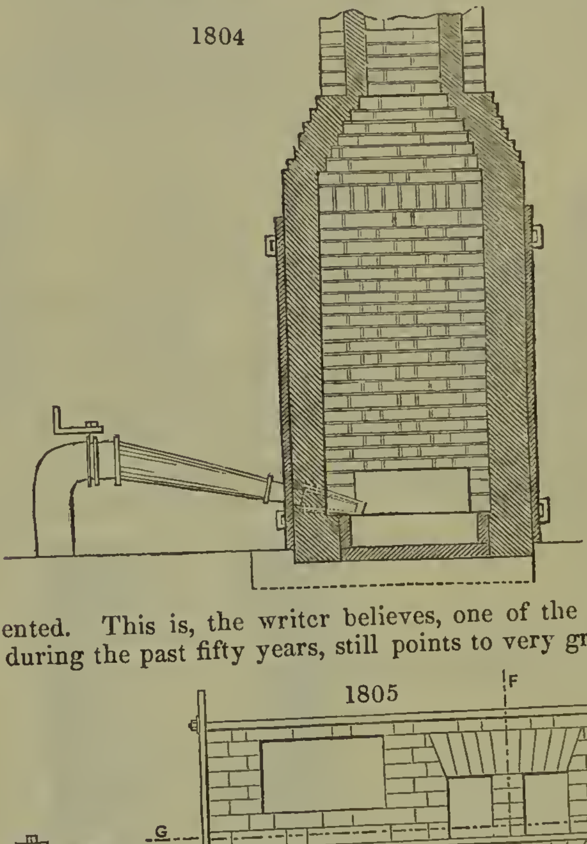
The charge for the finery was about $1\frac{1}{2}$ cwt. of pig iron: this, under the first process, was reduced to $1\frac{1}{4}$ cwt. It was, when ready, put under the forge hammer, and shaped into a "bloom," about 2 feet long and 5 inches thick; this was then heated in the chafery, and under the tilt hammer drawn out to a "bar," 3 to 4 inches wide, and half inch thick.

The manufacture up to this point, until a recent period, was carried on by the iron masters, and the iron in this state was sold under the name of "tin bars" to the plate makers. The average price for these bars, from 1780 to 1810, was 21*l.* per ton. The sheet and cold rolls were then in use nearly as at the present time.

In 1807, Mr. Watkin George, whose position had been established as one of the first engineers of his time, by the erection of the great water-wheel and works at Cyfarthfa, removed to Pontypool, and undertook the remodelling of the old works there. He clearly saw that the secret of the manufacture was to produce the largest possible quantity with least possible machinery and labour. His inventions, to this end, worked a complete change in the trade. His plans were: to first reduce the pig iron in a finery under coke, and then bring this "refiners' metal" (so termed) into the charcoal finery. The charcoal finery was built as shown in *figs.* 1802, 1803, and 1804: *fig.* 1802 being a front elevation, *fig.* 1803 a horizontal, and *fig.* 1804 a vertical section.

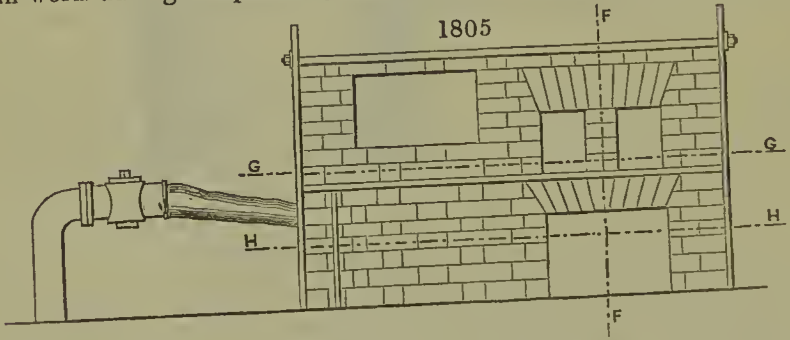
A charge of 3 cwt. of iron was used in this, and as it became malleable it was reduced under the hammer to what he termed a "stamp:" this was a piece of iron about 1 inch thick, and of any shape horizontally. It was next broken in pieces of a convenient size, and about 84 lbs. were "piled" on a flat piece of tilted iron, with a handle about 4 feet long. This rough shovel, or holder, was called the "portal," or the "staff." To re-heat this "pile" in the chafery would be a work of great cost and difficulty, and the brick hollow fire (as shown in *figs.* 1805, 1806, 1807, 1808, 1809, and 1810; *figs.* 1805 and 1806 being elevations, and *figs.* 1807, 1808, 1809, and 1810,

1804



sections) was invented. This is, the writer believes, one of the inventions which, although in work during the past fifty years, still points to very great improvements

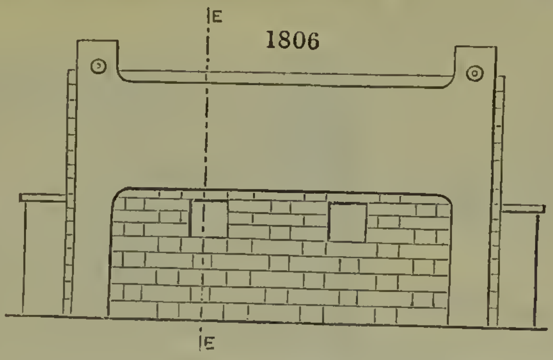
1805



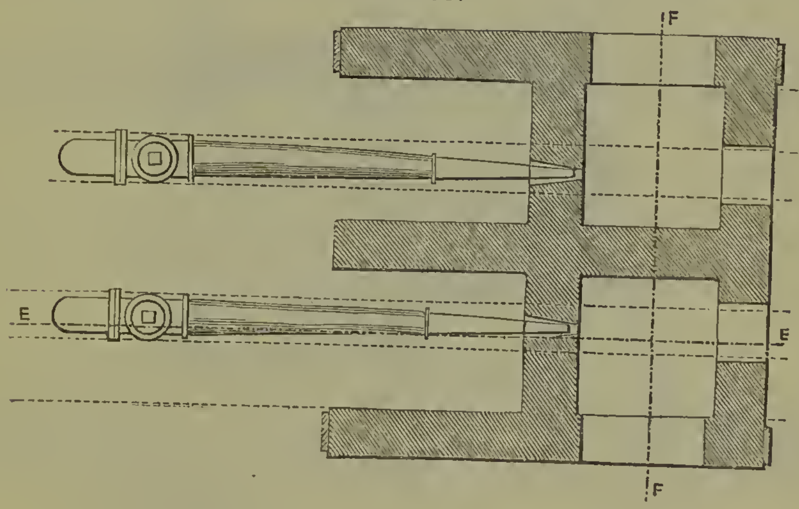
in the manufacture of iron. It is in substance the plan of using the gases produced by the decomposition of fuel for the working of iron.

The *charcoal finery* is also worked by the use of the gases to a much greater extent than is generally known. The workman sends his blast directly into the mass of iron, and the charcoal seems to be simply the means by which he is better enabled to manipulate the iron in the finery, and keep it covered, so as to revive the oxidised metal, and thus prevent waste. A few hours spent with any intelligent workman at the side of his charcoal finery would show the wasteful and expensive character of the so-called *new* schemes for converting cast into wrought iron by the use of air alone. The late belief in these schemes, by men of high repute and practical knowledge in the trade, is a direct proof of the deficiency in knowledge of exact science, as at present applied to the manufacture of iron.

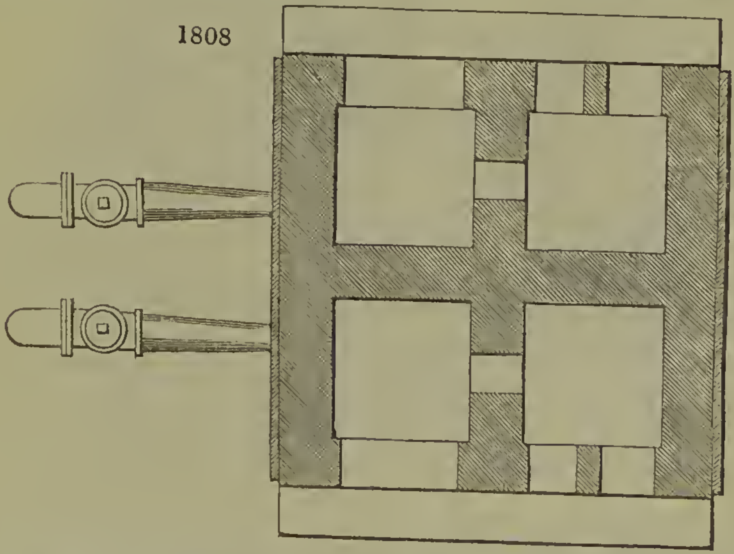
The pile was now placed in the hollow fire, and brought to a soft welding or washing heat—again hammered out to "slabs," 6 inches wide and three-quarters



inch thick; these were re-heated, cut up, and aftewards passed through rolls, reducing them to "bars" 6 inches by half-inch. These were known in the trade as "hollow

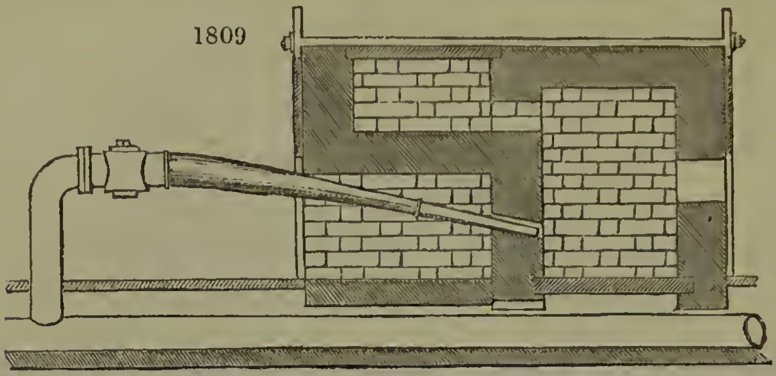


fire iron," or "tin bars." The result of Mr. Watkin George's improvements was, to reduce the cost and double the production with the same outlay in machinery. All



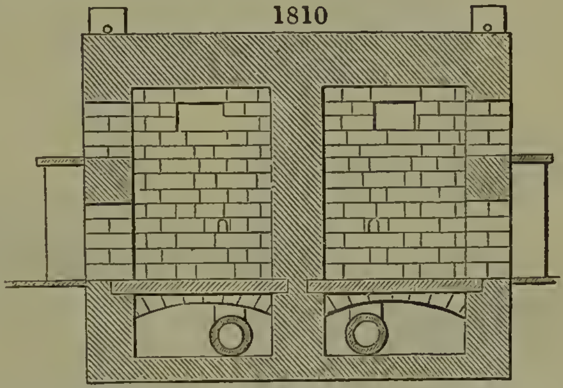
the tin plates made at this time had the great defect of a rough and smooth side. In the year 1820, Mr. Wm. Daniell, (a gentleman still living, and for whose invention the trade is and will be under great obligation,) found a mode to remedy this defect. Himself a maker of tin bars and plates, he had observed that the smooth side of the plate was always that corresponding to the flat part of the "portal," or "staff;" he at once, having ascertained this cause, remedied the defect by hammering out the pile, notching it, and doubling it over, so that the tilted blade of the "staff" was on

1809



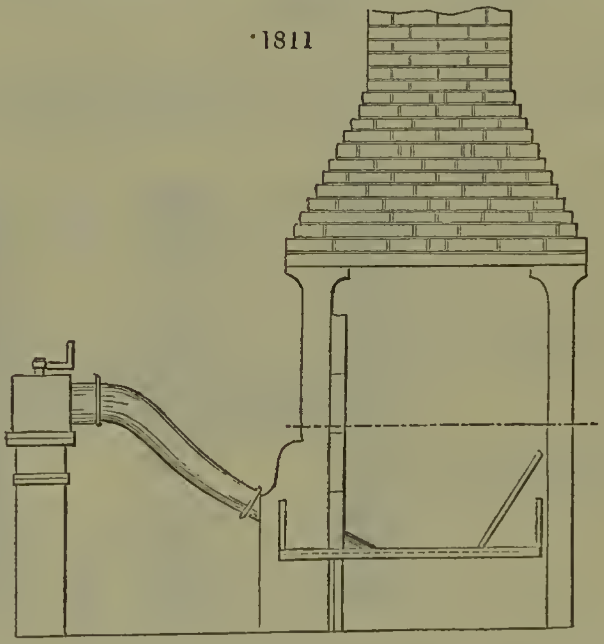
the top as well as the bottom of the pile. This was the invention of "tops and bottoms," and the writer need not remind practical men of the immense sums made by this discovery during the past thirty-seven years.

1810



Another improvement since 1807, is the use of the running-out fire: it is still adopted in only a few works. This is represented by *figs.* 1811, 1812, and 1813. *Fig.* 1811 is a front elevation; *fig.* 1812 a horizontal section; and *fig.* 1813 a vertical

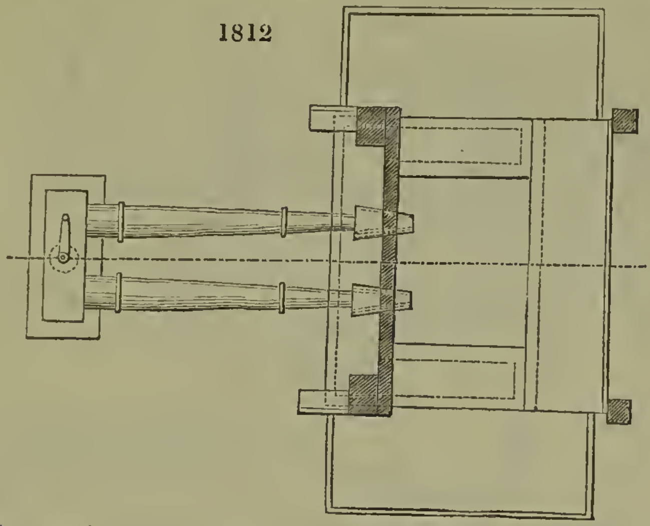
1811



section. This process saves waste of heat and labour, by running the refined metal at once into the charcoal finery.

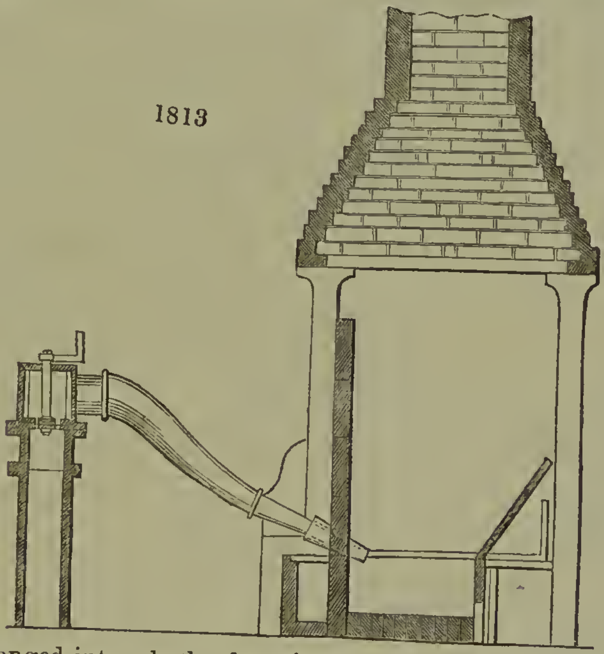
The "tin bars" before referred to, 6 inches by half-inch, are heated and run through rollers until they form a sheet of sufficient width; this sheet is then doubled and passed through the rolls, and this repeated until this sheet is quadrupled.—the laminæ are then cut to size, and separated as before described. The writer asks careful attention to the fact, that the last part of the rolling is done when the iron is nearly cold. These sheets are next annealed, and were formerly bent separately by

1812



hand, into a saddle, forming two sides of a triangle, thus ∧, and placed in a reverberatory furnace, so that the flame should play amongst them, and heat them to redness;

1813



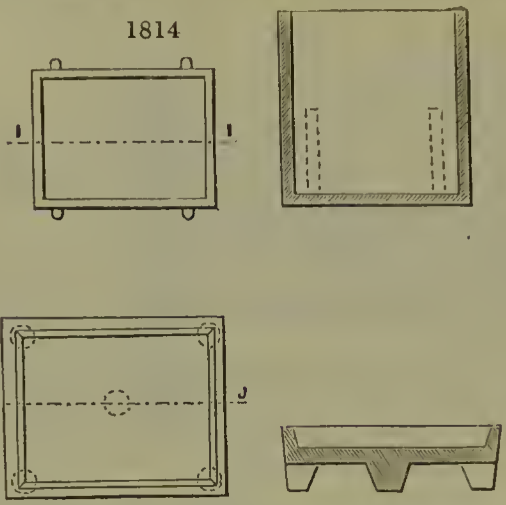
they were then plunged into a bath of muriatic acid, or sulphuric acid and water, for a few minutes, taken out, and drained on the floor, and again heated in a furnace; after which, a scale of oxide of iron separates from the plate during the work of bending them again straight, on a cast-iron block.

The plates should be now free from rust or scale, and are then passed cold through the chilled rolls: this last process is most important, as the ductility and the strength and colour of the tin plate depend upon this; at this point bad iron will crack or split, and any want of quality in the iron, or skill in the manufacture, will be shown.

A great improvement in the process of annealing was made in 1829 by Mr. Thomas Morgan: the plates were piled on a stand, and covered with a cast-iron box, now termed an "annealing pot;" in this they were exposed to a dull red heat in a reverberatory furnace for 24 hours. This annealing pot with its stand is represented by *fig.* 1814, in plan and vertical section.

A very important invention in the manufacture of iron for tin plates, and which is yet only partially carried out, was made by Mr. William Daniell in 1845. About 2½ cwt. of refined metal is placed in the charcoal finery; this is taken out in one lump, put under the hammer and "nobbled," then passed at once through the balling rolls, and reduced to a bar 6 inches square and about 2 feet 6 inches long. This bar is either cut or sawed off in pieces 6 inches long, and these rolled endways to give a bar about 6 inches wide, 2½ inches thick, and 12 inches long, and in this state the inventor calls it a "billet." This is heated in a small balling furnace and rolled down to a bar one-quarter inch thick and eleven inches wide, and will be about six feet long.

1814



This is taken at once to the tin plate mill, and the process saves great expense in fuel and machinery.

By the old method of annealing, a box of tin plates required about 13 lbs. of tin. This is now done with about 9 lbs. for charcoal and 8 lbs. for coke plates.

In referring to tin plates the standard for quotation is always taken as 1 C. (Common, No. 1.) This is a box containing 225 plates which should weigh exactly 112 lbs.

The following are the Marks, Weights, and Measurement of the Tin Plates now in common use : —

Names.	Sizes.	No. in a box.	Weight of each box.			Marks on the boxes.
	Inches.		cwt.	qrs.	lbs.	
Common, No. 1 - -	$13\frac{3}{4}$ by 10	225	1	0	0	C 1
Do. No. 2 - -	$13\frac{1}{4}$ „ $9\frac{1}{4}$	„	0	3	21	C 1 1
Do. No. 3 - -	$12\frac{3}{4}$ „ $9\frac{1}{2}$	„	0	3	16	C 1 1 1
Cross, No. 1 - - -	$13\frac{3}{4}$ „ 10	„	1	1	0	X 1
Two Crosses, No. 1 -	„ „	„	1	1	21	XX 1
Three Crosses, No. 1 -	„ „	„	1	2	14	XXX 1
Four Crosses, No. 1 -	„ „	„	1	3	7	XXXX 1
Common Doubles - -	$16\frac{3}{4}$ by $12\frac{1}{2}$	100	0	3	21	C D
Cross ditto - - -	„ „	„	1	0	14	X D
Two Cross ditto - -	„ „	„	1	1	7	XX D
Three Cross ditto - -	„ „	„	1	2	0	XXX D
Four Cross ditto - -	„ „	„	1	2	21	XXXX D
Common Small Doubles -	15 by 11	200	1	2	0	C S D
Cross do. do. -	„ „	„	1	2	21	X S D
Two Cross do. -	„ „	„	1	3	14	XX S D
Three do. do. -	„ „	„	2	0	7	XXX S D
Four do. do. -	„ „	„	2	1	0	XXXX S D
Waster's Common, No. 1	$13\frac{3}{4}$ by 10	225	1	0	0	W C 1
Ditto Cross, No. 1 - -	„ „	„	1	1	0	W X 1

One of the great items of expense in the manufacture of best iron, as before described, is the cost of charcoal for the fineries. This limits at present the production of iron made by these means; but the superior quality of iron made in the charcoal finery is always admitted. About 1850 the attention of the writer was directed to the use of a substitute for charcoal in the finery. Careful thought and experiment led him to the conclusion that some coals could be charred in such a way as to produce a mechanical structure analogous to charcoal, and, at the same time, when deprived of sulphur might be used in the finery. These experiments resulted in the manufacture of a substance the writer names "*charred coal.*" This material has been worked at several of the principal manufactories in South Wales, and declared equal in every respect to charcoal. Some tin plates made by this process were shown at the Great

Exhibition in 1851; as also the charred eoal used in the finery. (See the *Juror's Reports, &c.*) The quality of the plates was admitted as equal to the best ehareoal.

The preparation of the "*charred coal*" is very simple. The coal is first redueed to small, and washed by any of the ordinary means: it is then spread over the bottom of a reverberatory furnace to a depth of about 4 inehes; the bottom of the furnaee is first raised to a red heat. When the small eoal is thrown over the bottom a great volume of gases is given off, and mueh ebullition takes plaee: this ends in the production of a light spongy mass which is turned over in the furnace, and drawn in about one hour and a half. To eompletely clear off the sulphur, water is now freely sprinkled over the mass until all smell of the sulphuretted hydrogen gas produeed ceases. The result is "charred coal." The quantities of "charred coal" hitherto produced have been made on the floor of an ordinary coke oven, whilst red hot after drawing the charge of coke. The following analysis of the coal from whieh this "charred eoal" is made, is extracted from the "Report on the Coals suited to the Steam Navy," by Sir H. De la Beehe and Dr. Playfair:—

Abercarn Coal.

Carbon	81·26
Hydrogen	6·31
Nitrogen	·77
Oxygen	9·96
Sulphur	1·86
Ash	2·04
	102·20

Some points of great praetieal value may be elicited from this deseription of the manufacture of iron for tin plates. The stamp iron is highly erystalline, and falls to pieces under the hammer unless eautiously handled. The pile itself, after heating, is also crystalline and brittle; but after passing through the rolls it becomes less crystalline. When redueed to a sheet it is still less erystalline and more duetile; but after passing the cold rolls all the erystalline charaeter is apparently destroyed, and it beeomes a homogeneous mass, and very duetile, hard, and tough. The hammering and rolling appears to alter the strueture of the iron, and, instead of allowing the atoms to arrange themselves in crystals, to bring them into a homogeneous or amorphous mass, whieh is then held together by the law of eohesion, and is more dense and eloser than when crystallised. In practice this principle is eonstantly used. Every smith knows the practical result of what is termed "hammer hardening."

Tin coating of iron and zinc, by Mr. Morries Stirling's patent process. For this purpose the sheet, plate, or other form of iron, previously eoated with zinc, either by dipping or by depositing from solutions of zine, is taken, and after eleaning the surfaee 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 whieh it is to be eoated, it is dipped into melted tin, or any suitable alloy thereof, in a perfeetly fluid state, the surface of which is eovered with any suitable material, sueh 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 eondueted in a like manner to the proeess of making tin plate or of coating iron with zine. When a fine surfaee is required, the plates or sheets of iron coated with zine may be passed between polished rolls (as already described) before and after, or either before or after they are eoated with tin or other alloy thereof. It is preferred in all eases to use for the eoating pure tin of the deseription known as grain tin.

Another part of the invention consists in covering either (wholly or in part) zinc and its alloys with tin, and sueh of its alloys as are suffieiently fusible. To effect this, the following is the process adopted: — A sheet or plate of zinc (by preferenee sueh as has been previously rolled, both on aeeount of its ductility and smoothness) is taken, and after eleaning its surface by hydrochlorie or other acid, or otherwise, it is dried, and then dipped or passed in any eonvenient 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 eonduet the dipping, or passing through, as rapidly as is consistent with thorough coating of the zinc, to prevent as mueh as possible the zine beeoming alloyed with the tin. It is reeommended also that the tin or alloy of tin should not be heated to a higher temperature than is neeessary for its proper fluidity. The metal thus eoated, if in the form of sheet, plate, or eake, ean then be rolled down to the required thiekness; and should the eoating of tin or alloy be found insuffieient or imperfect, the dipping is to be repeated as above deseribed, and the rolling also, if desired, either for smoothing the surfaee or further redueing the thiekness.

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.

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. 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 ensure 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.

Crystallised tin-plate. See MOIRE 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 vulgarised by its cheapness, it is still interesting in the eyes of the practical chemist. The English plates marked F, 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 crystallisation 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.

TITANIUM is a rare metal, discovered by Klaproth, in Menachanite, in 1794. Small cubes of a copper-red colour, and so hard as to scratch quartz, which have been found in some of the blast furnaces in Yorkshire, Wales, and Cumberland, were thought to be titanium; they have recently been shown to be represented by the formula $TiCy,3Ti^3N$. This metal 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 crystallised, even in nitro-muriatic acid; but only when in fine powder. According to Hassenfratz, its presence in small quantity does not impair the malleability of iron. 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. Others derive the name from Tabac, an instrument used by the natives of America in smoking this herb. 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.

Tobacco is prepared as follows:—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, 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 volatilising 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 quick-lime 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 azotised 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 volatilise 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 Martinique; 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 spirit of wine being poured in, the mixture is to be equably, but sparingly, sprinkled with 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 slag 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. 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.

Dr. Ure was employed some years ago by the Excise to analyse a quantity of snuff, seized on suspicion of having been adulterated by the manufacturer. He found it to be largely drugged with pearl-ashes, 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.

The Editor of this work knows that the refuse leaves and roots, such as senna, rhubarb, and the like, after their medicinal properties have been extracted in the manufacture of infusions, extracts, and tinctures, by the druggists, are ground, coloured with burnt sienna or yellow ochre, made pungent with ammonia, and then sold in large quantities to the snuff manufacturers.

According to the recent analysis of Posset and Reimann, 10,000 parts of tobacco-leaves contain 6 of the peculiar chemical principle *nicotine;* 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.

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, chlorophylle (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, nicotinine. 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.

Virginia leaf costs in bond		$3\frac{1}{2}$*d.* per lb., the duty is		1,100 per cent.	
Ditto strips	,,	$5\frac{1}{2}$*d.*	,,	700	,,
Kentucky leaf	,,	$3\frac{1}{4}$*d.*	,,	1,200	,,
Ditto strips	,,	$4\frac{3}{4}$*d.*	,,	800	,,
Havannah cigars	,,	8*s.*	,,	112	,,
Manilla cheroots	,,	6*s.*	,,	150	,,
East India cheroots		1*s.*	,,	900	,,
Negrohead and Cavendish		6*d.*	,,	1,800	,,

Rates of duty on tobacco in foreign countries:—

	Per English Pound.
Austria—leaf tobacco - - -	3*d.*
Belgium ditto - - -	$\frac{1}{4}$*d.*
Bremen ditto, $\frac{1}{2}$ per cent. ad valorem.	
Denmark, leaves and stems - -	$\frac{1}{4}$*d.*
Prussia, Saxony, Bavaria, Brunswick, Würtemberg, Frankfort on the Maine } Zoll-Verein States	2*d.*
Other German States - - -	$\frac{1}{3}$*d.*
Hamburgh $\frac{2}{3}$ per cent. ad valorem.	
Holland 2 per cent. ad valorem.	
Ditto, cigars - - - -	2*d.*
Ionian Islands, leaf stems - -	2*d.*
Ditto manufactured - -	3*d.*
Russia, 30 per cent. ad valorem on foreign.	
Sweden and Norway - -	about 1*d.*

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 license 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.

The total quantities of tobacco retained for home consumption in 1842 amounted to nearly 17,000,000 lbs. Professor Schleiden gives a singular illustration of the quantity of tobacco consumed. North America alone produces annually upwards of 200,000,000 lbs. of tobacco. The combustion of this mass of vegetable material would yield about 340,000,000 lbs. 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 lbs.; a large contribution to the annual demand for this gas made upon the atmosphere by the vegetation of the world.

It has been observed by Lane, the learned annotator of the *Arabian Nights* (and the observation is confirmed by the experience of Mr. Layard, M.P., the explorer of Assyria), that the growth and use of tobacco amongst oriental nations has gradually reduced the resort to intoxicating beverages; and Mr. Crawford, in a paper "*On the History and Consumption of Tobacco*," in the Journal of the Statistical Society for March 1853, remarks, that simultaneously with the decline in the use of spirits in Great Britain, has been a corresponding increase in the use of tobacco.

Year.	Population.	Quantity of Tobacco consumed.	Consumption per head.
1821	21,282,960	15,598,152	11·71 oz.
1831	24,410,439	19,533,841	12·80 ,,
1841	27,016,972	22,309,360	13·21 ,,
1851	27,452,262	28,062,978	16·86 ,,

Number of rolls of tobacco exported from Bahia, which nearly all goes to Portugal:—

1841 to 1843	4,460	rolls annually.
1844 to 1846	2,775	,,
1847 to 1849	2,350	,,
1850 to 1852	2,323	,,
1853 to 1855	1,486	,,

Bales of tobacco exported from Bahia:—

1841 to 1843	3,970	bales annually.
1844 to 1846	12,270	,,
1847 to 1849	13,150	,,
1850 to 1852	49,480	,,
1853 to 1855	62,010	,,

Of mangotes of tobacco there were exported in 1853, 21,273 mangotes; in 1854, 26,839; 1855, 41,114 mangotes. Of the three varieties the quantity in tons was, for the three years ending 1855:—1853, 5,860 tons, value 151,383; 1854, 7,270, value 161,863; 1855, 7,128, value 154,440.

The quantity of tobacco imported into this country was as follows, in the last three years:—

		Retained for home consumption.
1857	43,747,959 lbs.	32,851,365 lbs.
1858	62,217,705 ,,	34,110,851 ,,
1859	50,671,264 ,,	34,791,261 ,,

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.

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, in Dorsetshire, and in Devonshire, at Newton Abbot. 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.

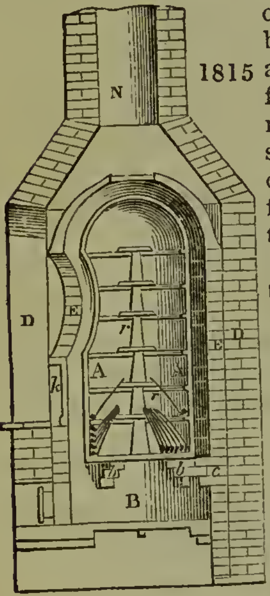
The pipe is finished by means of a folding brass or iron mould, channelled inside, of the shape of the stem of the bowl, and capable of being opened at the two ends. It is formed of two pieces, each hollowed out like a half-pipe, cut as it were lengthwise; and these two jaws, when brought together, constitute 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 50 gross in from 8 to 12 hours. A workman and a child can easily make 5 gross of pipes in a day.

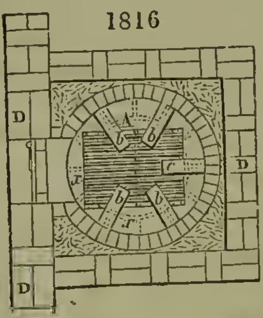
No tobacco-pipes are so highly prized as those made at Natolia, in Turkey, out of meerschaum, a somewhat plastic magnesian stone, of a soft greasy feel, which is formed into pipes after having been softened with water. It becomes white and hard in the kiln.

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.* 1815 and 1816, is a cylinder, covered in with a dome. It is placed over the fireplace B, and enclosed within a furnace of ordinary brickwork D D, lined with fire-bricks E, E. 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.* 1816 (the dotted circle representing the cylinder). These ribs are perforated with occasional apertures, as shown in *fig.* 1815, 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.

1815



1816



The lining F, E, E, 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.* 1815, 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 cylindric 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 cylindric 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 eight or nine 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.*

TOLUIDINE. $C^{14}H^{9}N$. A volatile base isomeric with lutidine, formed from toluole, by processes analogous in all respects to those by which aniline is produced from benzole.—C. G. W.

TOLUOLE. $C^{14}H^{8}$. Syn., *Hydruret of toluenyle*. A hydrocarbon produced in the destructive distillation of the resin of Tolu. It is also produced by the decomposition of toluylic acid by baryta at a high temperature. Coal naphtha contains it in large quantity. For its physical properties, see CARBO-HYDRIDES.—C. G. W.

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.

TOMBAC. White copper. See ALLOY.

TON. An English weight of 20 cwt., according to the statute, or 2240 lbs. It varies in different districts:—

South Wales, from 2400 lbs. to 2618 lbs.
Ayrshire, from 2464 lbs. to 2520 lbs.
North Staffordshire, coal, 2400 lbs.
Do. do. stone, 2520 lbs.

Copper ores are sold by the ton of 21 cwt. of 112 lbs. or 2352 lbs.

In Newcastle the leases are by the ton of 440 bolls of 36 gallons each = 48 tons, 11 cwt. 2 qrs. 17 lbs. statute.

TONKA BEAN. The fruit of the *Dipterix odorata*, affords a concrete crystalline volatile oil (*stearoptene*), called *coumarine* 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. Teeth are made of the best ivory; the following, however, is one of the processes adopted for the artificial manufacture of teeth. Pure crystallised 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

* Contributions to the History of the Coco-nut Tree. By Henry Marshall, Esq., Deputy Inspector of Hospitals

powder. Artificial teeth are composed of two parts, 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, pulverised, 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-ful is driven without breaking into a fine board, until it is even with the surface of the wood.

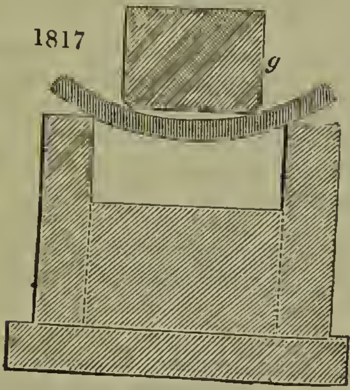
TOPAZ. The fundamental form is a scalene 4-sided pyramid; but the secondary forms have a prismatic character, and are frequently observed in oblique 4-sided prisms, acuminated by 4 planes. The lateral planes of the prism are longitudinally striated. Fracture conchoidal, uneven; lustre vitreous; colours, white, yellow, green, blue, generally of pale shades. Hardness 8; spec. grav. 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 crystallisation, 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 crystallisation 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 Kamtschatka; in Brazil, where they generally occur in loose crystals, and pebble forms of bright yellow 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.

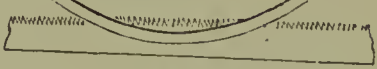
TORTOISE-SHELL, or rather scale a horny substance, that covers the hard strong covering of a bony contexture, which encloses the *Testudo imbricata*, Linn. The lamellæ or plates of this tortoise are thirteen in number, and may be readily separated from the bony parts by placing fire beneath the shell, 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.* 1817, is bent like an arch in the direction of the length of the teeth, as in *fig.* 1818. 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

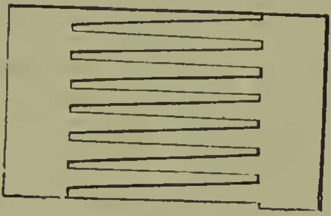
1817



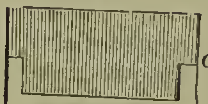
1818



1819

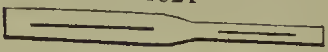


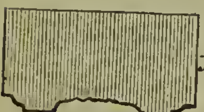
1823



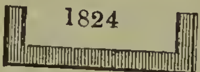
1820

1821

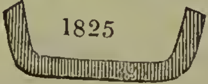




1824



1825



1822

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.* 1820, 1821 and, 1822. 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-sheel boxes, the round plate of shell is first placed centrally over the edge of the ring, as in *fig.* 1823; it is slightly squeezed with the small round edgeblock *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.* 1825, 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.* 1824, 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.

Tortoise or Turtle shell *imported* in 1850, 43,085 lbs.

TOUCH-NEEDLES, and TOUCH-STONE, are means of ascertaining the quality of gold trinkets. See Assay.

The touch-needles are bars of known composition, and the touch-stone is black basalt; according to the streak made by the article to be tested, as compared with that made by the needles, its quality is inferred.

TOW. See Flax.

TRAGACANTH, GUM. (*Gomme adracante*, Fr.; *Traganth*, Germ.) See Gum.

TRASS, or TARRAS. A German term for a tertiary earth—probably volcanic, which occupies wide areas in the Eifel district of the Rhine. Its basis appears to be pumice stone, mixed with fragments of basalt and calcined slate. When powdered it is used like the pozzolano of Italy—as an hydraulic cement.

TRAVERTIN. A white concretionary limestone deposited from springs holding lime in solution. Travertin is compact. Tufa is a porous body.

TREACLE is the viscid brown uncrystallisable syrup which drains from the sugar-refining moulds. Its spec. grav. is generally 1·4, and it contains upon an average 75 per cent. of solid matter, by Dr. Ure's experiments.

TRIPOLI (*Terre pourrie*, Fr.; *Tripel*, Germ.) is a mineral of an earthy fracture, a yellowish-grey or white colour, composition impalpably fine, meagre to the touch, does not adhere to the tongue, and burns white.

M. Ehrenberg has shown that these friable homogeneous rocks, which consist almost entirely of silica, are actually composed of the exuviæ or rather the skeletons of infusoria (*animalcula*) of the family of *Barcillariæ*, 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 $\frac{1}{288}$ 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 Franeisbad, near Eger.

Tripoli is said by Brooke and Miller to be found "near Prague in Saxony, France, England, (?) Tripoli, Corfu." Tripoli has been confounded by many writers with the English Rottenstone. Mr. Kirwan, in his *Elements of Mineralogy*, says, "Mr. Haase, who has lately analysed it, found 100 parts of it to contain 90 of siliceous earth, 7 of argill, and 3 of iron; but the red sort probably contains more iron. According to M. Gerhard, magnesia has sometimes been extracted from it. It is evidently a volcanic product; for a coal mine near St. Etienne having accidentally taken fire, and the fire in its progress having extended to some strata of schistus and bitumen, tripoli was found in those parts of the strata that the fire had acted upon, but not in any other."

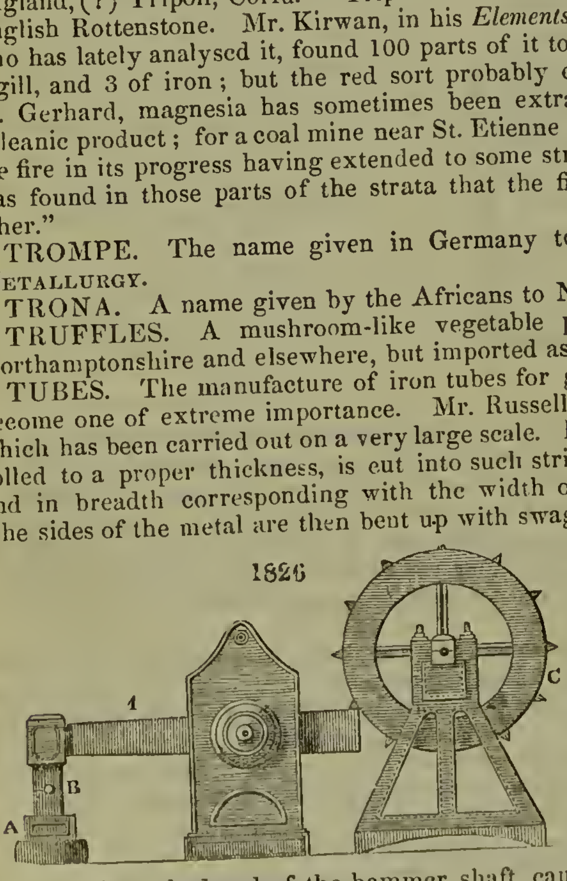
TROMPE. The name given in Germany to the water-blowing engine. See Metallurgy.

TRONA. A name given by the Africans to Natron, which see.

TRUFFLES. A mushroom-like vegetable production found underground in Northamptonshire and elsewhere, but imported as a luxury from Italy.

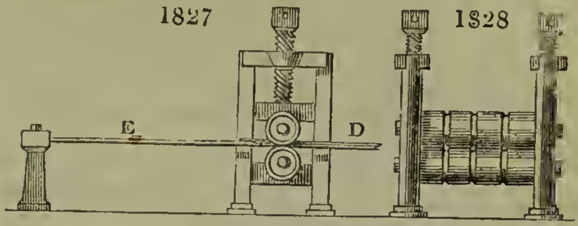
TUBES. The manufacture of iron tubes for gas, water, and other purposes has become one of extreme importance. Mr. Russell of Wednesbury patented a process which has been carried out on a very large scale. In this process plate iron, previously rolled to a proper thickness, is cut into such strips or lengths as may be desirable, and in breadth corresponding with the width of the tube intended to be formed. The sides of the metal are then bent up with swages in the usual way, so as to bring the two edges as close as possible together. The iron thus bent is then placed in an air or blast furnace, and brought to a welding heat, in which state it is withdrawn and placed under the hammer. *Fig.* 1826, A, is the anvil having a block or bolster, with a groove suited to and corresponding with a similar groove B, in the face of the block. C is a wheel with projecting knobs, which, striking in succession upon the iron-shod end of the hammer shaft, causes it to strike rapidly on the tube. In this process the tube is repeatedly heated and hammered, until the welding is

1826



complete from end to end. A mandril may be inserted or not during this operation. When the edges of iron have been thus thoroughly united, the tube is again heated in a furnace, and then passed through a pair of grooved rollers similar to those used in the production of rods, *fig*, 1827. Suppose a tube D, to be passing through these rollers, of which *fig*. 1828, represents a cross section, immediately upon its being delivered from the groove it receives an egg-shape core of metal fixed upon the extremity of the rod E, over which the tube sliding on its progress, the inside and outside are perfected together. Mr. Cort patented a similar process for the manufacture of gun barrels.

1827 1828



Brass or copper 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 sealy 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.

Lead pipes are produced by forcibly squeezing the lead through a circular orifice over a mandril.

TUBULAR BRIDGES, *and other structures*. In the former edition of this work there was a long article bearing the heading of FAIRBAIRN'S TUBULAR BRIDGES. This article no longer appears. In the first place, it ought never to have formed a place in a work which has nothing whatever to do with engineering science; and in the next place, it was calculated to inflict the most serious injury on the names of two men to whom this country is much indebted for works of surpassing magnitude and durability. Mr. Fairbairn has obtained a reputation for his mechanical, experiments, his engineering skill, and his extensive knowledge, so great that he is placed far above the necessity of seeking to assume any position to which he is not fairly entitled.

Without attempting to enter into the discussion which was, with much unfortunate feeling, obtruded in the last edition of the Dictionary, we purpose merely retaining so much of the original article as is purely descriptive of the applications of iron to tubular structures. The whole question is so completely settled by Mr. Fairbairn himself in his *Account of the Construction of the Britannia and Conway Tubular Bridges*, that beyond quoting his own words nothing need be said:—

1st. "I, however, cherish the hope that the perusal of this correspondence will establish the fact that it was in a great degree owing to my determined perseverance that *Mr. Stephenson's original conception* has been successfully carried into execution, and that the elaborate series of experiments which I performed have established the true principle upon which tubular bridges should be constructed. *To this early conception I make no claim*, but with regard to the services which I afterwards rendered I must leave the estimate of their merits to the unbiased judgment of the reader."—*Fairbairn, Preface*, p. 7.

2nd. "Mr. Robert Stephenson conceived the *original idea of a high tubular bridge to be constructed of riveted plates*, and supported by chains, and of such dimensions as to allow of the passage of locomotive engines and railway trains through the interior of it."—*Fairbairn*, p. 2.

This honest statement by Mr. Fairbairn himself shows that he had no intention of assuming the position which belongs to the originator of a great idea. Indeed, the following, the third quotation, shows exactly what was Mr. Fairbairn's position.

3rd. "I was asked whether such a design was practicable, and whether I could accomplish it; and it was ultimately arranged that the subject should be investigated experimentally to determine *not only the value of Mr. Stephenson's original conception*, but that of any other *tubular form of bridge* which might present itself in the prosecution of my researches" —*Fairbairn*, p. 3.

With the other matters in dispute we have little to do; a most careful study of Mr. Fairbairn's own work shows:—

1st. That Mr. Robert Stephenson conceived the idea of a tubular bridge through which railway trains should pass.

2nd. That Mr. William Fairbairn carried out the preliminary experiments for Mr. Robert Stephenson, and determined that the use of chains as supporting the tube might be done away with entirely.

3rd. That Mr. Eaton Hodgkinson also made experiments and calculations for determining the strength of tubular constructions. A careful study of the work already quoted by Mr. Fairbairn, and "*The Britannia and Conway Tubular Bridges*," by Edwin Clark, will place the above three engineers, each one in his proper, and each one in a most honourable position. They have built for themselves an enduring monument, which will speak to future ages of the engineering powers, of the originating mind, and of the mechanical and mathematical skill by the agency of which that grand idea became a sublime material fact. The Britannia and Conway Bridges exist, the pride of the country which possesses them, triumphs of the constructive arts, and immortal monuments to the men who were associated in their contrivance and execution. It is to be deplored in every respect that jealousies and rivalries should have arisen under circumstances where so much renown and merit was to be divided.

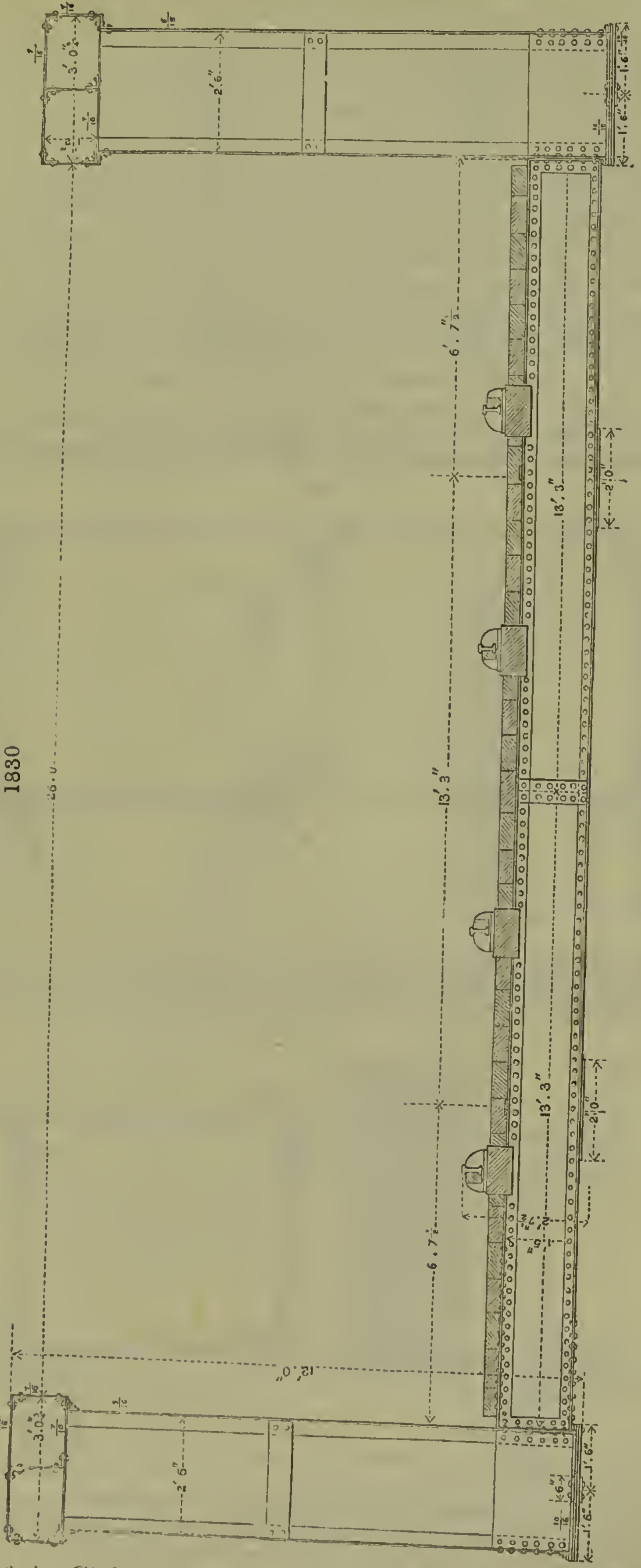
As an outgrowth of the remarkable introductory experiments made in connection with these wonders of North Wales, we must regard the equally important, though less imposing tubular girder system. A tubular girder, as the name implies, is a hollow beam constructed of metal plates firmly riveted or fastened together. When subjected to a transverse strain or load tending to break it, the law, which is applicable to every body, be it solid or hollow, is observable. The parts of the girder above the neutral axis have to arrange themselves to a resistance of a compressive strain, while those below that line are violently subjected to a force tending to draw them asunder. The extreme ductility of wrought iron, and its great power to resist tension, were well known, and in the earlier stages of the inquiry it was considered feasible, and frequent efforts were made to arrange the parts in such manner that these known properties might be taken advantage of in both the upper and lower sides of the girder, but every experiment baffled the ingenuity of the contrivance, and nature soon taught the constructor that her unerring laws were not to be disregarded.

The description of one of the best constructed tubular girders will give the most correct idea of their power and peculiarity. We select for illustration the beautiful bridge erected across the Trent at Gainsborough. *Fig.* 1829 represents a general

1829

elevation of the bridge which carries the Lincolnshire railway across the Trent. Its total length is 332 feet, the two main spans being 154 feet each. The width of roadway between the two main girders is 26 feet, giving ample room for double lines of railway. The width of the centre pier is 12 feet, and the tubular girders have a bearing on each land abutment of 6 feet. *Fig.* 1830 represents a cross-section form of the main girders, and to this we must direct especial attention in order to make the peculiarities of the system well understood. The height of each girder from end to end is 12 feet; this parallelism is not the best form to give a maximum resistance with a minimum amount of material; but from the greater facilities of construction is preferable to the parabolic form, and practically the proportions of the strength may be adjusted by varying the thicknesses, instead of the linear dimensions of the parts.

The Bottom of the Girder.—The bottom is framed of double thicknesses of long rolled plates, connected together in the manner hereafter described. Being subjected solely to a tensile strain, the material is condensed as much as possible, so as to assimilate that part of the structure to one unbroken solid sheet, which, if practicable, would be the best distribution or form. Each plate is 12 feet long by 18 inches wide, varying in thickness according to its position from the centre line of each span, where the greatest amount of material is accumulated. The bottom is necessarily connected to the sides of the girder by long bars of heavy angle iron, firmly riveted to both.



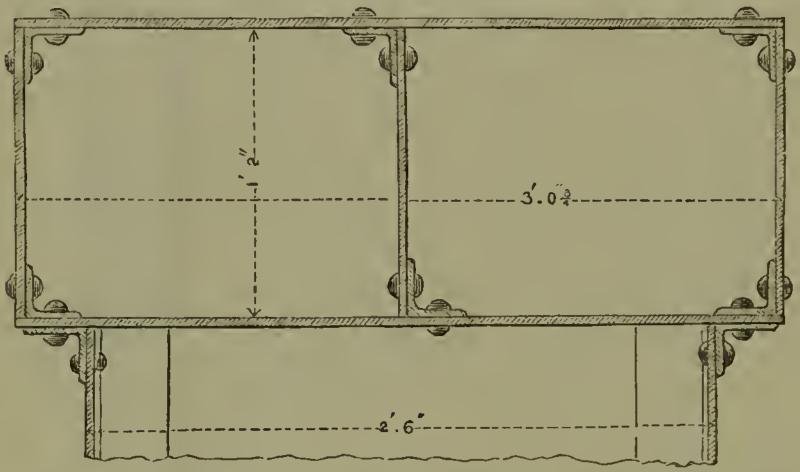
1830

The Sides of the Girder.—The side plates are 2 feet wide throughout, and of uniform thickness, excepting in the immediate neighbourhood of the piers and abutments, where they are strengthened and stiffened by pillars of strong T iron, to offer a due resistance to the dead weight of the girder itself. The joints are made with external covering plates 4½ inches wide, and internal ribs of T iron, which suffice to keep the side plates rigid, and enable them to accomplish their duty of separating the top and bottom of the girder.

The Top of the Girder.—In this part the principal novelty and ingenuity are observable. A single sheet of iron, like a sheet of paper, is easily put out of shape by a compressive strain. It crumples up, and at once loses all power of resistance. A sheet of common writing paper, which when placed on edge will merely support itself, when rolled into a cylinder, say of 1 inch diameter, will carry a considerable weight. In the same manner a given sectional area of plate, if placed in that simple form in the top of the Trent girder, would crumple up with a comparatively small weight, but when distributed according to the cellular system, as indicated by the Millwall experiments, it offers extraordinary resistance to compression.

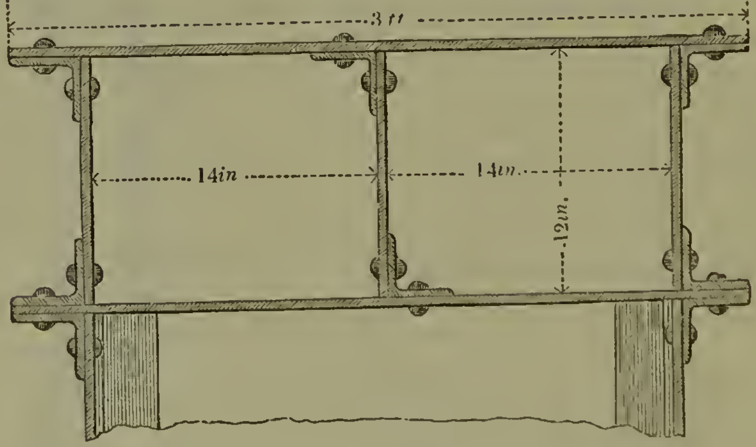
The value of this arrangement will be understood when it is stated that, notwithstanding the superior tenacity of wrought iron, a well constructed tubular girder only requires an excess of sectional area in the top over the bottom of $\frac{1}{12}$. In the Trent girder (see *fig.* 1831) the top compartment is 3 feet ¾ inches wide, and 15 inches deep, divided by a vertical plate into two rectangular cells, and all firmly connected by rivets and angle iron. Those angle irons constitute important elements in its strength.

1831



Since the construction of the Trent bridge, the cost of construction of tubular girders has been much diminished by a different arrangement of the parts of the top compartment, as shown in the following, *fig.* 1832. This form is equally powerful in its

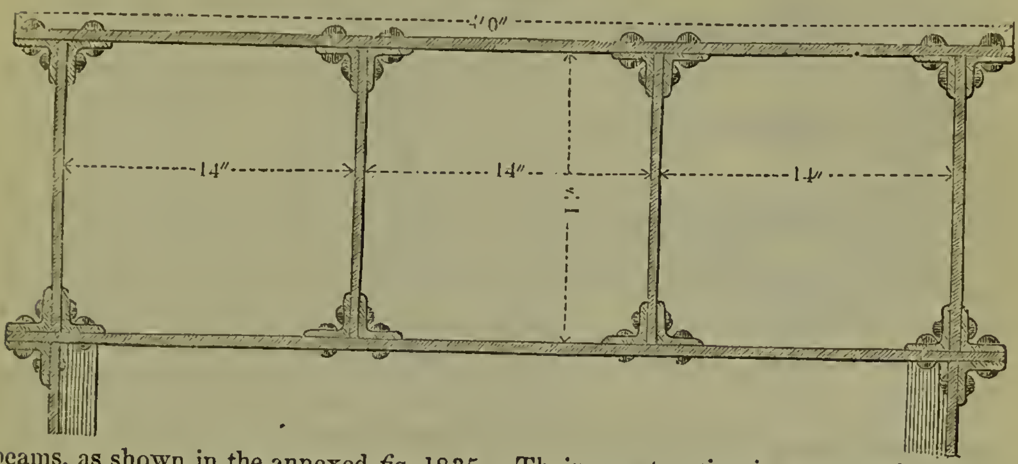
1832



resistance. When the span of the bridge reaches 180 or 200 feet, the top compartment is arranged as shown in *fig.* 1833, and when it is under 60 feet as shown in *fig.* 1834. It will be noticed that in every case the cells are proportioned, so as to admit of the entrance of a man for the purposes of painting or repairs.

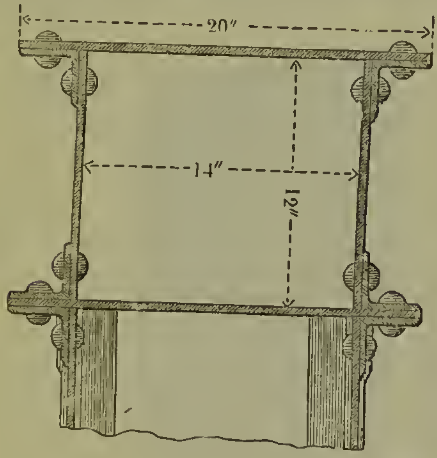
The Cross Beams or Supports of the Roadway.—These are generally, and ought to be universally, made of iron. In the Trent bridge they are made hollow or box

1833

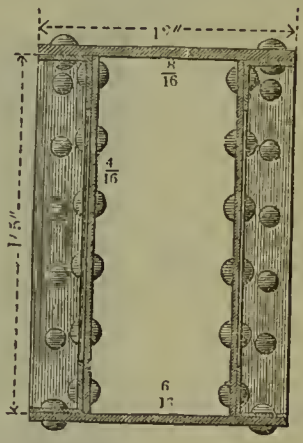


beams, as shown in the annexed *fig.* 1835. Their construction is now much simpler and equally good, thus, *fig.* 1836.

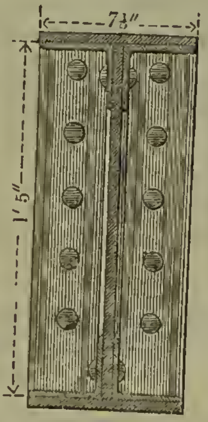
1834



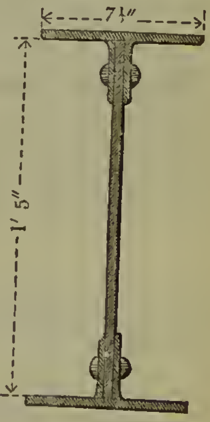
1835



The Riveting. — Upon the judicious fastenings of the plates together depends in a great measure the safety of a tubular girder bridge. The system of riveting followed in the several parts should have reference to the strains which occur in those parts. What are technically called "lap joints," where the ends of the plate overlap each other, and are connected by a single row of rivets (vide *fig.* 1837), should be avoided in every part of the structure, as they have been proved to be weak and insufficient. Mr. Fairbairn (*Phil. Trans.* part ii. 1852) gives the value of single and double-riveted joints as 70 and 56 respectively, the solid plate being assumed to be 100.



1836



"Butt joints" and covering plates are used throughout the girder, the length and substance of these covering plates and the number of rivets varying according to situation. In the top compartment the ends of the plates having been carefully fitted to each other, so as to take their portion of the strain the moment the load is applied, are covered by strips of sufficient width to receive a double row of rivets, one on each side of the joint, thus, as shown in *fig.* 1838. This arrangement effectually prevents some such effect as indicated in *fig.* 1839, which would occur were the lap joint used, and the load very great. In the tops the rivets are generally spaced 3 inches apart from centre to centre.

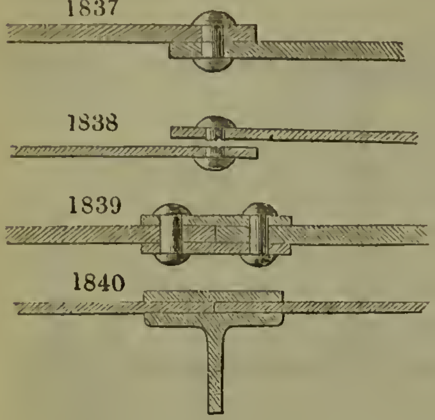
As before mentioned, instead of simple strips covering the vertical joints of the side plates, inside T iron bars are used to afford stiffness, and prevent the approach of the top and bottom (vide *fig.* 1840). Thus, the rivets being spaced 3 inches, the strips give to the external elevation of the girder the appearance of a series of panels.

1837

1838

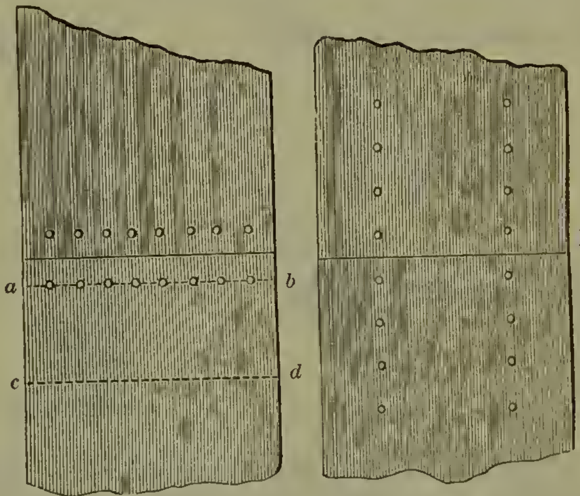
1839

1840



In the bottom an exceedingly ingenious and beautiful arrangement of riveting has been introduced by Mr. Fairbairn. It is evident that to join two plates together (these two plates having to resist a force tending constantly to separate them) a certain number of rivets or pins are required, and according to the old system of jointing, these rivets were placed in single rows along the edge of the plates, being in fact either single lap joints or single butt joints. Suppose the plates in *fig.* 1841 to be each 2 feet wide, and ½ inch thick, and that to connect them there were wanted 16 rivets, each 1 inch diameter: it is evident the resisting powers of the plates are weakened exactly by the amount of material punched out, in this case one-third, the section of resistance being through the line *a b*, and not through the line *c d*. But if these 16 rivets, instead of being placed all parallel with the joint, are arranged as shown in *fig.* 1842, and covered with long "covering plates" instead of "strips," it is

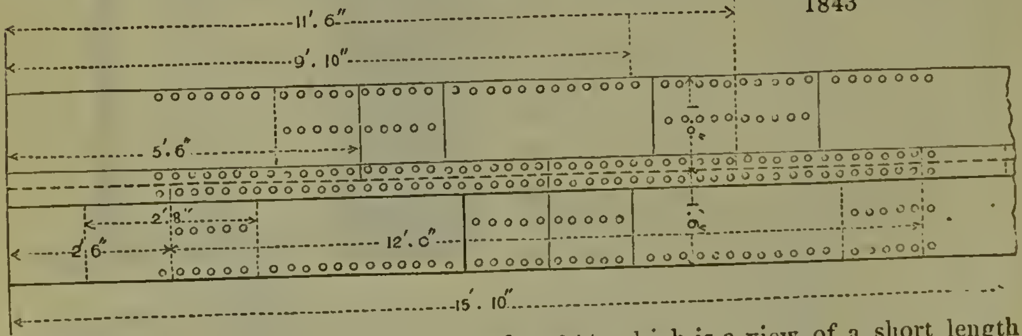
1841



1842

equally evident that they are in this position equally fitted to their duty of joining the plates and that the punching has weakened the resisting powers of the plates only $\frac{1}{12}$ instead of $\frac{1}{3}$. These proportions will readily explain the saving in material and weight which Mr. Fairbairn's "chain riveting" has effected, and the following figure of the "bottom" of the Trent bridge will show how it is practically applied (*fig.* 1843). The joints of the angle irons in the bottom are also jointed by long

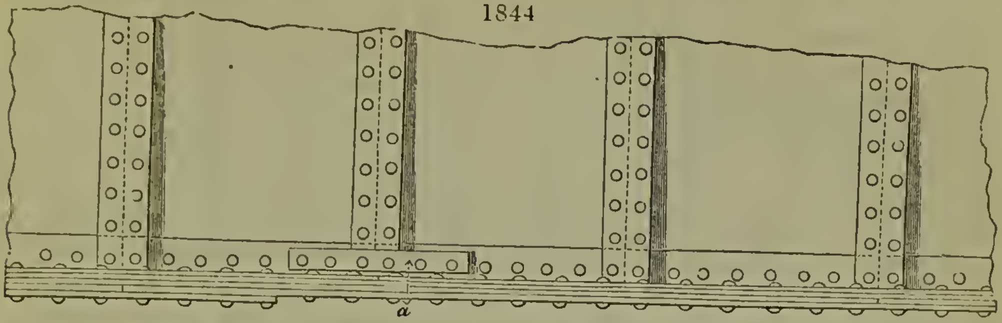
1843



corner pieces, as may be noticed at *a* in *fig.* 1844, which is a view of a short length of the bottom of the main Trent girder. Having thus described the tubular girder bridge in its best and most generally adopted form, a glance at the following figures (*figs.* 1845, 1846) will indicate modifications of the system which have gained favour in some quarters.

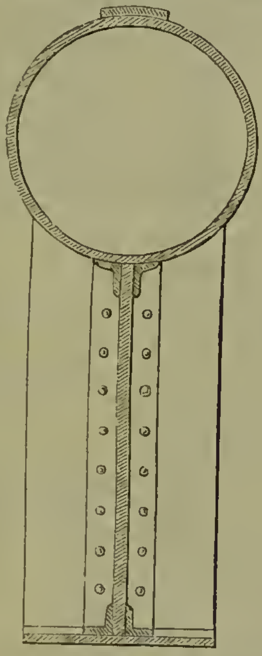
The Proportions and Strength of Tubular Girders.—The limits of this article will not admit of a lengthened examination of these interesting topics. A well proportioned beam or girder should have such a sectional distribution of its material, that when subjected to a transverse strain, the top should yield to compression and the bottom

1844

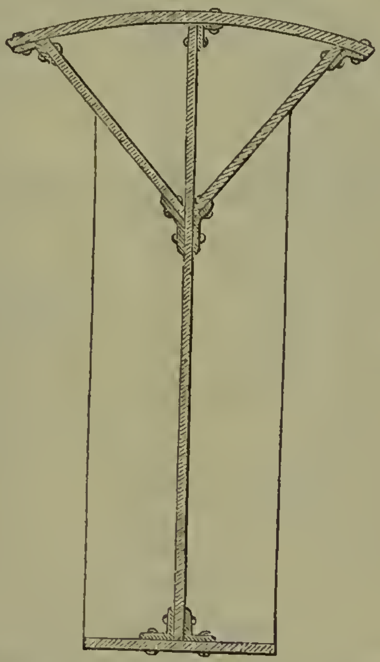


to extension at one and the same time; and as nearly all materials offer unequal resistances to the two forces, direct experiment can alone determine the exact relative proportions of the two parts. Thus, the resisting power of cast iron to compression is nearly six times greater than that which it offers to extension; but Mr. Fairbairn's ingenious distribution of the wrought-iron plates in the "cellular top" has enabled

1845



1846



him to fix the relative sectional areas of the tops and bottoms of tubular beams in the ratio of 12 to 11.

The tables in the following page show the proportions for tubular girder bridges of spans from 30 up to 300 feet.

Mr. Fairbairn's formula for calculating the strength of tubular girder bridges has been much disputed, but at the same time it has had many able defenders, and may be followed with perfect reliance and safety. If it errs, it errs on the right side—that of understating the real strength; it is

$$w=\frac{a\,d\,c}{l}$$

where w=the centre breaking weight in tons irrespective of the weight of the girder;
a=sectional area of bottom in inches;
d=depth of beam in inches;
c=a constant derived from experiment for the particular form of girder; and
l=length of girder between the supports in inches.

The formula always assumes a well made and well proportioned girder, having the relative areas of 12 to 11 in the top and bottom and the chain riveting.

The constant c for the tubular girders we have described was ascertained to be 80. Let us now find by this formula the strength of one of the spans of the Trent bridge which we have described. By reference to *fig.* 1830 it will be observed that here a=58·5, d=144, and l=1848.

$$w=\frac{a\,d\,c}{l}=\frac{58\times144\times80}{1848}=364{\cdot}6\text{ tons}$$

as the weight which a tubular girder 154 feet between the supports will carry suspended from one point in the centre before fracture. Now the actual weight of this girder itself is under 70 tons, and it may safely be asserted that no other form of construction would give so favourable a result. The centre breaking weight of one girder being 364½ tons, it would carry 729 tons equally distributed along its entire length, and there being two main girders to the bridge, the ultimate strength of the structure is in round numbers 1500 tons. It would be possible, by both lines of railway being covered with heavy goods trains, to have a load on the bridge of about 250 tons at one and the same time, and we thus see there is a margin of strength of six times the greatest possible load. Engineers differ in opinion as to the excess of strength which it is desirable that railway structures should possess: some are satisfied with even as low an ultimate breaking strength as three times the load; but with a comparatively untried material, and one moreover liable to deterioration from atmospheric influences, the larger excess is the better.

Table showing the Proportions of Tubular Girder Bridges, from 30 *to* 150 *Feet Span.*

Span Feet.	Span In.	Centre Breaking Weight of Bridge. Tons.	Sec. Area of Bottom of one Girder. Inches.	Sec. Area of Top of one Girder. Inches.	Depth at the Girder in the Middle. Feet.	Depth In.
30	0	180	14·63	17·06	2	4
35	0	210	17·06	19·91	2	8
40	0	240	19·50	22·75	3	1
45	0	270	21·94	25·59	3	6
50	0	300	24·38	28·44	3	10
55	0	330	26·81	31·28	4	3
60	0	360	29·25	34·13	4	7
65	0	390	31·69	36·97	5	0
70	0	420	34·13	39·81	5	5
75	0	450	36·56	42·67	5	9
80	0	480	39·00	45·50	6	2
85	0	510	41·44	48·34	6	7
90	0	540	43·88	51·19	6	11
95	0	570	46·31	54·03	7	4
100	0	600	48·75	56·88	7	8
110	0	660	53·63	62·56	8	6
120	0	720	58·50	68·25	9	3
130	0	780	63·38	73·94	10	0
140	0	840	68·25	79·63	10	9
150	0	900	73·13	85·31	11	6

Table showing the Proportions of Tubular Girder Bridges, from 160 *to* 300 *Feet Span.*

Span. Feet.	Span In.	Centre Breaking Weight of Bridge. Tons.	Sec. Area of Bottom of one Girder. Inches.	Sec. Area of Top of one Girder. Inches.	Depth at the Girder in the Middle. Feet.	Depth In.
160	0	960	90·00	105·00	10	8
170	0	1020	95·63	111·56	11	4
180	0	1080	101·25	118·13	12	0
190	0	1140	106·88	124·69	12	8
200	0	1200	112·50	131·25	13	4
210	0	1260	118·13	137·81	14	0
220	0	1320	123·75	144·38	14	8
230	0	1380	129·38	150·94	15	4
240	0	1440	135·00	157·50	16	0
250	0	1500	140·63	164·06	16	8
260	0	1560	146·25	170·63	17	4
270	0	1620	151·88	177·19	18	0
280	0	1680	157·50	183·75	18	8
290	0	1740	163·13	190·31	19	4
300	0	1800	168·75	196·88	20	0

Explanation of the Engravings, descriptive of the Hollow Girder Bridge over the Turnpike Road near Blackburn.

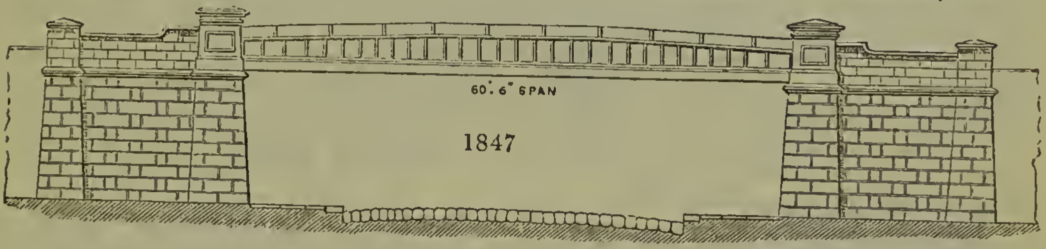
Fig. 1847 is an elevation or side view of the girder, eaeh 66 ft. long, and bedded on east-iron base plates.

Fig. 1848 is a transverse seetion of the bridge, showing the sides of the eross-beams, and the eross seetions of the outside and middle girders.

Fig. 1849 is an enlarged transverse seetion of the outside girder, showing the attachment of the eross-beams, which are riveted to the bottom of the girder, exelusive of two bolts *a a*, whieh extend through the bottom plates and angle iron of the girder. and the top and bottom plates of the cross-beam.

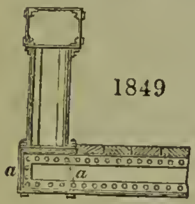
Fig. 1850 is an enlarged view of a part of the side of the large girder, exhibiting a transverse seetion of the eross-beam at *b*, whieh is made of wrought-iron, with the top and bottom plates so proportioned as to equalise its powers of resistanee to the foree of compression on the top, and that of tension on the bottom. It also exhibits the mode of riveting up the joints of the side plates with the eovering strip *c c c*, and the additional strength as obtained by the attaehment of T iron in the interior of the tube.

Fig. 1851 is a plan of the bridge. showing on one side the platform and the rails, and on the other the cross-beams, whieh in this bridge are plaeed 6 ft. asunder ; but in

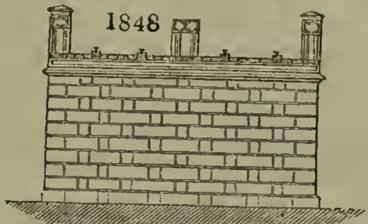


1847

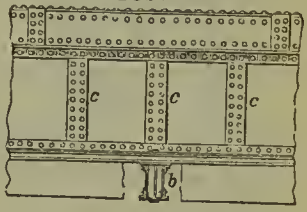
1849



1848



1850



1851

those more reeently construeted, I have plaeed them at distances of only 4 ft., and consider this arrangement preferable.

From the above deseription it will be seen that the whole is a strong and perfeetly rigid strueture. With three longitudinal girders, a bridge of this deseription will support a load equally distributed of 760 tons ; and in order to render it safe under every speeies of strain, the middle girder is made nearly double the strength of those on the outside. This is essential, as two trains may be passing the bridge at the same moment ; in whieh ease the middle girder would be subjeeted to a pressure equal to double the load on the outside girders.

In the eonstruetion of bridges of larger span, engineers generally prefer only two large longitudinal girders with strong eross-beams every four feet, of suffieient length to admit two lines of rails, and suffieient room for two trains to pass at the same time. This mode of eonstruetion is preferable to the three girders, as it effeets greater simplieity in the strueture, and, from every appearanee, renders the bridge equally effeetive and seeure.

For the details of the strueture of the Conway and Britannia Bridges, the interested reader must be referred to the works already quoted.

TUFA. A voleanie produet. See Mortar, Hydraulic.

TUFA, or TUF, is a grey deposit of calcareous carbonate from springs and streams.

TULA METAL is an alloy of silver, copper, and lead; made at Tula in Russia.

TUNGSTEN. (*Tungsténe*, Fr.; *Wolframium*, Germ.) Symbol, Ts or W. Its name is derived from the principal mineral from which it is obtainable. Tungsten, Swedish, *tung*, heavy, *sten*, stone, or Wolfram, German. This metal was discovered by the brothers De Luyart, about 1784, shortly after the discovery of tungstic acid by Scheele, from whom it is sometimes called Scheelium. It is never found in the native state, but is produced by a variety of processes. First, and most easily, by mixing the dried and finely-powdered tungstate or bitungstate of soda with finely-divided charcoal, such as lamp-black, placing the mixture in a crucible lined with charcoal, covering it with charcoal in powder, and then exposing the whole to a steady red heat for two or three hours. On removal of the crucible and cooling it, a porous mass is found, from which the soda is removed by solution in water, and the unconsumed carbon is separated by washing it off, the metal being left as a bright, glistening, blackish-grey metallic powder. It may also be obtained by treating tungstic acid in a similar manner, or by exposing the acid at a bright red heat, in an iron or glass tube, to a current of hydrogen gas. Tungsten is one of the heaviest metals known, its specific gravity being 17·22 to 17·6. It requires such a very high temperature for fusion that it has never yet been obtained in mass, more commonly as a fine powder, but sometimes in small grains. It is not magnetic. It is very hard and brittle. Alone it has not been rendered available for any useful purpose, but it has lately been employed for the manufacture of certain alloys. Tungsten is comparatively a rare substance, and is remarkable for the very limited extent to which in nature it is found to have been mineralised by combination with other substances. In none of these does it exist as a salifiable base, but as an acid, as in wolfram, Scheelite, yttrotantalite, and the tungstate of lead.

The most common ore of this metal is wolfram, known also to the Cornish miner as cal or callen, and gossan. It is most commonly found associated with tin ores, which contain besides the black oxide of tin or cassiterite, the metallic minerals, arsenical iron, copper, lead, and zinc sulphides; but its peculiarly characteristic associate is the metal molybdenum, for the most part mineralised as a sulphide. This metal is remarkable in connection with tungsten as producing isomeric compounds, and as having both its equivalent and its specific gravity equal to about one half that of tungsten, they being respectively as follows:—equivalents, Ts, 96, Mo, 48; sp. gr. Ts, 16·22, Mo, 8·615.

Amongst miners wolfram has the reputation of being an abundant mineral, but on close inquiry it is found to be comparatively rare, schorl, specular, and other iron ores, and gossan being commonly mistaken for it. From its association with tin ores, it has been until lately the source of great loss to the miner, as it was found quite impossible to separate it even to a moderate extent from the ore in consequence of its specific gravity 7·1 to 7·4, being so near to that of black tin, 6·3 to 7·0.

Pryce, in his Mineralogia Cornubiensis, 1778, says, "After the tin is separated from all other impurities by repeated ablutions, there remains a quantity of this mineral substance (gal), which being of equal gravity cannot be separated from the tin ore by water, therefore it impoverishes the metal and reduces its value down to 8 or 9 parts of metal for twenty of mineral, which without its brood, so called, might fetch twelve for twenty." This description of tin ores containing wolfram was still applicable until a very recent period, when a new process was invented by Mr. Robert Oxland, of Plymouth, and by him successfully introduced at the Drake Walls Tin Mine, at Gunnis Lake, on the banks of the Tamar, where it has been continued in operation ever since. At this mine, although the tin ore raised was of excellent quality, in spite of all that could be done by the old processes, it was left associated with so much wolfram that the ore fetched the lowest price of any mine in Cornwall.

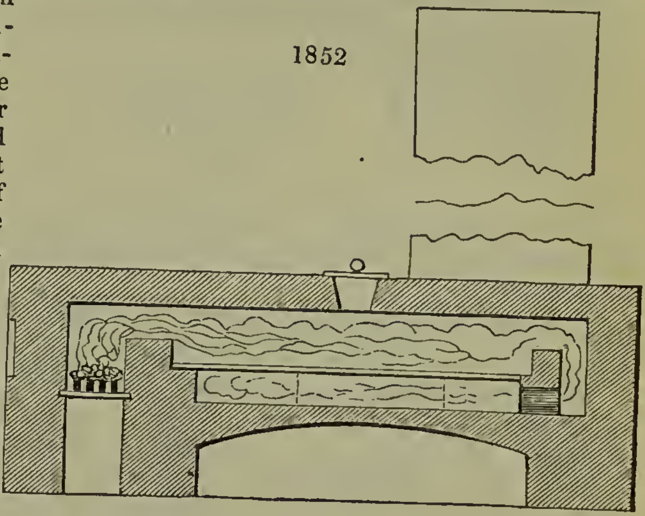
At the time of the introduction of the process the greater portion of the ore was sold for £42 per ton. The improvement effected by it was so great that the same sort of ore sold for £56 per ton. The Drake Walls ores are now known as the best of the mine ores in Cornwall.

The process is a neat illustration of the advantages obtainable by the careful direct application of scientific principles, guided by practical experience, to the improvement of the results obtainable by mining operations.

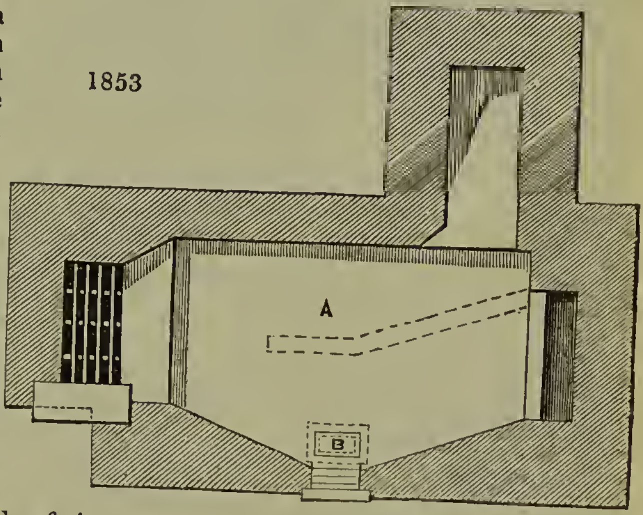
The process consists in taking tin ores mixed with wolfram, dressed as completely as possible by the old process, and having ascertained by analysis the quantity of wolfram contained therein, then mixing therewith such a quantity of soda ash of known value as shall afford an equivalent of soda for combination with the tungstic acid of the wolfram, which is the tungstate of iron and manganese; the object of the process being by calcination to convert the insoluble tungstate of iron and manganese into the soluble tungstate of soda, leaving the oxides of iron and manganese in a very finely-divided state and of low specific gravities, so that they can be easily washed off with water.

The mixture, in charges of five to ten cwt., is roasted in a reverberatory furnace on a cast-iron bed of the construction shown in the annexed engraving. The use of the cast-iron bed is attended with considerable economy in the consumption of fuel, and it is admirably well adapted for the calcination of the raw ores, for the evolution of the sulphur and arsenic contained in them, but it is especially necessary instead of fire-brick or tile, to avoid the loss which would accrue from the reaction of the soda ash on the silica of the brick, and the formation of soda silicate of tin which would consequently take place. The mixture is introduced to the bed through a hole in the crown of the furnace; from a side door it is equally distributed over the bed, and from time to time it is turned over by the furnace-man until the whole mass is of a dull red heat, emitting a slight hissing sound, and in an incipient pasty condition. In successive quantities the charge is then drawn through a hole in the bed of the furnace into the *wrinkle* or arch beneath, whence it is removed to cisterns, in which it is lixiviated with water, and the tungstate of soda is drawn off in solution. The residuary mass left in the cisterns, — the whole of the soluble matter having been washed out, — is removed to the burning-house floors, and is there dressed over again in the usual manner, the final product of the operations being very nearly pure black oxide of tin.

1852



1853



The liquid obtained is either evaporated sufficiently for crystallisation when set aside to cool, or is at once dried down to powder. The crystals of tungstate of soda thus obtained are colourless, translucent, of a beautiful pearly lustre, having the form of rhombic prisms or of four-sided laminæ. The composition of the crystallised and of the anhydrous tungstate of soda is as follows: —

	Anhydrous.	Crystalline.
Soda	20·63	18·44
Tungstic acid	79·37	70·92
Water	·00	10·64
	100·00	100·00

It has been proposed to use this substance as a mordant for dyeing purposes, as a source of supply of metallic tungsten for the manufacture of alloys, for the manufacture of the tungstates of lime, barytes, and of lead to be used as pigments; and still more recently it has been found to be valuable, and preferable to any other substance, for rendering fabrics not inflammable, so as to prevent the terrible accidents constantly occurring from the burning of ladies' dresses. For this purpose a patent has lately been obtained by Messrs. Versmann and Oppenheim.

For the manufacture of metallic alloys a patent has been obtained by Mr. R. Oxland, as a communication from Messrs. Jacob and Koeller. Steel of very superior quality, manufactured under this patent, is now coming extensively into use in Germany. It is prepared by simply melting with cast steel, or even with iron only, either metallic tungsten, or preferably, what has been termed the native alloy of tungsten, in the proportion of two to five per cent. The steel obtained works exceedingly well under the hammer. It is very hard and fine grained, and for tenacity and density is superior to any other steel made. The native alloy is obtained by exposing to strong heat in a charcoal-lined crucible a mixture of clean powdered wolfram with fine carbonaceous matter. A black, steel-grey metallic spongy mass is obtained resembling metallic tungsten. The composition of the alloy is shown in the following statement of the composition of wolfram:—

Tungstic acid.		Oxide of iron.		Oxide of manganese.		
Tungsten	76·25	Iron	17·75	Manganese	6·00	= 100
Oxygen	19·06	Oxygen	5·07	Oxygen	1·71	= 25·84
						125·84

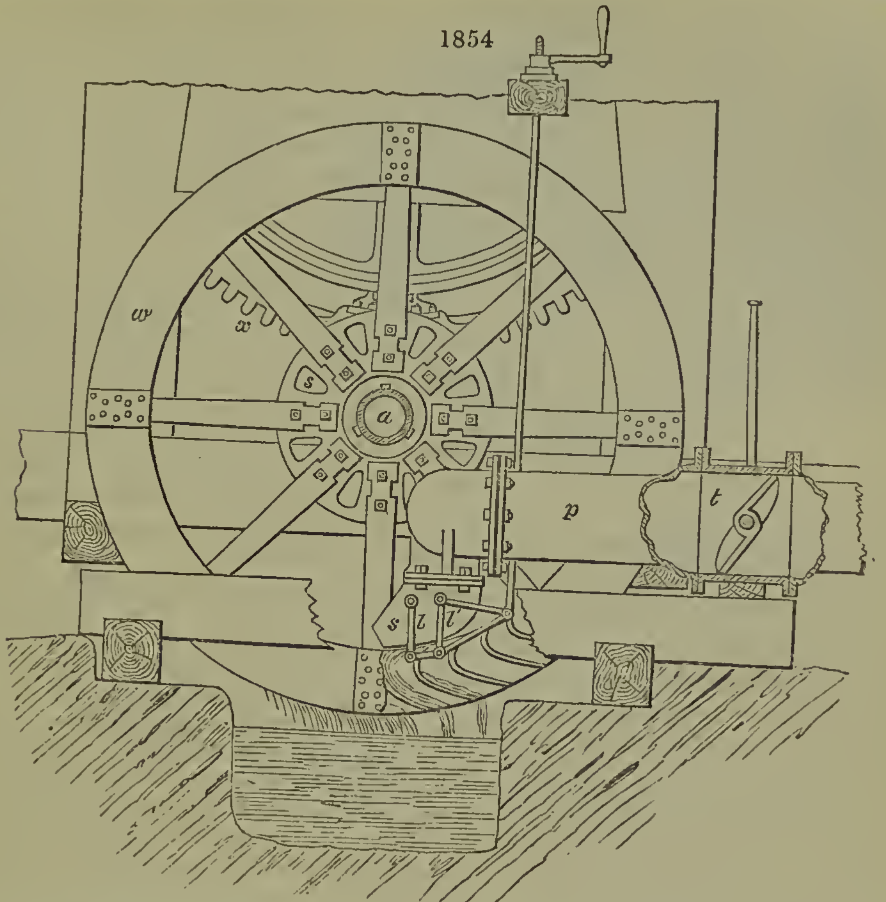
The tungstate of soda is used in dyeing; metallic tungsten, or native alloy, is also used for the manufacture of packfong or Britannia metal, by alloying with copper and tin.

By these useful applications this metal has already become a desideratum, which only a few years since was regarded as one of the most deleterious associates of tin ores, and the only one that was perfectly unmanageable.—R. O.

TURBINE. 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.

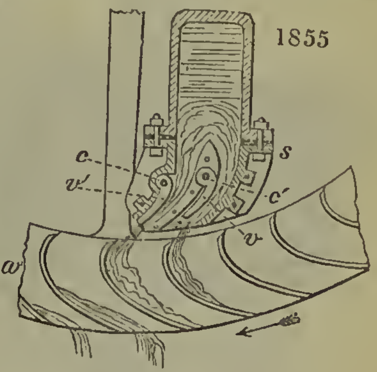
Turbines for mining purposes. Although the horizontal water-wheel has been known and employed under various forms from the highest antiquity, and has latterly been improved by Fourneyron, Fontaine, Jouval, and others, so as to rank among the most perfect of hydraulic motors, it has only recently been applied to mining uses (pumping, loading, &c.), and where so employed its success can scarcely be said to be yet decided. The failures may be attributed to the following causes. First: The plan of causing the water to flow simultaneously through all the buckets, necessitates the use of wheels of small dimensions, making a very great number of revolutions per minute, and thus requiring a considerable train of intermediate gear to reduce the speed to the working rate. Second: The complex nature of the ring sluices employed between the guide curves and the mouths of the buckets, renders them uncertain in action, and from their small dimensions liable to be easily choked by any mechanical impurities in the water; and lastly, the lubrication of the foot spindle of the vertical wheel, revolving at very great velocity, is attended with considerable difficulty and inconvenience, especially where the engine-room is at a considerable distance below the surface of the earth, and it is requisite, as in the case of pumping wheels, to keep the machinery in action continuously for long periods of time. The form of wheel of which a notice is here appended, was introduced into the Saxon mines about the year 1849 by Herr Schwamkrug, inspector of machinery at the Royal Mines and Smelting Works at Freyberg, and since that time several have been introduced for pumping, winding, driving stampheads, &c. The example selected for illustration was built to take the place of two overshot waterwheels, employed in pumping water at the mine "Churprinz Friedrich August;" it differs from the usual form of turbine in having the wheel placed vertically, and in having the water supplied through a small number of guide curves near the lowest part. In this latter respect it resembles the tangential turbine of General Poncelet, with this difference, that the water flows from the inner to the outer circumference, instead of the reverse way, as is the case in Poncelet's wheel. The construction of the wheel is as follows: *a*, *fig.* 1854, is the tubular axle of cast iron which carries the seating for the arms, *s*, which is similar to that usually used for large water wheels; to the ends of the arms is attached the wheel *w*, which is formed of two brags or shroudings of sheet iron, each 13

1854



inches deep, measured radially, and of a total height of 10 feet 2 inches; these two rings are maintained at a distance of 6 inches apart, by means of 44 sheet-iron buckets of the form shown in the smaller detailed figure, *fig.* 1855; the driving water is admitted through the pressure pipe, *p*, in which is placed the admission throttle, *t*, and turned through a pipe of rectangular section (shown in the smaller figure) into the sluice box, *s*, which contains the two guide curves, *v*, *v'*, which are movable about the centres, *c*, *c'*, by means of the levers, *l*, *l'*, by means of these guide curves when fully opened, as shown in the figure; the water is admitted into the buckets in two parallel streams or jets of $5\frac{3}{4}$ inches in breadth, and $1\frac{3}{10}$ inches in thickness; the power is transmitted from the axle of the wheel by a pinion with 28 teeth, which draws the large toothed wheel, *x*, which acts on a third shaft carrying the pump cranks. The wheel is constructed to work under a head of 147 feet, and makes about 130 revolutions per minute, with a maximum quantity of 550 cubic feet of water, equal to nearly 175 horse power. A series of dynamometrical experiments on a wheel of similar construction of 7 feet 9 inches in diameter, with a discharge varying from 39 to 134 cubic feet, with a head of 103 feet, gave an available duty of from 58 to 79 per cent., the number of revolutions varying from 112 to 148 per minute.

1855



In conclusion it may be remarked that the vertical turbine may be employed with advantage where the available fall of water is too great to be employed on a single overshot water-wheel; and although a less perfect machine than the water-pressure engine, it is of simpler construction, and may be preferred where, from the hardness or yielding nature of the rock, it becomes difficult to construct large machine rooms or wheel pits underground. In practice it is found necessary to surround the wheel with a casing of wood, in order to prevent the affluent water being projected to a distance from centrifugal action.

A fine model of one of these turbines, with two sets of buckets, constructed for the purpose of winding (*Turbinengöpel*), may be seen at the Museum of Practical Geology, Jermyn Street.

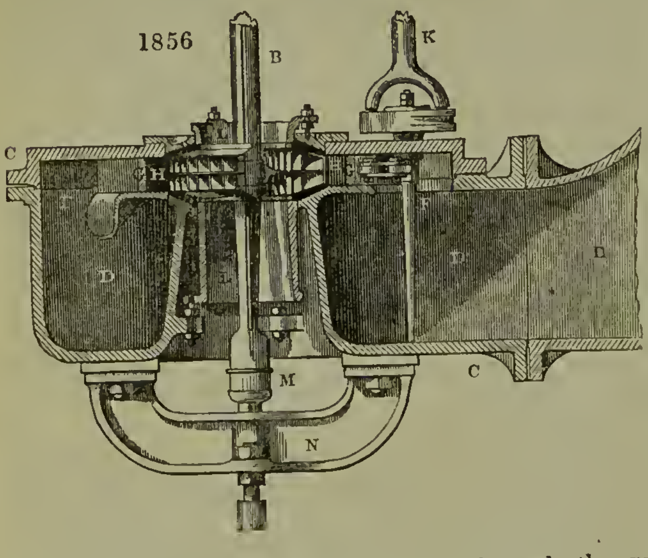
For further information on this subject, we may refer to the *Polytechnisches Central Blatt*, Nos. 8 and 9, for 1849, and No. 3 for 1850; to the *Jahrbuch für den Berg- und Huttenmann*, for 1850 and 1853. The subject of turbines is treated in great detail in Wenbach's *Mechanics of Machinery and Engineering*. Redlenbache's *Theorie und Bau der Turbinen und Ventilatoren*, Mannheim, 1844, is the best and most complete work on the subject. Notices of Fourneyron's, Jouval's, and Fontaine's turbines are to be found in Glyn's Rudimentary Treatise on Water Power, in Weale's series; the original notice of Fourneyron's turbine is published in the *Bulletin de la Société d'Encouragement*, for 1834, and several new forms are noticed in the various volumes of Armergand's *Publication Industriel.*

The name of Vortex Wheel has been given to a modification of the turbine 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. 1856 and 1857 are respectively a vertical section and a plan of a vortex 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 B, 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 E, and delivers it into the outer part of the upper division by four large openings F, 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, G, 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.* 1857, 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, 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 H, H, *fig.* 1857, 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

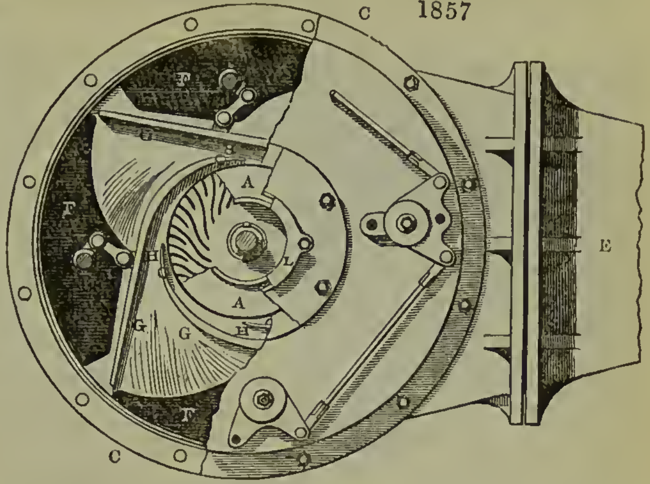
1856



* In these figures, as also in *figs*. 1858, 1859, some unimportant modifications are made for the purpose of simplifying the drawings, and rendering them more easily understood than they would otherwise be.

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 movable round gudgeons or centres near their points; and a spindle K, 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.* 1857 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. M 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. N is a hanging bridge which forms the fixture of the pivot.

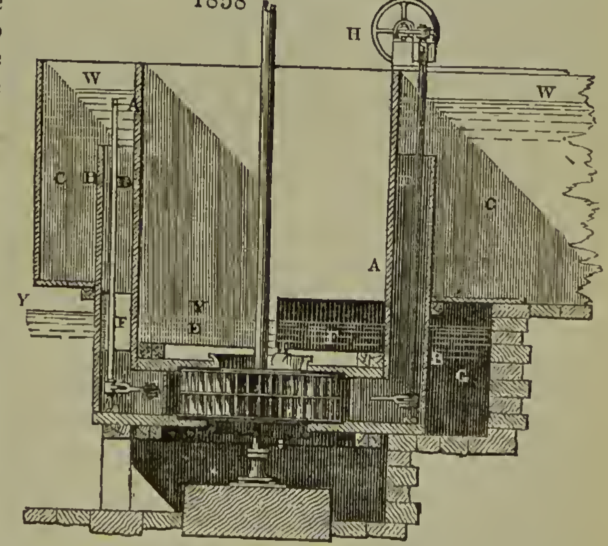
1857



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.

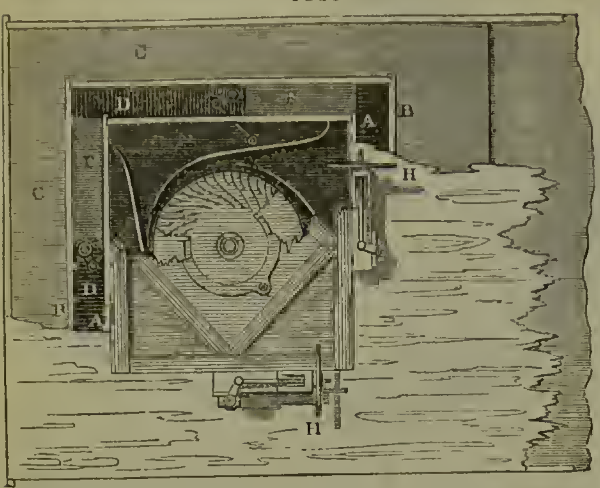
A low-pressure vortex constructed for another mill near Belfast, is represented in vertical section and plan, in *figs.* 1858 and 1859. This is essentially the same in principle as the vortex already described, but it differs in the material of which the case is constructed, and in the manner in which 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 one likewise it makes 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 E, within the innermost tank, finds a free escape to the tail race through boxes and other channels F and G, 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 Y Y, *fig.* 1858, 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 H, by which motion is communicated to itself alone.

1858



The foregoing descriptions are sufficient to explain the principal points in the structural arrangements of these water-wheels.

1839



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 equalisation 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.

TURBITH'S MINERAL. The yellow sub-sulphate of mercury, called Queen's yellow.

TURF (*Peat*, Scotch; *Tourbe*, Fr.: *Torf*, 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 removed, several processes having been patented for converting the lightest and poorest 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 fireworks to Vauxhall, has proved, by the severe test of coloured fires, that turf charcoal 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. 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 coked in suitable ovens. (See CHARCOAL, and PITCOAL, COKING OF.) Mr. Williams, by his patent, 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 carbonised 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. See PEAT.

TURKEY RED, is the name given to one of the most beautiful and durable of known dyes. The art of dyeing cotton with this colour seems to have originated in India. In his *Philosophy of Permanent Colours*, Bancroft has given a detailed account of the process as practised in that country, and this process will be found to agree in all essential particulars with that pursued by the Turkey-red dyers of Europe, except that in India the chaya root is employed as the dyeing material in the place of madder. In the middle ages the art was practised in various parts of Turkey and Greece, especially in the neighbourhood of Adrianople, and hence this colour is often called *Adrianople red*. Even as late as the end of last century the manufacture of Turkey-red yarn seems to have been extensively carried on at Ambelakia and other places in the neighbourhood of Larissa. An interesting account of the manufactures and trade of this then flourishing district, by Felix, will be found in the *Annales de Chimie*, t. xxi. 1799. About the middle of last century the art of Turkey-red dyeing was introduced into France by means of dyers brought over from Greece. The French were also the first to dye pieces with this colour, the art having previously been applied merely to the dyeing of yarn. The first establishments for dyeing this colour in Great Britain were founded and conducted by Frenchmen. At the present day Turkey-red dyeing is carried on in various parts of France and Switzerland, at Elberfeld in Germany, in Lancashire, and at Glasgow.

Turkey-red dyeing is essentially distinguished from other dyeing processes by the application previous to dyeing of a peculiar preparation consisting of fatty matter combined with other materials. Without the use of oil or some fatty matter it would be impossible to produce this colour, of which indeed it seems to form an essential constituent. If the colour of a piece of Turkey-red cloth be examined in the manner described above, (see MADDER,) it will be found to consist of red colouring matter and fat acid, combined with alumina and a little lime. The colouring matter thus obtained is so little contaminated with impurities as to appear on evaporating its alcoholic solution in yellowish-red crystalline needles. What part the fat acid plays, whether it merely serves to give to the compound of colouring matter and alumina the power of resisting the action of the powerful agents used after the operation of dyeing, or whether it also modifies and imparts additional lustre to the colour itself, is quite unknown. The formation of this triple compound of colouring matter, fat acid, and alumina, seems at all events to be the final result which is attained. Nevertheless, this apparently simple result can only be arrived at by means of a long and complicated process, each step of which seems to be essential for its final success. The details of the process vary considerably both in their nature and number, in different countries and different dyeing establishments. They may however be described in general terms as follows:—

The goods, after being passed through a soap bath or weak alkaline lye, are oiled. For this purpose a mere impregnation with oil would not be sufficient. The oil must be mixed with a solution of carbonate of potash or soda, to which there is often added a quantity of sheep or cow dung, the ingredients being well mingled, so as to form a milky liquid or emulsion. Olive or Gallipoli oil is the kind generally used, and an impure, mucilaginous oil is preferred to one of a finer quality. Drying oils are not adapted for the purpose. In this liquid, the goods are steeped for a short time, so as to become thoroughly impregnated with it. In the case of pieces the liquid is generally applied by means of a padding machine. After being taken out of this liquid the goods are often left to lie for some days in heaps, and if the weather is fine, they are then exposed on the grass to the action of the air; otherwise, they must be hung up in a hot stove. This process of steeping and exposing to the air is repeated a number of times, until the fabric is thoroughly impregnated with fatty matter. During this part of the process there can be no doubt that the oil undergoes a partial decomposition and oxidation, so as to become capable of uniting, on the one hand, with the vegetable fibre, and, on the other hand, with the colouring matter, with which it is subsequently brought into contact. The dung, by inducing a state of fermentation among the ingredients probably promotes the decomposition of the oil into fatty acid and glycerine, and the alkali serves to convey the fatty acid into every part of the fabric, and to assist in its oxidation on exposure to the air. The process of oxidation which takes place is sometimes so active as to produce spontaneous combustion of the goods in the stove. It might be supposed that by previously saponifying the oil, impregnating the goods with the soap, and after sufficient exposure, decomposing the latter by means of an acid, the same object might be more easily attained than by the long process usually employed. This is, however, not the case, which proves that we are still ignorant of the exact chemical nature of the change which takes place during the oiling process. The supposition formerly entertained, that the effect of the oiling consisted in a so-called *animalisation* of the vegetable fibre, is quite untenable. In some establishments, the goods, after being oiled and stoved, are passed through a bath of very dilute nitric acid, and then exposed to the air before being oiled again, the process being repeated after every oiling. The nitric acid is supposed to contribute to the oxidation of the oil. Several years ago a patent was taken out by Messrs. Mercer and Greenwood for preparing the oil, previous to its being applied to the cotton, by treating it with sulphuric acid, and then with chloride of soda, but their invention, though apparently of some importance, has not generally been adopted by Turkey-red dyers.

After being oiled, the goods are steeped for some hours in a weak tepid solution of carbonate of potash or soda. This operation, which is called by the French *dégraissage*, serves to remove the excess of fatty acid, or that portion which has not thoroughly combined with the vegetable fibre. The liquid thus obtained is carefully preserved for the purpose of being mixed with the liquid used for the oiling of fresh goods, the quality of which it serves to improve.

To this operation succeeds that of galling and mordanting. The goods, after being washed, are passed through a warm solution of tannin, prepared by extracting galls or sumac with boiling water and straining, after which they are impregnated with a solution of alum, to which sometimes a little chalk or carbonate of potash is added, or with a solution of acetate of alumina, prepared by double decomposition from alum and acetate of lead. Sometimes the alum is dissolved in the decoction of galls, and thus the two operations are combined into one. The goods, after being dried in the stove, passed through hot water containing chalk, and rinsed, are now ready to be dyed. It has been asserted that the galling is not an essential part of the process, that it merely serves to fix the alumina of the mordant, and may be dispensed with when acetate of alumina is used instead of alum. It is certainly difficult to conceive how it can permanently affect the appearance of the colour, since the tannin of the galls is undoubtedly removed from the fibre during the subsequent stages of the process.

The dyeing is performed in the usual manner. (See MADDER and CALICO PRINTING.) The materials employed are madder, chalk, sumac, and blood, in various relative proportions. The heat of the dye bath is gradually raised to the boiling point, and the boiling is continued for some time. The part played by the chalk in dyeing with madder has been explained above. (See MADDER.) It was formerly supposed that the red colouring matter of the blood contributed in producing the desired effect in Turkey-red dyeing; but to the modern chemist this supposition does not appear probable. Nevertheless, it is certain that the addition of blood is of some benefit, though it is uncertain in what the precise effect consists. Glue is occasionally employed in the place of blood. Sometimes a second mordanting with galls and alum, and a second dyeing, is allowed to succeed the first mordanting and dyeing.

After being dyed the goods appear of a dull brownish-red colour, and they must therefore be subjected to the brightening process, in order to make them assume the bright red tint required. For this purpose they are first treated with a boiling solution of soap and carbonate of potash or carbonate of soda, and then with a mixture of soap and muriate of tin crystals. This operation is usually performed in a close vessel under pressure. The alkalies remove the brown colouring matters and the excess of fat acid contained in the colour, and the tin salt probably acts by extracting a portion of the alumina of the mordant, and substituting in its place a quantity of oxide of tin, which has the effect of giving the colour a more fiery tint. The last finish is given to the colour by treating the goods with bran or with chloride of soda.

The chief objects which the Turkey-red dyer seeks to attain are, 1st, to obtain the desired effect with the least possible expenditure of time and material; 2nd, to produce a perfect uniformity of tint in the same series of dyeings; and, 3rd, to impart to his goods a colour which, though perfectly durable, shall be fixed as much as possible on the surface of the fabric. The last point is one of importance in the case of calicoes dyed of this colour, since this kind of goods is much employed for the production of a peculiar style of prints, in which portions of the colour are discharged, in order either to remain white or to be covered with other colours. (See CALICO PRINTING.) And if the red dye is too firmly fixed, or too deeply seated, it becomes more difficult to discharge it. In this respect the art has in modern times attained to such a degree of perfection, that the interior of each thread of Turkey-red cotton will be found on examination to be perfectly white. This is particularly the case with the Turkey reds from the establishment of Mr. Steiner of Accrington, Lancashire, whose productions in this branch of the art of dyeing are also unrivalled for the brilliancy and purity of their colour.—E. S.

TURMERIC (*Curcuma*, *Terra merita*, *Souchet* or *Safran des Indes*, Fr.; *Gelb-*

wurzel, 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 alkalies, 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.

Turmeric *imported* in 1858, 2541 tons.

TURNSOLE. See ARCHIL and LITMUS.

TURPENTINE. (*Térébinthine*, Fr.; *Turpenthin*, Germ.) The term *Turpentine* is applied to a liquid or soft solid product of certain coniferous plants, and of the *Pistachia Terebinthus*.

The following varieties are those which are usually found in the market:—

American or *White Turpentine.*
Bordeaux Turpentine.
Venice Turpentine.
Strasburg Turpentine.
Canadian Turpentine, or Canada Balsam.
Chio Turpentine.
Frankincense.

In nearly all cases the processes of collecting are similar. A hollow is cut in the tree yielding the turpentine, a few inches from the ground, and the bark removed for the space of about 18 inches above it. The turpentine runs into this hollow for several months, especially during the summer months. In general character these turpentines have much in common, they are oleo-resins varying slightly in colour, consistency, and smell; they enter into the composition of many varnishes.

Turpentine *imported* in 1858, 246,458 cwts.

TURPENTINE, OIL OF. This is obtained by distilling American turpentine (which has been melted and strained) with water in an ordinary copper still. The distilled product 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. Rectified oil of turpentine is known as spirits or essence of turpentine. When oil of turpentine contains a little alcohol, it burns with a clear flame; but otherwise it affords a very smoky flame. (See CAMPHINE.) Chlorine inflames this oil; and hydrochloric acid converts it into a crystalline substance, like camphor. It is employed extensively in varnishes, paints, &c., as also in medicine.

TURQUOISE. This gem is a compound of phosphate of alumina, phosphate of lime, with silica, oxide of iron, and copper, according to Berzelius.

The Silesian turquoise, according to John—alumina, 44·50, phosphoric acid, 30·90, water, 19·00, oxide of copper, 3·75, oxide of iron, 1·80; while the blue Oriental turquoise was found by Hermann to consist of alumina, 47·45, phosphoric acid, 27·34, water, 18·18, oxide of copper, 2·02, oxide of iron, 1·10, manganese, 0·50, and phosphate of lime, 3·41.

Turquoise occurs in the mountainous ranges of Persia, and when finely coloured it is highly esteemed as a gem. The King of Persia is said to retain for his own use all the more remarkable specimens.

Major Macdonald discovered a new locality for the turquoise in Arabia Petrea. Of the discovery of these, Major Macdonald gives the following account:—

"In the year 1849, during my travels in Arabia in search of antiquities, I was led to examine a very lofty range of mountains composed of iron sandstone, many days' journey in the desert, and whilst descending a mountain of about 6000 feet high by a deep and precipitate gorge, which in the winter time served to carry off the water, I found a bed of gravel, where I perceived a great many small blue objects mixed with the other stones; on collecting them I found they were turquoises of the finest colour and quality. On continuing my researches through the entire range of mountains, I discovered many valuable deposits of the same stones, some quite pure, like pebbles, and others in the matrix. Sometimes they are found in nodules varying in size from a pin's head to a hazel nut; and when in this formation they are usually of the finest quality and colour. The action of the weather gradually loosens them from the rock, and they are rolled into the ravines, and, in the winter season, mixed up by the torrents with beds of gravel, where they are found. Another formation is, where they appear in veins, and sometimes of such a size as to be of immense value. They also occur in a soft yellow sandstone, enclosed in the centre, and of a surpassing brilliancy of colour. Another very curious formation is where they are combined with innumerable small coloured quartz crystals, and which has the appearance of a mass of sand, small pebbles, and turquoise, all firmly cemented together. This formation is one of the most peculiar in the whole collection."

The price of turquoise has of late years much diminished, that of an Oriental gem is generally four times higher than the occidental; one the size of a pea is worth about 23*s*. " A good turquoise, sky blue and oval cut, five lines long, and four and a half lines broad, was sold in France for 241 francs; and a light blue, greenish lustre, and oval cut, five and a half lines long, and five broad, was sold for 500 francs; whereas an occidental turquoise, four lines long, and three and a half broad, brought only 121 francs."—*Feuchswanger, Treatise on Gems.*

The occidental turquoise, frequently called the bone turquoise, is said to be fossil bones, or teeth, coloured with oxide of copper.

Turquoise is imitated by adding to the ammonia sulphate of copper, or oxide of copper dissolved in ammonia, finely powdered calcined ivory. They are allowed to remain together for about a week, at a moderate heat. The coherent mass is dried and exposed to a gentle heat.

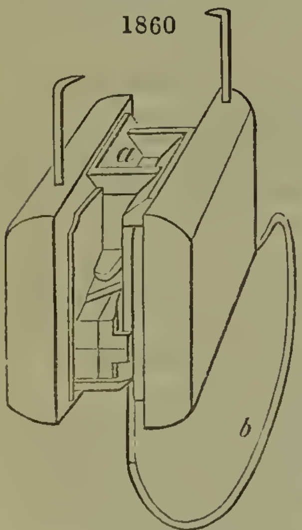
TUTENAG or TUTENAGUE, and NICKEL, sometimes called *Chinese silver.* It is the *packfong* of the East Indies.

A white metal of the Chinese, frequently stated to be an alloy of copper and zinc. It is in fact a compound resembling German silver: and nickel, in combination with zinc and copper, is found in most specimens. This name is given in commerce to the zinc or spelter of China.

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 Cyclopædia.*

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.* 1860, 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.

1860



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 reapplying 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 this he does so rapidly as to clear from 2000 to 5000 types in an hour; a very remarkable despatch, 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 slab 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 2000 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 several 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	$41\frac{1}{2}$	Small Pica	83	Minion	128
Paragon	$44\frac{1}{2}$	Long Primer	89	Nonpareil	143
Great Primer	$51\frac{1}{4}$	Bourgeois	$102\frac{1}{4}$	Pearl	178
English	64	Brevier	$112\frac{1}{2}$	Diamond	205
Pica	$71\frac{1}{2}$				

U.

ULTRAMARINE (*Outremer*, Fr.; *Ultramarins*, Germ.) is a beautiful blue pigment, obtained from the 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 mill, 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 fifteen 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. MM. 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° Fahr. 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.

The blue colour of *lazulite* had been always ascribed to iron, till MM. 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.

ULTRAMARINE, ARTIFICIAL. 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 MM. 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. 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 (China 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 sulphide of sodium, and that to the reaction of the last constituent upon the former its colour is due.

The price of the finest ultramarine was formerly as 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 the pound, and even to a little more than one shilling wholesale, for a fair article. 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. Two kinds of ultramarine occur in commerce, the blue and the green, which are true ultramarines; that is, sulphur compounds.

Both native and artificial ultramarine have been examined very carefully by several eminent chemists. 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	35·8
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	47·306
Sulphuric acid	4·679
Resin, sulphur, and loss	12·218

	Analysis of Ultramarine, by Warrentrap. Lapis Lazuli.	Artificial from Meissen.	*By Elsner.* Blue.	Green.
Potash		1·75		
Soda	9·09	21·47	40·0	25·5
Alumina	31·07	23·30	29·5	30·0
Silica	42·50	45·00	40·0	39·9
Sulphur	0·95	1·68	4·0	4·6
Lime	3·52	0·02		
Iron	0·86	1·06	1·0	0·9
Chlorine	0·42			
Sulphuric acid	5·89	3·83	3·4	0·4
Water	0·12			

Dr. Elsner published a very elaborate paper upon ultramarine in the 23rd number of *Erdmann's Journal.* 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; 2nd, 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. 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 of 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.

Ultramarine *imported* in 1858—it is not stated in the returns whether real or artificial; it is inferred to be chiefly the latter — 14,562 cwt. Declared value, 77,268*l.*

UMBER. A mechanical mixture of limnite (brown hematite) and hydrated oxide of manganese and clay. It occurs in beds with brown jasper in the island of Cyprus. It is used by painters as a brown colour, raw or burnt.

URANIUM is one of the rare metals, and was first discovered by Klaproth in 1786 in the mineral called *pechblende*, which was, previous to this, mistaken for an ore of zinc. He called it uranium after the planet discovered by Herschel about the same time. The ores of uranium are few; the principal are, *pechblende* (*pitchblende*), a brownish or velvet-black mineral, containing about 79 to 87 per cent. of protoxide of uranium, with silica, lead, iron, and some other impurities. It occurs in veins with ores of lead and silver in Saxony, and with tin in Cornwall. *Uranite*, a phosphate of copper and uranium, occurs in France; and is found of great beauty near Callington in Cornwall. *Samarskite*, *urano-tantalite*, oxide of uranium with niobic and tungstic acids. *Johannite*, uran vitriol, sulphate of uranium.

The metal itself can only be obtained by the intervention of potassium or sodium, in the same manner as magnesium. It is described as a black coherent powder, or a white malleable metal, according to the state of aggregation, not oxidised by air or water, but very combustible when exposed to heat. It unites also with great violence with chlorine and with sulphur. M. Peligot admits three distinct oxides of uranium, and two other compounds of the metal and oxygen, which he designates as suboxides.

Protoxide, UO.—This is the body formerly considered as the metal. It is a brown powder, sometimes highly crystalline.

Proto-sesquioxide; black oxide; U^4O^5, or $2UO + U^2O^3$.—This oxide was formerly considered as the protoxide, and is produced whenever either of the other oxides are strongly heated in the air, the sesquioxide losing, and the protoxide gaining, oxygen. It forms no salts, but is resolved by solution in acids into protoxide and sesquioxide.

Sesquioxide, U^2O^3.—This is the best known and most important of the oxides. It forms a number of beautiful yellow salts; its colour, when prepared by heating the nitrate to 480° in an oil bath till no more nitrous fumes are disengaged, is a chamois yellow. It may be obtained from *pitchblende*, by acting on the finely powdered mineral with nitric acid, which dissolves the lead, iron, and uranium; but if excess of the mineral has been used, no iron dissolves; then the solution of lead and uranium is saturated with sulphuretted hydrogen, which separates the lead; after filtration, the solution of uranium, which should contain a little free nitric acid, to prevent the formation of subsalts, is evaporated, and the nitrate of uranium crystallised out, which is purified by recrystallisation, and lastly by dissolving it in alcohol and again crystallising. When the iron is dissolved with it, the solution, after the separation of the lead, is treated with an *excess* of carbonate of ammonia, which precipitates the iron, leaving the uranium in solution, when, on expelling the carbonate of ammonia by boiling, the oxide of uranium precipitates, and may be collected and dried, and from this all the other compounds may be prepared.

Pitchblende is sometimes more impure, and contains copper, nickel, cobalt, and zinc, as well as lead and iron, which makes the separation of the uranium more tedious.

The only application of uranium is to enamel-painting and glass staining; the protoxide giving a fine black colour, probably by absorbing oxygen and becoming black oxide, and the sesquioxide a delicate yellow.

Uranium has been found in a German blue pigment used by paper-hanging manufacturers. It contained both copper and uranium; but it is not known for what purpose it is mixed with the copper, if to improve the colour or not, or if present previously in the mineral from which the pigment was made.—H. K. B.

URAO. See Natron.

UREA. This is one of the principal constituents of urine, being always present in it, but in variable quantities; the average quantity in healthy urine is about 14 or 15 parts in 1000 of urine, but of course this varies from several circumstances, as in disease, drinking a large quantity of liquid, &c. The urine passed the first in the morning gives a fair estimate of the quantity of urea yielded by the urine of an individual. It seems to be the principal form in which the waste nitrogenous compounds of the body are eliminated from the system. It is very prone to decomposition when in contact with albumen, mucus, or any fermentable matter; and this is the cause of urine, which, when first passed, is generally slightly acid, becoming alkaline, and a precipitate being formed; the change being much more rapid in hot than in cold weather, the mucus, &c. beginning to ferment sooner. The urea is decomposed into carbonate of ammonia, water being at the same time assimilated.

$$\underbrace{C^2H^4N^2O^2}_{\text{Urea.}} + \underbrace{4HO}_{\text{Water.}} = \underbrace{2(NH^4,CO^3)}_{\text{Carbonate of ammonia.}}$$

The carbonate of ammonia neutralises the acid which keeps the phosphates in solution, and hence the precipitate.

In some diseases the quantity of urea in the urine amounts to 30 parts, and even more, in the 1000 parts of urine.

It is interesting as being the first organic base which was made artificially. It was found that cyanate of ammonia, which has exactly the same ultimate composition as urea, when dissolved in water and boiled for some time, became completely changed, neither cyanic acid nor ammonia being detected by the ordinary test in the solution, and that it had in fact been converted by a molecular change into urea.

$$\underbrace{NH^4,C^2NO^2}_{\text{Cyanate of ammonia.}} = \underbrace{C^2H^4N^2O^2}_{\text{Urea.}}$$

Its presence in the urine is detected thus: evaporate a portion of the urine over a water bath to about one-fourth of its bulk, and when cold add half its volume of *pure* nitric acid, when after a little time abundant crystals of nitrate of urea will be formed.

The *quantity* of urea in any sample of urine may easily be estimated by a process invented by Liebig. It consists in treating the urine with a standard solution of pernitrate of mercury. A copious white precipitate is formed, with liberation of nitric acid. As this acid prevents the further action of the nitrate, the urine is previously treated with a solution of two vols. of saturated baryta water, and one vol. of saturated solution of nitrate of baryta, which precipitates the phosphates, and the excess of baryta neutralises the nitric acid as soon as it is liberated. The addition of the nitrate of mercury is continued until the last portion added causes a yellow *binoxide of mercury* instead of a white precipitate. The quantity of urea present in a given sample of urine may thus be readily deduced from the quantity of the nitrate required to precipitate it completely, the solution of nitrate of mercury being so arranged that every 100 grains of it shall be equal to one grain of urea.

It is also to be noticed that no precipitate is formed in the presence of common salt; *that* therefore has to be also removed by addition of nitrate of silver before using the nitrate of mercury. By an ingenious application of this fact, the quantity of common salt in any sample of urine may also be determined by the same solution of nitrate of mercury. Urea when in solution acts as an alkali on test paper; it unites with acids forming salts, the nitrate and oxalate being the least soluble of them. Although urea is so easily decomposed, a *pure* solution of it may be kept a considerable time unchanged.—H. K. B.

V.

VACUUM PAN. For a description of it, see SUGAR.

VALUE. Two methods have been adopted for ascertaining the value of our exports; one by means of the *official* value, the other according to the *declared* value. In *Lowe's Present State of England* (1822), there is a very succinct and clear account of these methods, which is here extracted: —

"The *official* value of goods means a computation of value formed with reference not to the prices of the current year, but to a standard, fixed so long ago as 1696, the time when the office of Inspector-General of the imports and exports was established, and a Custom-house ledger opened to record the weight, dimensions, and value of the merchandise that passed through the hands of the officers. One uniform rule is followed, year by year, in the valuation, some goods being estimated by weight, others by the dimensions, the whole without reference to the market price. [Worsted stuffs are valued at 1*l.* 11*s.* 8*d.* the piece, according to MacGregor's Commercial Statistics.] This course has the advantage of exhibiting, with strict accuracy, every increase or decrease in the quantity of our exports.

"Next as to the value of these exports in the market: — In 1798 there was imposed a duty of 2 per cent. on our exports, the value of which was taken, not by the official standard, but by the declaration of the exporting merchants. Such a declaration may be assumed as a representation of, or at least an approximation to, the market price of merchandise, there being on the one hand no reason to apprehend that merchants would pay a percentage on an amount beyond the market value, while on the other the liability to seizure afforded a security against undue valuation."

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. See LEATHER. Valonia *imported* in 1858, 19,572 tons.

VANADIUM is a metal discovered by Sefström, in 1830, in a Swedish iron remarkable for its ductility, extracted from the iron mine of Jaberg, not far from Jonkoping. 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 Jaberg iron contains more vanadium than the metal itself. It exists in it as vanadic acid. For the reduction of this acid to vanadium, see Berzelieus'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 a very excellent writing-ink.

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 Oronoco.

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 misletoe. 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 embedded black, brilliant, very small seeds. Its smell is ambrosial 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 *leq* vanilla; it is about 6 inches long, from $\frac{1}{4}$ to $\frac{1}{3}$ 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 *givrées*, 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 $\frac{1}{2}$ to $\frac{3}{4}$ of an inch. It is brown, soft, viscid, almost always open, of a strong smell, but less agreeable than the *leq.* 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. Berzelius says that the efflorescences are not acid.

VAPOUR (*Vapeur*, Fr.; *Dampf*, Germ.) is the state of elastic or aëriform fluidity into which any substance, naturally solid or liquid at ordinary temperatures, may be converted by the agency of heat. See Evaporation.

VAPOUR. A *visible* fluid floating on the atmosphere, as distinguished from a gas which is ordinarily — unless it be coloured as chlorine gas — invisible. The vapour of water is Steam, which see.

VAREC. The name of kelp made on the coast of Normandy.

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 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 50 to 80 gallons, as occasion may require; when wanted, set it upon the boiling furnace, and fill it up with linseed oil within 5 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 paiut.

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 8 lb. bags of gum copal all ready weighed up as will be wanted; put one 8 lb. 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. 8 lbs. 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 3½ 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 8 lbs. 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 24 lbs. 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 15 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 12 gallons of turpentine mixed, and even that may be too much. Therefore, when 12 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 linseed 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;
¼ lb. of white copperas;
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. 2nd sorted African copal;
2½ gallons of clarified oil.
Boiled till very stringy.
¼ lb. of dried copperas;
¼ lb. of litharge;
5½ gallons of turpentine.
Strained, &c.

(1.) 8 lbs. of 2nd sorted gum animé;
2½ gallons of clarified oil;
¼ lb. of dried sugar of lead;
¼ 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 2nd sorted gum animé;
2¾ gallons of fine clarified oil;
5¼ gallons of turpentine;
¼ lb. of litharge;
¼ lb. of dried sugar of lead;
¼ lb. of dried copperas.
Boiled and mixed as before.

Wainscot varnish.

8 lbs. of 2nd sorted gum animé;
3 gallons of clarified oil;
¼ lb. of litharge;
¼ lb. of dried sugar of lead.
5½ gallons of turpentine.
To be well boiled until it strings very strong, and then mixed and 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.

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 string 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 drier in varnish renders 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.

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 be commenced too soon; and the pot be 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.

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.

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.

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 anything 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 anything 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 $2\frac{3}{4}$ 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, $4\frac{1}{2}$ 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 everything ought to be quite ready, and perfectly clean and dry, as oily tins, funnels, strainers, or anything 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, add 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 Cochin-China, China, and Siam. It forms the best of all varnishes.

Gold lacker.—Put into a clean 4-gallon tin, 1 pound of ground turmeric, 1½ ounces of powdered gamboge, 3½ pounds of powdered gum sandarac, ¾ 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 lacker.

2 gallons of spirits of wine;
1 pound of dragon's blood;
3 pounds of Spanish annotto;
3¼ pounds of gum sandarac;
2 pints of turpentine.
Made exactly as the yellow gold lacker.

Pale brass lacker.

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 lacker 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 heat 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.

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., 100 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; annotto, 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 *mordant* 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.

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 canvass, 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 aud Pompeii owe their freshness at the present day.

Black japan is made by putting into the set-pot 48 lbs. 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.

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 iuto 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 iutroduce, 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.

VEGETABLE EXTRACT. In offering anything new, more especially as connected with an art so long practised as that of brewing malt liquors, Mr. Hodge, whose patent we are about to describe, is fully aware that changes in old established methods are never received readily. It is, however, evident that there are certain points to be attained in the production of malt liquors, which, if carried out on scientific principles, would be a great boon to the profession.

The present practice of first making an extract of malt, and then adding the hop-leaves to the wort in the copper, for the purpose of getting out their extractive matter (in a liquid already nearly to the point of saturation) is not in accordance with scientific principles.

It is a well-known fact that, without long boiling, the resin, lupuline, and tannic acid of the hops are not readily disengaged from the leaf; hence we find all brewers say that they *like a good, long, sharp boil to make the beer keep well.*

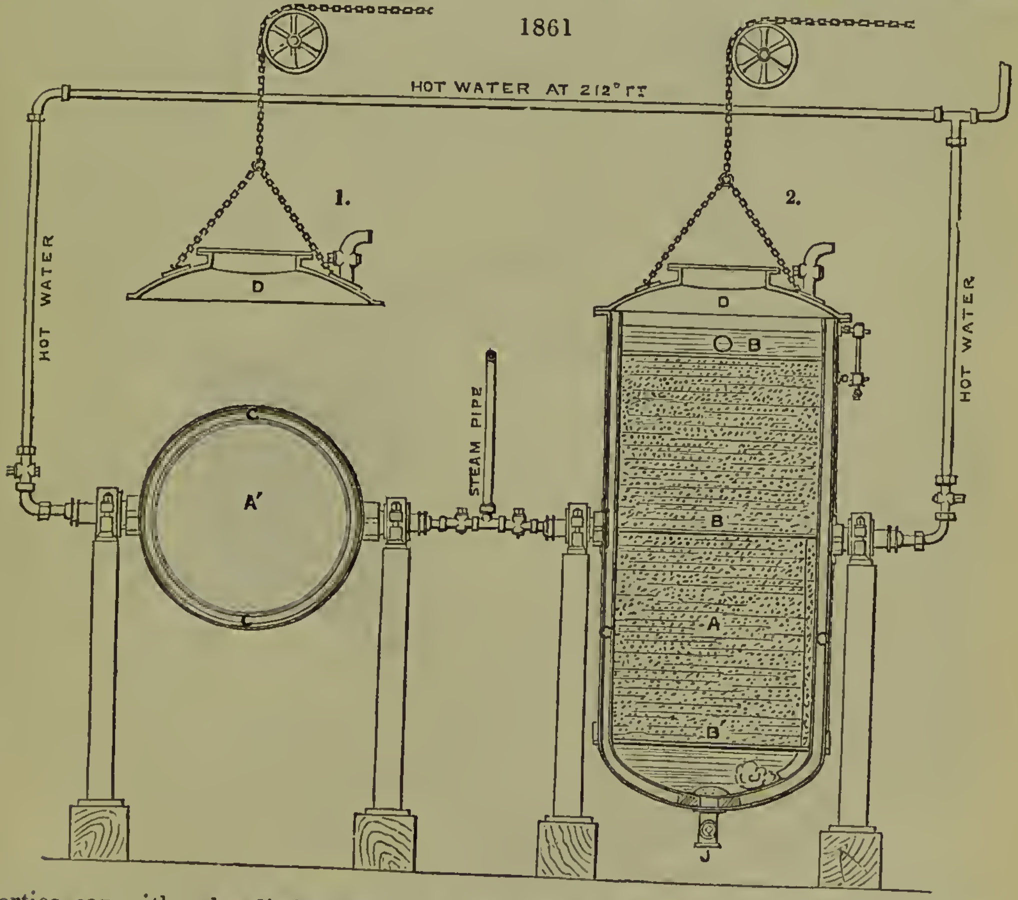
The two most antiputrescent ingredients are the lupuline and tannic acid; but while the long boiling is going on to get these two ingredients liberated, the volatile oil, or that which gives the softening principle, as well as the aroma, to the ales, passes off into the atmosphere and is lost, so that the beer or ale has a nasty, rough, acrid taste, somewhat like gentian root. The great question is, what are the constituents of wort liquor when drawn from the mash tun, what do we want to retain, and what to get rid of. The worts are composed of water, saccharine matter, starch in small quantity, albumen, and gluten. The saccharine matter is the only thing we want to retain, save its proper proportion of water. The other ingredients are nitrogenous, and liable to produce putrid fermentation.

Boiling of the worts is intended to coagulate the nitrogenous matter; two minutes will do this at 200° Fahr. What must now be effected is to bring these particles of coagulated matter into contact with the tanning, resinous, and lupuline properties of hop, rendering them insoluble, which chemical change prevents, in a measure, further decomposition for a time, until they are nearly all got rid of by fermentation or after precipitation.

There cannot be a doubt that boiling worts to a certain extent is necessary, but long boiling is decidedly injurious, as there must be a decomposition of the saccharine matter going on, as well as a reglutinisation of the albumen and other compounds, unless these particles are immediately brought into contact with those properties of the hop to arrest it.

All these difficulties can be prevented by first making an extract of hop in a close digester, as is represented in the enclosed drawing, *fig.* 1861. The most volatile pro-

1861



perties can either be distilled over, or drawn off from the top, and added to the worts after they are cooled, and before fermentation. The keeping principle of the hop will then be drawn off in a strong decoction and added to the worts after they are allowed to boil a few minutes, when the particles of nitrogenous matter will be immediately changed, retaining the aroma and other delicate properties of the hop.

Hence the advantage of the separate extract of hop, in vessels where the temperature can be regulated to the greatest nicety, and where the air cannot come into contact to change the colour of the liquid or lose the aroma.

Another advantage in this process is, not allowing the hop leaf to go into the wort, thereby saving one in every 30 barrels brewed, or 3 per cent. on all malt extract, which to some brewers would amount to 20,000*l.* per annum.

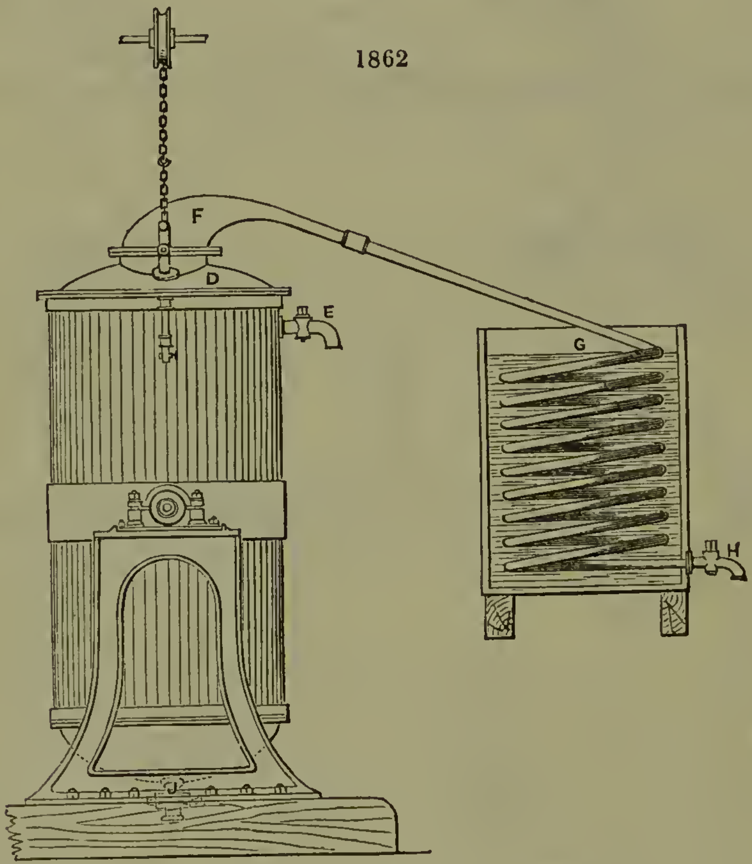
Figs. 1861, 1 and 2 (A and A′), are two digesters, which are supplied with water to the interior at 212° Fahr. This is admitted by the water-pipe passing through the hollow journal, and thence down the side pipe in the interior of the vessel below the perforated platform B′. The hops are placed between these platforms B B and B′. Steam is let on from the steam-pipe, passing through the hollow journal, and into the steam-jacket C, C, C, which keep up the temperature of the mass at or above 212° Fahr., as may be deemed necessary; at the same time no steam is allowed to escape, hence the whole of the aromatic properties of the hop are preserved. This is done in two ways, first by drawing off the top of the extract through the cock E (this is added to the beer after it is cool); or the hop oil is distilled over by means of the hood F, and condenser G, and is run off through the cock H, *fig.* 1862. The cover is then drawn up by the chain and counter-weight. The extract is then drawn off through the bottom cock J, and is added to the boil. The perforated platform is removed, and the vessel, which swings on the trunyons, is turned upside down and the spent hops drop into a press. See BREWING.

Cooling. — The quicker worts are cooled down to the fermenting temperature after being boiled, the better. The less it is exposed to the action of the atmosphere the less liable it is to absorb oxygen, preventing acetous fermentation.

Rapid cooling to all brewers is of vital importance, for if wort be permitted to come into contact with the air during the time its caloric is given off, acidity must set in, especially in summer time.

The best method to cool worts is that which is shown and described in the drawing annexed, *fig.* 1862.

1862



The worts are passed through copper tubes, *thoroughly tinned.* Instead of passing a current of water round these tubes, a dew jet of water is sprinkled all over the outer surface, at the same time a current of cold air is brought into contact with the moist surface of the tube, so that as fast as the molecules of caloric are transmitted to the water through the metal tubes, they are blown away, giving place to others. By this process heat from liquids can be abstracted more rapidly than by any other. In fact, worts can be brought down to freezing temperature, although the water used may be 80° to 100° Fahr. Another great advantage is, that the quantity of water used is about one-half.

These tubes can be cleaned with a brush with perfect ease.

VEGETABLE ETHIOPS. A charcoal prepared by the incineration in a covered crucible of the *fucus vesiculosus*, or common sea wrack.

VEGETABLE PARCHMENT. See Parchment, Vegetable.

VEINS (*Filons*, Fr.; *Gänge*, Germ.) are the fissures or rents in rocks, which are filled with peculiar mineral substances, most commonly metallic ores. See Mines, Mining, &c.

VEIN STONES, or GANGUES, are the mineral substances which accompany, and frequently enclose, the metallic ores. See Mines, Mining, &c.

VELLUM is a fine sort of Parchment, which see.

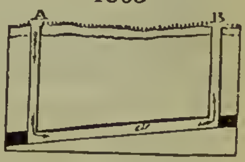
VELVET. (*Velours*, Fr.; *Sammet*, Germ.) A peculiar stuff, the nature of which is explained under Fustian and Textile Fabrics.

VENETIAN CHALK is Steatite.

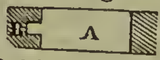
VENTILATION OF MINES. In our subterranean operations, especially where quantities of carbonic acid are constantly being produced by respiration and combustion, and where, as especially in our coal mines, the workmen are constantly exposed to the efflux of explosive gas—light carburetted hydrogen—it becomes necessary to adopt the means of removing, as rapidly as possible, the air by which the miner is surrounded.

The production of 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.* 1863, 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 siphon, 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.

1863



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 represented *fig.* 1864, 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.



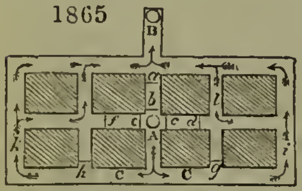
1864

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 aërial 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.* 1865, where A shows the downcast shaft, in which the aërial 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 aërial 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 aërial 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.

1865



If this mode of disjoining and insulating air-courses from each other be once fairly conceived, its continuance 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. 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.* 1866 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 moated 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.

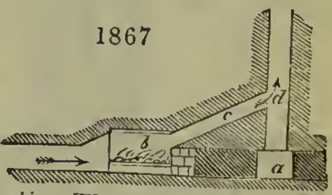
1866

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 $2\frac{1}{2}$ 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 circulation will still go on, the air of the upcast pit being rarefied by the heat remaining in the sides of the shaft.

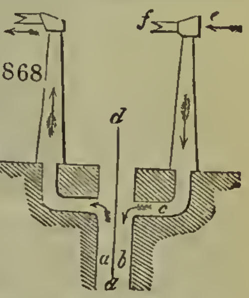
To prevent the annoyance to the onsetters at the bottom from the hot smoke, the following plan has been adopted, as shown in the wood-cut, *fig.* 1867, where *a* represents the lower part of the upcast shaft; *b*, the furnace, built of brick, arched at top, with its sides insulated from the solid mass 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 incumbrances, but remains comfortably cool.

1867



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.* 1868 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 high wind will rather aid than check the ventilation by this plan.

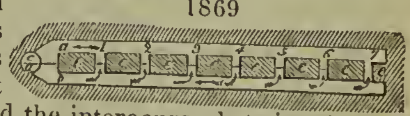
1868



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.* 1869, 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

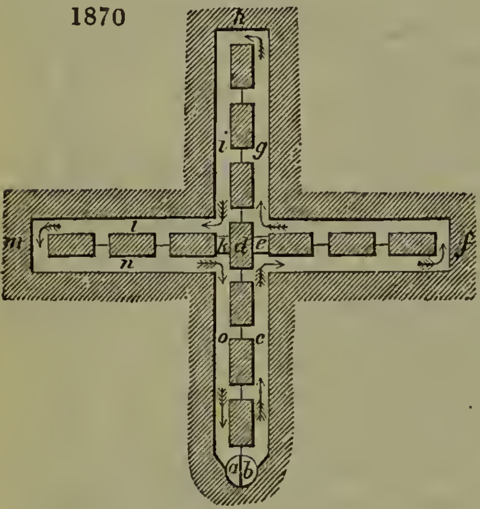
1869



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.* 1870, where *a* is the upcast and *b* the downcast shaft.

1870

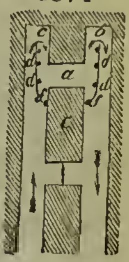


The air advances along the heading *c*, but cannot proceed further in that direction than the pillar *d*, being obstructed by the double doors at *e*. It therefore advances in the direction of the arrows to the foreheads at *f*, and passing through the last thirling made there, returns to the opposite 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 aërial 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 woodcut 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 2½ 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.* 1870, 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 coaly strata, that the miners dare not proceed forwards more than a few feet from that aërial 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 ¾ 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.

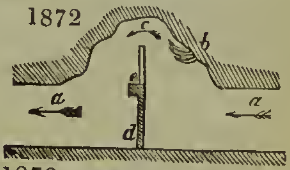
The mode of applying these temporary brattices, or deal partitions, is shown in the accompanying figure (1871), which shows how the air circulates freely through the thirling *d*, *d*, before the brattices are placed. At *b* and *c*, we see two heading boards or rooms, which are so full of inflammable air as to be unworkable. Props are now erected near the upper end of the pillar *e*, betwixt the roof and pavement, about 2 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 aërial 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 *c*, whereby 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.

1871

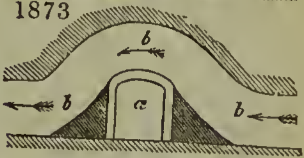


When blowers occur in the roof, and force the strata down, so as to produce a large vaulted excavation, the accumulated gas must be swept away; because, after filling that space, it would descend in an unmixed state under the common roof of the coal. The manner of removing it is represented in *fig.* 1872, where *a* is the bed of coal, *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 aërial 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.

1872



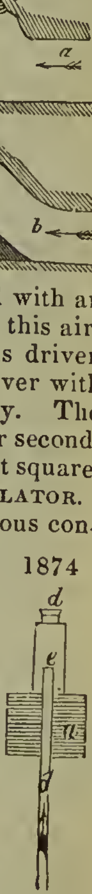
1873



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.* 1873, 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 2½ miles per hour, and their internal dimensions vary from 5 to 6 feet square, affording an area of from 25 to 36 square feet. See STRUVE'S MINE VENTILATOR.

The hydraulic air-pump, 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 *e*, 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 *e*, but is thrown out into the atmosphere through *d* at the next descent.

1874



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*, to be presently described, was invented by Mr. Spedding of Cumberland.

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. 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. 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, and returns by the air-head to the upcast pit.

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.

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 nearly all coal mines a sufficient quantity is extricated to produce the most direful consequences, if it be not neutralised, 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 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 very far 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.

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. 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 well constructed furnace is the most secure method. If mechanical means should become necessary, Mr. Struve's exhausting cylinders, or Mr. Nasmyth's fan, supply powerful and effective apparatus.

According to the ordinary system adopted in the collieries of the South Staffordshire 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 always found that a current of air does take 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.

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 feet 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.

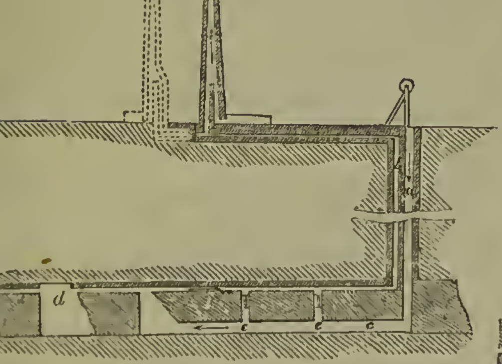
A series of "spouts" or openings are driven upwards from the gate-road into the air-head, at intervals of 10 or 15 yards (as the coal may give out more or less gas), to carry off the gas, and produce a current of air for the workmen,— each spout being closed up when a new one is made in advance. The excavation of the whole thickness of the stratum of coal, 30 feet 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.

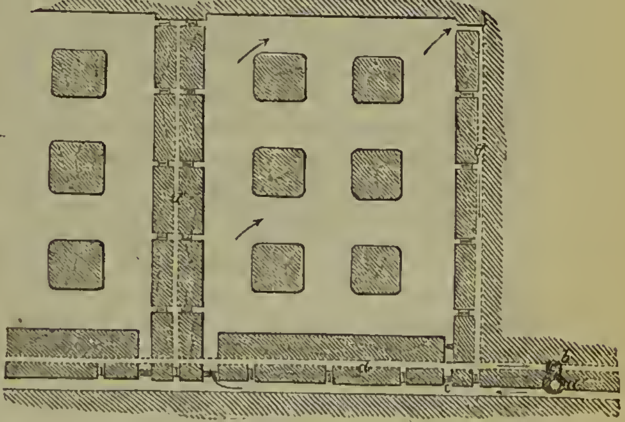
By this plan we ventilate the mine, until the lower 15 feet of the coal is excavated; but where the whole thickness of the coal above the air-head has been removed, by undergoing the coal from the bottom, and dropping it down in large masses, the upper portion of the cavity, being above the level of 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.* 1875 the system adopted and carried into operation by Benjamin Gibbons is shown. One pit *a*, is sunk, instead of two; and in the side of the shaft a smaller

1875



1876



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 three 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's 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.

Ventilation is nowhere exhibited to such advantage as in the coal mines of Northumberland and Durham, where they have 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*; who was also the inventor of the flint wheel formerly used to give light

* Mining engineers use the term *good pitman*, as admirals do *good seaman*, to denote a proficient in his calling.

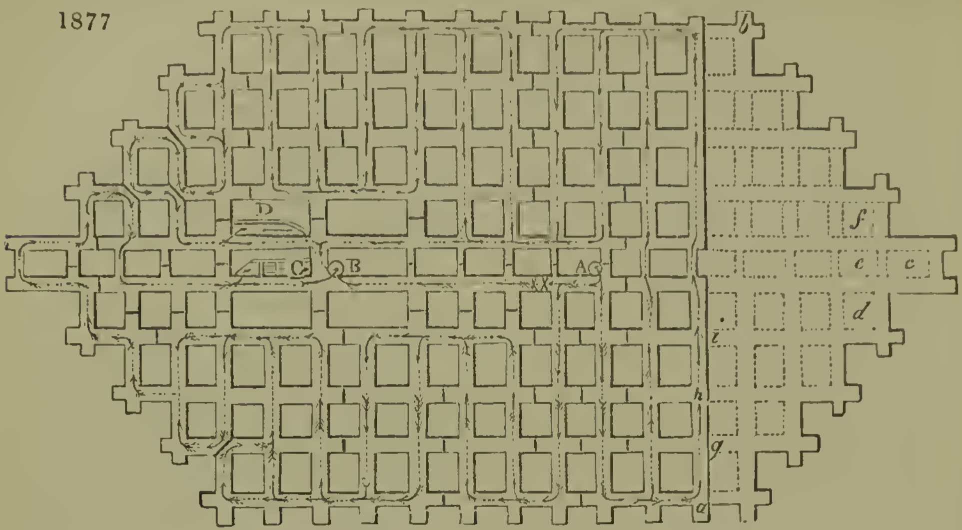
to the miner when working in dangerous situations. He converted the whole of the passages into air-pipes, so to speak, drew the current of air from the downcast pit, then traversed it up and down, and round about, through the several sheaths of the workings, so that no particular gallery was left without a current of air. 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 labyrinthan 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, "Halloa, 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.* 1877), 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 kept in readiness, under the name of the waterfall, to be let down to extinguish the fire in a moment. Many explosions at that time occurred, from the furnaces below, 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 of the air which, descending in the downcast pit A, coursed through the *clean* workings, through the active furnace C, *fig.* 1877, and the portion of the air from the *foul* workings up the dumb furnace D, 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.

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, 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 of pillars has been removed, as at *d*, *e*, *f*, no power remains of dislodging the gas from 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 vacuity, or *goaf*, 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, which, abound-

1877



ing in gas, sends it down in large quantities, and keeps the goaf below continually replenished.

Description of the Ventilating Fan at the Abercarn Collieries.—The mode of ventilation that is still generally used in the collieries of this country is the old furnace ventilation, where the required current of air through the mine is maintained by the rarefaction of the column of air in the ascending shaft, by means of a large fire kept constantly burning at the bottom of the shaft. In Belgium and France, on the contrary, this plan is almost superseded by the use of machinery to maintain the current of air; as the furnace ventilation, although possessing the important advantages of great simplicity and freedom from liability to derangement from disturbing causes, has some serious objections and deficiencies, and in some cases becomes so imperfect a provision for ventilation as to render a better system highly desirable and even necessary.

Mr. E. Rogers having occasion to ventilate the workings in some extensive and very fiery coal seams recently won at Abercarn in South Wales, under circumstances where the furnace ventilation could not be applied, after carefully collecting every accessible information as to the ventilating machines used in Great Britain and on the Continent, came to the conclusion that a plan of machine proposed for the purpose some years since by Mr. James Nasmyth would be the most suitable and effective. After consultation with Mr. Nasmyth, it was resolved to test the principle and plan by actual practice; and the ventilating fan described was made at Patricroft by Mr. Nasmyth, and is erected at the Abercarn Collieries.

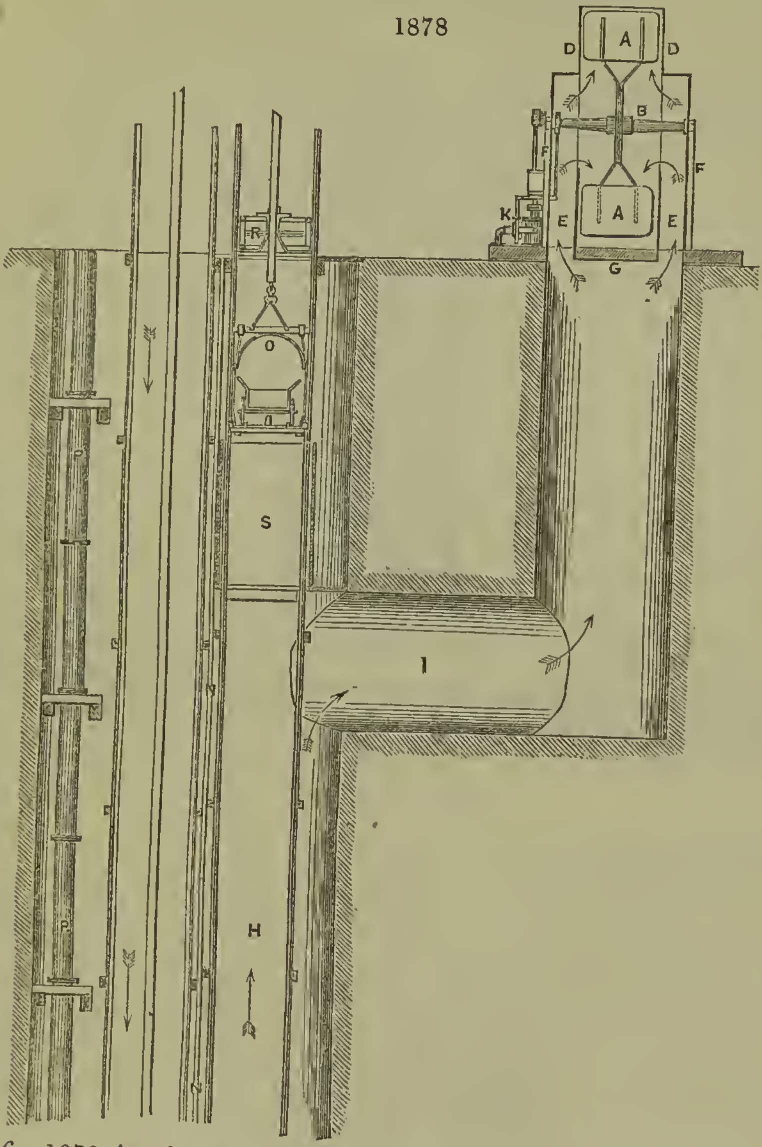
The general arrangements of the top of the shaft and the ventilating fan are shown in *figs.* 1878 and 1879. *Fig.* 1880 is a side elevation of the fan and engine, to a larger scale; and *fig.* 1879 a vertical section of the fan.

The fan A A, *fig.* 1879, is 13½ feet diameter, with 8 vanes, each 3 feet 6 inches wide and 3 feet long. It is fixed on a horizontal shaft B, 8 feet 7 inches in length from centre to centre of the bearings, which are 9 inches long by 4½ inches diameter. The vanes are of thin plate iron, and carried by forked wrought-iron arms secured to a centre disc, C, fixed upon the shaft B. The fan works within a casing, D D, consisting of two fixed sides of thin wrought plate, entirely open round the circumference and connected together by stay rods; the sides are 3 inches clear from the edges of the vanes, and have a circular opening 6 feet diameter in the centre of each, from which rectangular wrought-iron trunks, E E, are carried down for the entrance of the air, the bearings for the fan shaft B being fixed in the outer sides of these trunks, which are strengthened for the purpose by vertical cast-iron standards F bolted to them and resting upon the bottom foundation stone G.

The two air trunks E E join together below the fan, as shown in *fig.* 1878, and communicate with the pit H by means of a horizontal tunnel I, which enters the pit at 21 feet depth from the top.

The fan is driven by a small direct-acting non-condensing engine K, which is fixed upon the face of one of the vertical cast-iron standards F, and is connected to a crank on the end of the fan shaft B. The steam cylinder is 12 inches diameter and 12 inches stroke, and is worked by steam from the boilers of the winding engine of the pit, at a pressure of about 13 lbs. per square inch. The eccentric L for the slide valve is placed just inside the air trunk E, and works the valve through a short weigh shaft M with a lever on the outside.

1878

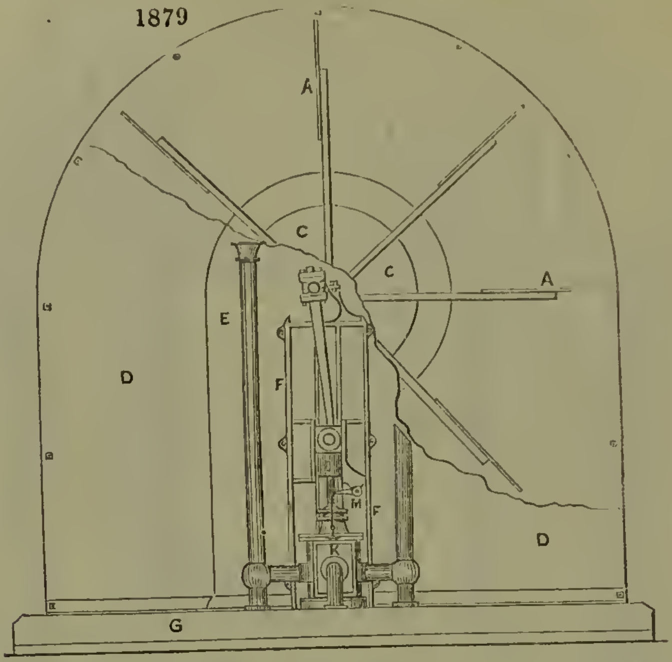


The pit H, *fig.* 1878, is of an oval form, 10 feet by 18 feet, and divided near the centre by a timber brattice N, the one side forming the upcast shaft and the other the downcast. Both of these are used for winding, and the cages O, in which the trucks, &c., are brought up, work between guides fixed to the timbering of the pit. The pumps P are placed in the downcast shaft.

In order to allow of the upcast shaft being used for winding, the top is closed by an air valve R, which is formed by simply boarding up the underside of the ordinary guard upon the mouth of the shaft, leaving only the hole in the centre through which the chain works. This air valve R is carried up by the cage O on arriving at the top of the shaft, as in *fig.* 1878, and then drops down again flat upon the opening when the cage is again lowered. During the time that the valve is lifted, its place is occupied by the close bottom of the cage O, which nearly fills the rectangular opening left at the top of the shaft. By this simple means it is found practically that a complete provision is made for keeping the top of the upcast shaft closed, and maintaining a uniform current of air up the shaft; for the leakage of air downwards through the top whilst the cage is in the act of opening or closing the air valve, and through the small area that always remains open, is found to be quite immaterial, and the surplus ventilating power of the fan is amply sufficient to provide against it.

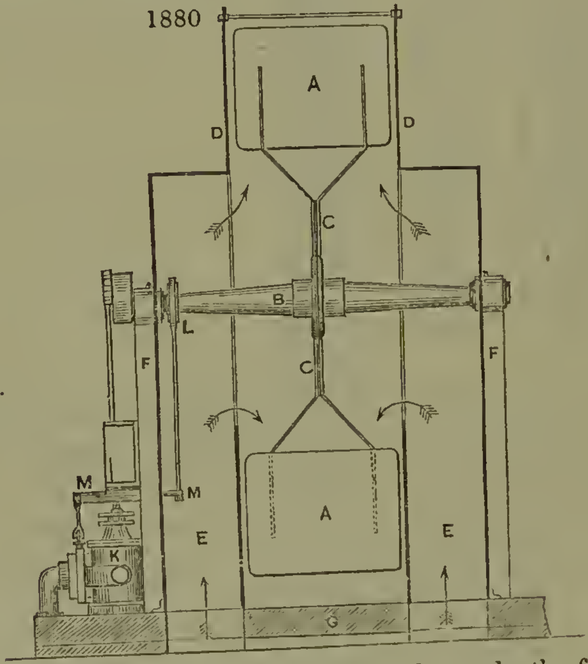
In the original construction a more perfect air valve was supposed to be requisite, and was provided by the inclined flaps S S, which are fixed just above the horizontal tunnel I. These are fitted closely together, leaving only a small opening in the centre for the chain to pass through, and were intended to be opened by the ascending cage coming in contact with them, closing again directly by means of balance weights before the air valve R at the top of the shaft was opened, so as to preserve a thorough closing of the top of the shaft. The flaps were to be opened again by a lever from

1879



the top to allow the cage to descend. However, it was found on trial that the valve R at the top was amply sufficient; and consequently, although the other valves were also provided, they have never been put into use.

1880



The total depth of the pit is nearly 300 yards, and at a depth of 120 yards a split of air is taken off, and coursed through workings from which coal and fire-clay are got; the larger portion of the air descends to the bottom of the pit, and is there split into many courses, to work two separate seams of coal and a vein of ironstone. The total length of road laid with plates or rails in the workings is about 7 miles, and the working faces amount to nearly double that distance. The longest distance that is traversed by any single course or split of air in passing from the downcast to the upcast shaft is nearly 2 miles. The quantity of materials raised from the pit is about 500 tons daily.

The following table gives the results of a series of experiments made with this ventilating fan by Mr. R. S. Roper, showing that the quantity of air delivered at the velocities of 60 and 80 revolutions of the fan per minute is 45,000 and 56,000 cubic feet per minute, with a velocity of current of 782 and 1037 lineal feet per minute respectively, or about 9 and 12 miles per hour; and the degree of vacuum or exhaustion in the upcast shaft is ·5 and ·9 inch of water respectively.

Synopsis of Experiments on Fan Ventilation.

	Height of Barometer.		Temperature by Fahrenheit's Thermometer.				Revolutions of Fan per minute.	Water gauge.	Velocity of Air in feet per minute.	Cubic feet of Air per minute.	Steam gauge on Fan.	Theoretical Consumption of Coal per hour.
	At the Surface	At the Bottom	Top of Downcast.	Bottom of Downcast.	Bottom of Upcast.	10 yards from top of Upcast.						
	ins.	ins.	degs.	degs.	degs.	degs.	revs.	ins.	ft. p. min.	c.ft. p. min.	lbs.	lbs.
Mean of twelve experiments, Natural Ventilation - -	29·61	30·60	41·10	51·73	55·56	48·00	- -	·15	446·0	24,325		
Mean of four experiments, Fan Ventilation - - -	29·85	30·85	38·10	50·10	53·93	47·30	60	·50	781·8	45,187	13·0	17·4
Mean of five experiments, Fan Ventilation - - -	29·65	30·61	41·40	50·70	55·10	48·70	80	·90	1037·0	56,555	19·3	23·2

The speed at which the ventilating fan is usually worked is about 60 revolutions per minute, giving a velocity at the circumference of the fan of 2545 feet per minute; 45,000 cubic feet of air per minute are then drawn through the mine, nearly one third of which ventilates the upper workings, and the rest passes through the lower workings.

In these experiments the mode adopted for ascertaining the velocity of the air currents was by calculation from the difference of pressure, as observed by means of a carefully constructed vacuum gauge, the result being checked by the anemometer and by the time of passage of the smoke of powder fired at fixed distances by means of wires from a voltaic battery at the top of the shaft.

VENUS is the mythological name of copper.

VERANTINE. See MADDER.

VERATRINE. $C^{61}H^{52}N^{2}O^{16}$. An alkaloid contained in white hellebore (*Veratrum album*), and in cevadilla (*Veratrum sabadilla*). It is exceedingly poisonous, and if introduced into the nostrils excites violent and prolonged sneezing. In the form of ointment it has been found a valuable remedy in neuralgic disorders.—C. G. W.

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 actuates 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, everything 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.

The manufacture of verdigris at Montpellier is altogether domestic. In most wine 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 crystallised 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 supended by its summit in the liquid. All these vessels are transported into crystallising 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 crystallised binacetate of commerce consists, by my analysis, of—acetic acid, 52; oxide of copper, 39·6; water, 8·4, in 100.

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 oxidised *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 twenty-four or thirty-six 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*, fifteen 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.*

h. 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 thirty-six to forty-eight 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.

VERDITER, BLUE. 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 *cendres 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 four open-headed casks; add to each of these

45 pound measures of a boiling-hot solution of muriate of lime, of spec. grav. 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 twelve 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 four casks; composing in all 670 pound measures of a green liquor, of 1·151 spec. grav.

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 pearlash 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 hogshead 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.*

VERJUICE. (*Verjus*, Fr.; *Agrest*, Germ.) A harsh kind of vinegar, containing much malic acid, made from the expressed juice of the wild crab apple.

VERMICELLI, a paste of wheat flour, drawn out and dried in slender cylinders, more or less tortuous, like worms — whence the Italian name. The flour of southern countries is best suited for its manufacture.

It may be 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.

VERMILION, 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 Vermilion. It is, properly speaking, a bisulphide 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 oxidised; 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 sulphide 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 sulphides of mercury; and many conjectures were made with this view, the whole of which were refuted by Seguin. He demonstrated that a mere change of temperature was sufficient to convert the one sulphide 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 sulphides 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.

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 Holland; 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. Braud, 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 lbs. of cinnabar, besides other mercurial preparations. The following process is pursued here: —

"The Ethiops is first prepared by mixing together 150 lbs. of sulphur with 1080 lbs. 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 of 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.

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.	Vermilion obtained.
114	75	330
115	75	331
120	120	321
150	152	382
120	180	245
100	180	244
60	180	142

VINE BLACK. A black procured by charring the tendrils of the vine and levigating them.

VINE DISEASE. *Oidium Tuckeri.* See WINES.

VINEGAR. See ACETIC ACID. The gross revenue derived from vinegar manufactured in England in the year 1845, amounted to 284,317*l.*, yielding a net 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 net revenue of 62,936*l.*

Our *importation* of vinegar in the year 1856 was as follows:—

From	In British vessels.	In Foreign vessels.	Total.	Retained for home consumption.	Computed value at 1s.3d. per gall.
	Galls.	Galls.	Galls.	Galls.	£
Hanover	201	955	1,156	579	72
Hans Towns	77	280	357	243	22
Holland	3,675	676	4,351	3,240	272
France	21,647	4,638	26,285	19,482	1,642
Portugal	240	1	241	1,067	15
Spain	197	39	236	1,180	15
Other parts	2,239	651	2,890	2,653	181
	28,276	7,240	35,516	28,444	£2,219

Our *exportation* of vinegar of British manufacture in the same year was 1230 tuns, at the *declared value* of 28,465*l.*; and of foreign vinegar, 8,216 gallons; computed real value, 515*l.*

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 nutgalls for every 100 pounds of cotton; second, to pass the stuff, still hot, through a mordant composed of — alum, 10 pounds; iron-liquor, at $1\frac{1}{2}°$ 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 pruneau* by a madder-bath, followed by a brightening with soap. See MUREXIDE, PURPLE.

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.

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 recommended.

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 13 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 spec. grav., 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 13·5 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 glaze 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 antimonic 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, 2½ 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 heated 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 grey 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 grey, as in the case of the lemon-yellow pigment.

Dark Yellow, 2.—20 parts minium, 2½ white sand, 4¼ 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 crystallised 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, of the oxide of uranium has dissolved in the fusing.

Green Pigments for painting upon Porcelain. Blue Green.—10 parts of the chromate of protoxide of mercury and 1 part of chemically pure oxide of cobalt are ground upon a glass plate, in order to produce as intimate a mixture as possible; the mixture is then heated in a porcelain tube, open at both ends, until the whole of the mercury is expelled. The beautiful bluish-green powder thus obtained is then transferred into a porcelain crucible, and the lid cemented to it with glaze. The full crucible is exposed to the highest temperature of the porcelain furnace during one firing, the crucible carefully broken after the cooling, and the pigment washed with water, to remove a small quantity of chromate of potash. In this manner a compound of oxide of chromium and oxide of cobalt is obtained in nearly equivalent proportions, which possesses the bluish-green colour of verdigris.

The blue-green pigment consists of a mixture of 1 part of the above compound of oxide of chromium and oxide of cobalt, $\frac{1}{2}$ part of oxide of zinc, and 5 parts of lead-glass (prepared by fusing together 2 parts minium, 1 part white sand, and 1 part calcined borax), which are mixed and ground upon the glass plate. By mixing this blue-green with lemon-yellow, any desired intermediate tint may be produced. 1 part of blue-green to 6 parts of lemon-yellow furnishes a beautiful grass-green.

Dark Green.—The chromate of mercury is treated separately in the same way as the mixture of it with oxide of cobalt for the blue-green; and 1 part of the beautiful green oxide of chromium thus obtained is mixed with 3 parts of the same lead-glass as given under blue-green, and ground upon the glass plate.

Green for shading.—8 parts chromate of mercury and 1 part oxide of cobalt are intimately mixed, and exposed in a shallow dish to the strongest heat of the porcelain furnace, during one of the bakings. In this manner a compound of oxide of chromium and oxide of cobalt is obtained, of a greenish-black colour, which, mixed with twice the weight of the lead-glass directed for the blue-green, furnishes a very infusible blackish-green colour, for shading other green colours.

When thin splinters of the green pigments of chromium, burnt-in upon porcelain, are examined under the microscope, it is distinctly seen that particles of the oxide of chromium, or of the oxide of chromium and cobalt, are suspended, undissolved, in the colourless lead-glass.

Blue Pigments for painting upon Porcelain. Dark Blue.—1 part chemically pure oxide of cobalt, 1 part oxide of zinc, 1 part lead-glass (prepared by fusing together 2 parts of minium and 1 of white sand), are well mixed and fused in a porcelain crucible, for at least 3 hours, at a red heat: then poured out, reduced to powder, and ground upon the glass. When this pigment cools slowly, it solidifies to a mass of acicular crystals. Long-continued fusion, at not too high a temperature, is requisite to obtain a beautiful tint; this is best attained by fusing it, during one of the bakings, in the second floor of the porcelain furnace; this is also the cheapest and best way of fusing the lead-glasses.

Light Blue.—1 part oxide of cobalt, 2 parts oxide of zinc, 6 parts lead-glass (prepared by fusing together 2 parts of minium and 1 of white sand, and $1\frac{1}{2}$ part lead-glass (prepared by fusing together 2 parts of minium, 1 part white sand, and 1 part calcined borax), are well mixed and fused, as directed for the dark blue.

Blue for shading.—10 parts oxide of cobalt, 9 parts oxide of zinc, 25 parts of lead-glass (obtained by fusing 2 parts of minium and 1 of white sand), and 5 parts of lead-glass (prepared by fusing together 2 parts of minium, 1 part of white sand, and 1 part of calcined borax), are mixed and fused, as directed for the dark blue. The colour is only used for shading, or to be applied upon or beneath the two preceding blue pigments, for which purpose it is admirably suited, from its being very difficult of fusion.

Sky Blue.—2 parts of dark blue, 1 part oxide of zinc, and 4 parts of lead-glass (prepared by fusing 4 parts minium with 1 of white sand), are intimately mixed and ground upon the glass plate. This pigment is employed, either alone, or mixed with other colours, only for painting the sky in landscape.

The blue pigments described likewise appear under the microscope, after having been burnt-in upon the porcelain, not to be homogeneous blue glasses, but mixtures of a transparent blue substance (silicate of cobalt and zinc?) and a colourless glass.

Turquoise Blue.—3 parts of chemically pure oxide of cobalt, and 1 part of pure oxide of zinc, are dissolved together in sulphuric acid; then an aqueous solution of 40 parts ammonia-alum added, the mixed solutions evaporated to dryness, and the residue heated to expel the whole of the water; then reduced to a powder, and exposed in a crucible to an intense red heat for several hours. The colour is most beautiful, when it has been exposed, during one firing, to the heat of the porcelain furnace. It is a combination of nearly 4 equivs. alumina, 3 equivs. oxide of cobalt, and 1 equiv. 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 ammonia-alum, zinc, and cobalt; with the above quantities, $\frac{1}{10}$ part of the chromate, calculated in the dry state, suffices.

The turquoise-blue vitrifiable pigment is prepared by mixing one part of the compound of alumina-oxide of zinc and cobalt with 2 parts of bismuth glass (prepared by fusing 5 parts of oxide of bismuth with 1 part of crystallised boracic acid).

The receipt for the preparation of the turquoise-blue pigment, communicated in the *Traité des Arts Céramiques* 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-grey 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 grey colours for painting upon porcelain.—Iridium Black.—Iridium, as obtained in commerce from Russia in the state of a fine grey 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 Grey.—1 part of the sesquioxide of iridium, 4 parts of oxide of zinc, and 22 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 grey and black pigments.

Black from cobalt and manganese.—2 parts of sulphate of cobalt deprived of its water of crystallisation, 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 2½ 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.

Grey 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 grey 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), 1⅔ part of oxide of manganese and cobalt, and 1⅔ 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 crystallised 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 heating the clear glass to its melting point, it loses its transparency, aud 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.

Chestnut 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 chestnut-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.

Flesh colour.—1 part red peroxide of iron, 4 parts of dark yellow 2, and 10 parts of lead-glass, prepared as described under chestnut-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, 12 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 greyish 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 2 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 oz. distilled water, and a solution of 1 drachm of gum in 3 oz. of water in the following proportions:—

Distilled water	3	oz.
Solution of gum arabic	28	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 0·958. 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 oz. of distilled water, and a solution of 1 oz. protochloride of tin in 6 oz. distilled water, and 10 drops of muriatic acid added until the whole has acquired a greenish colour, when a further addition of 16 oz. 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 $\frac{1}{5}$ 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 pearlash, 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 pearlash 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 1½ 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, ½ oz. *Stib. oxydat. alb. abl.*, 2 drms. oxide of zinc, 2 drms. 2 scruples calcined borax, ½ oz. silica, ½ drm. 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. See TURBINE.

W.

WACKE is a massive mineral, intermediate between claysalt and basalt. It is of a greenish-grey 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 *Apocyn*, 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.

WALNUT OIL. See OILS.

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 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 it is mixed with yellow, for the greens. Some recommend the sulphate to be nearly neutralised 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 cheap 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 fixed 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.

WANGHEES, or JAPAN CANES. A cane imported from China.

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 COAL. M. Berard is the inventor of a very successful apparatus for purifying small coal. He exhibited his arrangement at the Great Exhibition of 1851, receiving the council medal. The decoration of the Legion of Honour and a gold medal was also awarded to him at the Paris Exhibition in 1855. This apparatus, to be presently described, effects, without any manual labour, the following operations: —

1st. The sorting the coal by throwing out the larger pieces.

2nd. Breaking the coal, which is in pieces too large to be subjected to the operation of washing.

3rd. Continuous and perfect purification of the coal.

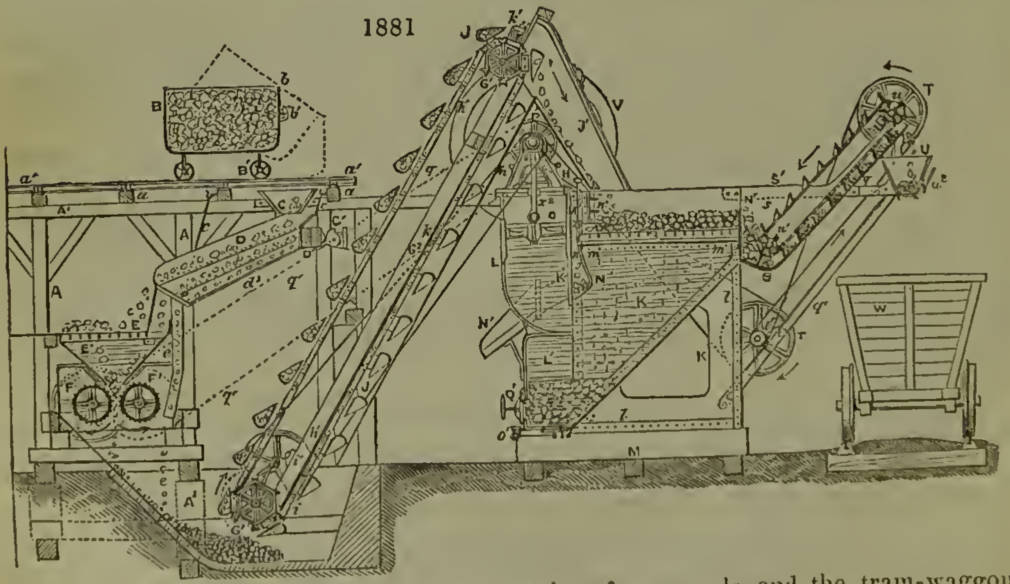
4th. Loading the purified coal into waggons.

5th. Loading the refuse (pyrites or schist) into waggons for removal.

The power required for the apparatus is that of from four to five horses, and the machine can operate upon from 80 to 100 tons of coal in about twelve hours, if fitted up near the colliery. The expense of the operation of purifying is stated to consist solely in the wages of the workmen charged to conduct the labour of the machine.

The following description of the *figs.* 1881 and 1882, will render the arrangements of M. Berard's machine readily intelligible.

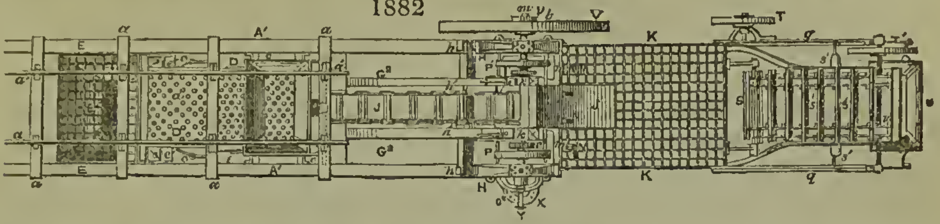
1881



The coal is carried from the mine on a staging, for example, and the tram-waggon

B is unloaded into a hopper, C, either by opening the bottom or by tilting it (as in the position represented by the dotted lines *b*), by means of a lever. It falls afterwards

1882



either on to a table or a movable grating, D, formed of frames, or of a series of stages, of sloping perforated plates, which immediately sorts it into as many sizes as there are perforated plates.

This grating is suspended out of perpendicular by four chains or iron rods, C C, fixed to the framework of the staging, A. It is moved by means of a cam motion (an arrangement of a cam and tongue mentonnet), C′, and falls back by its own weight against the stops, which produce concussions or vibrations favourable to the clearing out of the holes and to the descent of the materials. The motion communicated to the grating admits of a much less inclination being given to it than would be the case if it were fixed: the sorting is effected quicker and more perfectly, besides which the differences of level which it is necessary to preserve are maintained.

The larger pieces rejected by the first plate reach the picking table E, where a labourer picks out the largest stones and extraneous substances as fragments of castings, iron, &c.

The fragments which have passed through the upper plate, and are retained by that below, descend direct to the crushers F F′, situated below. Lastly, the fine portions of the coal which have passed through the second perforated plate fall on to a solid bottom, A′, whence they are thrown, delivered direct into the pit by means of a fixed shoot, *e*.

The crushing cylinders, F F′, are made with a covering of cast-iron, mounted on an iron shaft. This covering can be easily replaced when worn out. It has on its surface small grooves, which are usually placed longitudinally, parallel with the axis of the cylinder, in order to avoid the slipping of the substances operated on. But it is also necessary to crush fragments of slate which gain admission with the coal, and these consisting of thin, flattened laminæ, it would be necessary to bring the crusher closer than would be required to reduce the coal which is of a more cubical form to the proper size.

In order to obviate this difficulty another series of grooves are formed on the surfaces of the crusher transversely to those already described, the intersection of the two producing projections in the form of quadrangular pyramids, with slightly rounded tops. In coming between the projections of the crushers the fragments of slate, being unable to pass, are broken up without reducing the coal to a smaller size than is required.

When the coal has undergone a preliminary sifting, which has removed all the pieces exceeding 6 or 7 centimetres in size, one pair of crushers is sufficient. In that case the grating may be dispensed with altogether by discharging the coal direct into the pit, and returning from the sifter to the washer the pieces of coal which have not been able to pass beyond the first perforated plate.

The small coal resulting from the washer, or from the sifter, by means of the jigger, is delivered into a common pit placed under the washers. The pit is shaped like an inverted quadrangular pyramid, the three faces of which are inclined to one another at an angle of 45°, to facilitate the descent of the substance, and the fourth is usually vertical. It is on the latter that an opening is made, which is regulated by a flood-gate.

An elevator, formed of an endless chain, with buckets, raises the coal from the bottom of the pit, places itself sufficiently high to allow of the final discharge, which may take place into the waggon.

The rate of ascent of the buckets and their capacities are calculated so as to raise 160 to 200 tons of coal in the working hours; but this quantity may be diminished by means of the flood-gate in the pit.

The coal discharged by the elevator falls on the sorter, which ought immediately to divide it, according to size, and distribute it to the ferry-boats.

The classifier is formed of a kind of oblong rectangular chest, made of iron plates, in the inside of which are placed stages of perforated plates, the apertures in which decrease in a downward direction. Sufficient space is allowed between each plate for the motion of the materials. At the bottom of the perforated plates are disposed inclined planes for throwing on one side the product of the sifting, which escapes through a slope made on the side of the sifter. A bottom fixed to the classifier itself, and like it movable, receives the dust in the finest numbers, if the sifting has been effected in the dry way, or else this bottom is immovable and fixed to longerons which support the classifier, if the sifting take place in water, as we are about to point out.

The classifier is suspended by two or three pairs of articulated handles turning on axles fixed to longerons: by that means it enjoys an extreme freedom of motion in a longitudinal direction. A rapid reciprocating motion is communicated by a "*bielle*," which receives the action of a bent axle firmly established on a foundation fixed on the principal wall of the chamber of the machine. The motion of rotation is communicated to the axle by the disposition of an iron pinion *d'angle* working into *a*.

The *bac* is formed of a rectangular chest in cast-iron, L′, one part of the bottom of which is inclined at 45°, the other lower parts remaining horizontal.

Opposite one of the lesser sides of the rectangle is placed a cylinder O, opening into the oblong chest at about half its height. The chest L′ is prolonged under the cylinder, in order to increase the stability of the system and the capacity of the drain-well (puisard).

A cast-iron box, M M′, is firmly fixed in the interior of the bac, on flanges of cast-iron with vertical faces. This box has a slight inclination from M towards M′. It is covered with a perforated plate, usually of copper, fastened to the frame by a number of iron pins or bolts easy of replacement. The size of the holes varies according to that of the matters brought into the bac.

A cast-iron door, N, traverses, opening outward, is fixed at a slight height above the frame, serving as a kind of partition dividing the materials in the bac, and against it a flood-gate N′, by means of which the opening beneath the cast-iron door may be closed at pleasure.

A counter floodgate, N′, is placed at the lower extremity of the frame; in raising it a barrier is formed of variable height, by means of which the substances between the floodgate and counter floodgate may be arrested.

A piston, C, receives from the machine a sufficiently rapid reciprocating motion.

Everything being thus arranged, if the bac is supposed to be filled with water to the level of the front face at N′, and that the substances to be washed fill the space in the bac between this level and the perforated plate of the frame, the piston working upwards and downwards will press the water in the body of the cylinder, and will force it by its incompressibility to pass through the holes in the perforated plate; it will establish above this plate an ascending current, which, if of sufficient power, will raise the substances submerged.

The resistance to the rise of each body will be in proportion to its specific gravity, and the height it will be carried will follow an inverse law, supposing the fragments to be of nearly equal sizes.

The slates which fall over the counter floodgate fall into a pocket or reservoir N, whence they are discharged on opening a floodgate K′. Pressed by the upper column of water, they slide with a slight admixture of water on the inclined plane K′ N′, which can be pierced with holes; the water escapes, and the slate only falls directly into the waggon of discharge.

The bent axle of transmission S S, moves in a groove turning on a pivot at its extremity. The rotation of the axle communicates an oscillating motion to it.

The deposit formed in the drain-well is emptied through an opening of the floodgate placed at the lower part. An opening serving as a man hole is reserved for effecting internal repairs without the necessity of raising the frame.

All coal contains a portion of earthy matters or impurities which, in the form of bands or scales, are generally in some degree apparent to the eye, and constitute the ashes and clinker left by combustion. The small coal which is sent out of mines necessarily contains a still larger proportion, frequently exceeding 10 per cent., consisting chiefly of shale and iron pyrites derived from the roof or floor of the seam of coal, or from the bands of impurities interstratified with it. Generally these impurities are so incorporated with the mass of the coal that it must be crushed in order sufficiently to detach them. The pyrites, which contains nearly the whole of the sulphur found in coal seams, is well known to be very injurious either in a heating or smelting furnace, in the manufacture or working of iron, in gas-making, in coking, and other processes.

Many seams of coal already sunk to, or portions of seams in work, are left underground as unsaleable in consequence of the impurities they contain. Small coal sells at a low price chiefly in consequence of its impurities and the defective coking property which they occasion. It has been estimated that an amount not far short of the quantity of coal sold is sacrificed in producing a commercial article of adequate quality and description. The enormous consumption of coal in this country, amounting to 70 millions of tons per annum, renders the utilisation of a larger portion of the more valuable seams now in course of being exhausted, and the bringing into the market of other seams, objects of national importance.

The differences between the specific gravities of coal and its impurities, allow of their being separated by the action of water when sufficiently crushed. The water process hitherto most commonly adopted is that known as "jigging," which consists in forcing the water alternately up and down through the mass of coal. The downward current of water in "jigging" is prejudicial, and entails a large sacrifice of the finer particles of the best coal; whilst the upward current, from its rapidity and irregularity, is costly both in time and power, besides failing to effect the more perfect separation which is obtained by a slow, continuously ascending or pulsating current, regulated to the proportion of shale in the coal, and to the size of the particles to be acted upon.

Mackworth's patent coal purifier.— In the late Mr. Herbert Mackworth's purifier, *fig.* 1883, the water ascends with a velocity of an inch or two in a second. It is sufficient to keep the particles in constant agitation, and the area of the separator can be reduced to a small fraction of its former size. The coal is supplied into the machine in a uniform stream, and as it is purified is raised out of the water on to a perforated plate, and delivered by the coalsweep into a long perforated shoot, down which it descends into the tram or waggon placed to receive it. The purified coal is thus obtained for coking and other purposes in a comparatively drier state. The shale, which has during the separation accumulated in the shalebox, will discharge itself into another tram without stopping the machine, if the shale valves are first closed by the valve lever before throwing open the shale door. The pump, or agitator, is capable of throwing from 50 to 200 gallons of water per minute, according to the size of the machine. The endless band raises or lowers the coal from the hopper into which the coal trams are tipped.

The advantages of the machine may be thus summed up:—

1st. The more perfect separation of the impurities. If the coal is not sufficiently crushed, even the fragments of coal containing shale or pyrites can be separated as well as the shale, by regulating the velocity of the water. By increasing the speed of the machine and the velocity of the water, the separation of the impurities may be limited to any extent desired.

2nd. The saving of coal. This may be estimated at from 6*d.* to 1*s.* 6*d.* per ton. The ordinary washing processes sacrifice more than 20 per cent. in weight, of which more than one half is the best coal. In this machine the water does not pass out, but is used over and over again in a continuously circulating stream. The loss of coal does not exceed 2 per cent., and is generally under 1 per cent.

3rd. The economy in the power required to work the machine. 1-horse power will suffice to work a machine with pump and elevator capable of purifying 50 tons of coal per day.

4th. The saving in manual labour.

5th. The quantity of water required is comparatively insignificant. A small supply of water is required to replace that absorbed by the wetting of the shale and coal.

6th. The coal is delivered drier than by any other existing process.

7th. The largest machine stands in an area of 9 feet square, and motion can be given off any existing engine by a strap to a pulley making 40 revolutions per minute, at a height of about 12 feet above the ground. The height given to the machine is for the purpose of passing trams underneath it to receive the purified coal and shale as they are delivered. The machine requires no foundation, and is easily removable.

8th. The great economy of the process in every point of view is important to —

The coke trade.—Many coals when deprived of their impurities will coke which never coked before, and the quality of every description of coke may be greatly improved. In coals above the average in quality, it has been found that the clinker may by water purification be reduced by four-fifths in quantity. The two principal sources of clinker—the whitish scales of carbonate of lime and the iron pyrites—are removed. A coke more uniform in texture and better in appearance is produced, and different descriptions of coal may be simultaneously *mixed* and purified by this machine. A cost of 3*d.* per ton on the coke will remove those impurities for which the consumer now pays at the same rate as the coke itself. An increase in the make and quality of the iron results from using purified coke *in blast furnaces.*

Persons using steam.—The amount of ash and clinker from a coal, by no means represents the full amount of loss and waste occasioned by them. The coal is imperfectly burnt, and the fire bars are injured. By removing the impurities, much of the labour in attending *boiler fires* may be spared, and the steam kept up more regularly. In *steamers*, and whenever the freight of coal is heavy, these advantages are peculiarly important.

Gas companies.—Gas may be produced comparatively free from sulphur, as well as a purer and more valuable coke. By a small addition to the cost of the machine the coal may be delivered in a dry state.

Smiths and workers in metal.—A coal purer than the large coal is produced. Better work and metal and cleaner hearths are the results. Smiths are paying in several instances nearly double the former prices for coals which have been purified. In puddling-and other furnaces the advantages of pure coal have been well ascertained.

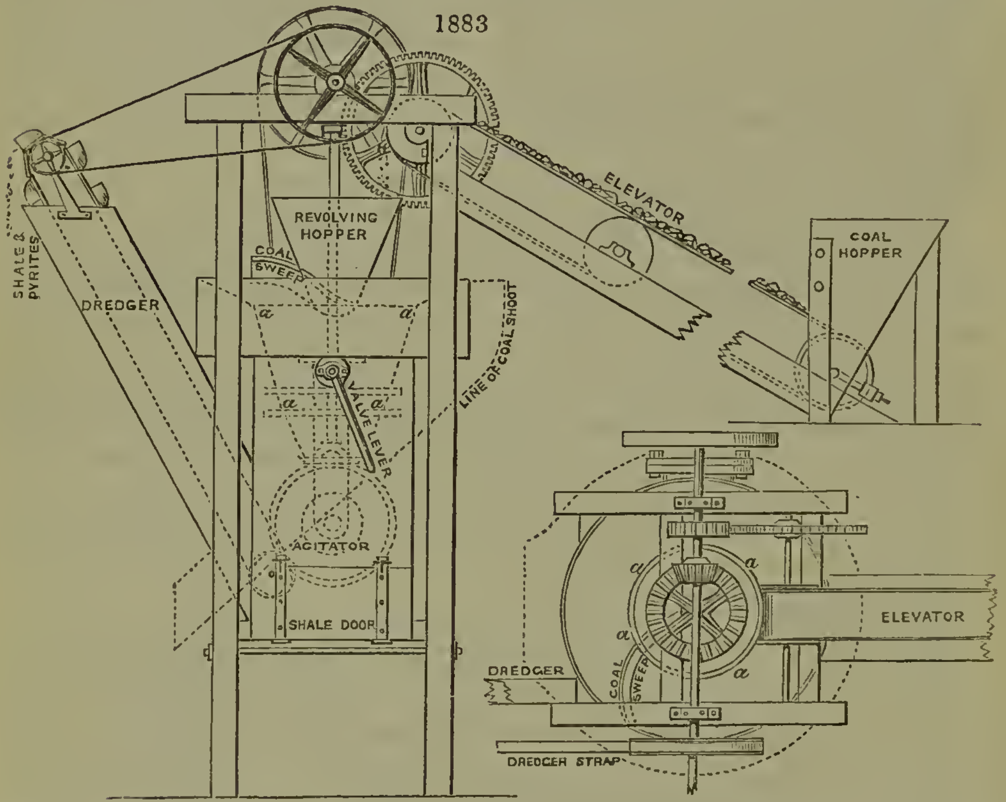
Patent fuel companies.—In all cases where freights are heavy and the manipulation of the fuel costly, purity in the raw material is essential.

Colliery owners.—Coal and shale in lieu of being thrown into the gob can be brought out of the mine and separated for from 1*s.* to 2*s.* per ton, including haulage, &c. Crop coal, old pillars, and creeps, may be turned to account.

The spontaneous combustion in the wastes of some mines may be prevented by bringing out the whole of the small coal and pyrites at a now remunerative price. New coal seams may be brought into the market, to the benefit both of the producer and consumer.

In working this machine the coal tram is tipped into the coal hopper; it is thence conveyed by the elevator in a continuous stream into the machine, and the purified

1883



coal is delivered continuously into a tram whilst the shale and pyrites are delivered in a continuous manner by the dredger, or Jacob's ladder. The workman has only to attend to the placing of these waggons and regulating the amount of opening of the valves which allow the shale to descend into the shale box after it is separated.

The revolving hopper allows the coal to descend gradually into the separator where a slow current of water is driven upwards through the mass of shale and coal, at a velocity of from 4 to 5 feet per minute, by the agitator or screw. This water passes back again by the finely perforated plate, and with the fine silt suspended in it, is again driven upwards by the screw to undergo a repetition of the process. The gentle agitation produced by this current separates the shale and pyrites from the coal in the separator, the two latter descend through the valves and are taken up by the dredger, whilst the former is pushed upwards out of the water by the curved arm; and as soon as the water has drained off, the coal falls on to the shoot, which conducts it to the tram. A brush following the arm helps to keep the holes in the perforated plate open. The valves remain constantly more or less open, according to the indications given by the dredger, and are regulated by the valve lever. The water required to replace that absorbed by the dry coal and shale enters by the hopper and flows slightly inwards through the shale valves as the shale is coming out.

The objects said to be attained by the machine are, 1st, a more perfect separation of the impurities than by the jigging or buddling processes; 2nd, a saving of from 5 to 15 per cent of coal; 3rd, economy of power and manual labour; 4th, saving of water and the delivery of the coal in a drier state.

Machines have been established in Scotland, Cumberland, Derbyshire, Gloucestershire, and Wales, to purify from 20 to 100 tons of coal per day, at a cost not exceeding 3*d.* per ton, and with a loss not exceeding 2 per cent. of coal.

WATER. (*Eau*, Fr.; *Wasser*, Germ.) There is no substance, not even including air, or oxygen itself, which is so extensively used in the operations of nature on our globe, as well as in the workshops of men, as water. To speak of its numerous relationships, even briefly, would demand too much space, and it will be needful to confine ourselves strictly to a consideration of its physical conditions.

Rain is the probable source of all water. It is almost absolutely pure water if it falls through uncontaminated air. Water is almost colourless, brilliant, without taste or smell, and very transparent. When seen through great depths it has a slightly blue shade of colour. It weighs 252·45 grains per cubic inch at 60° Fahr. in the air. The specific gravity of all substances liquid and solid are taken by their relation to water, which is called 1·000 or 1. Its boiling point at 29·92 bar. pressure is 212° Fahr.; it freezes at 32°, and it evaporates at all temperatures. Its boiling point at 760 metres pressure is called 100° Cent.; freezing point 0°. It assumes, therefore, the gaseous, liquid, and solid states with great facility. The specific heat of water at 32° F. is taken as 1000. Water is taken to measure amounts of heat also. The heat required to raise 1 gramme of water 1° Cent. is a unit of heat. The amount of heat required to raise 1 lb. of water, one degree of Fahr., requires for its evolution the expenditure of a mechanical force equal to the fall of 772 lbs. through the space of 1 foot. Or 1 gramme of water is heated 1° (Cent.) by an amount of heat represented by the fall of 423·55 grammes through the space of 1 metre. The latent heat of water and the amount required to convert ice at the freezing point into water is 144°, or 144·6 F. (80—80·34 Cent.) The refractive power of water, or its index of refraction of light, is 133·6; that is, the sine of the angle of incidence is to the sine of the angle of refraction as 1·336 to 1. Refractive power increases below 39·, although density diminishes. Water expands when heated or cooled beyond 39° Fahr., or 3·9 Centigrade; Playfair and Joule give 39·1; Fraukenhein, 38·95; Plücker and Gessler, 38·8; Hope, who discovered the property, gave 39·5. Water freezes in crystals, one form is not unlike Iceland spar, a rhomboid. Hail crystallises in six-sided pyramids, base to base; snow frequently with various stellar radiations.

Specific gravity of the vapour of water is 0·622; it is nine times heavier than hydrogen. Water itself is 812 times heavier than the atmospheric air. Water expands by heat, between 32° and 212°, 1 in 21·3 volumes. It expands in cooling below 32°, even if it be not allowed to crystallise. The expansion may be prevented by using smooth vessels and preventing disturbance. It may be cooled in this way to about 7° F. A slight agitation, or the presence of a rough substance, rapidly causes it to shoot out crystals in all directions. The spec. gr. of ice is 0·916, it therefore floats on water. It expands with irresistible force, bursting asunder iron vessels, however strong, in which it may be confined, water-pipes of whatever substance, porous stones which may have absorbed it, and vegetable cells in which it may be enclosed. By this simple act it performs a great part in breaking up the rocks, so as to renew the soil, and in defacing beautifully polished stones, causing an early decay.

Water heated to 212° F. boils. Long before this period, and even in heating it only a few degrees, it gives off bubbles, which are those of air, from which it is never found free in nature. At 212° the bubbles are distinctly formed of water; in vapour they rise to the surface. These bubbles form more readily on certain surfaces; on metals easily, especially if they are not polished. Gay-Lussac gave the difference of the boiling point in metal and glass as two degrees. Scrymgeour found it raised in any kind of vessel when there was oil present. M. Marcet found it raised to 221° when a glass flask had its inner surface coated with a thin film of shell-lac. When water has ceased to boil in a glass or porcelain vessel, it will begin again instantly if a metallic wire is introduced. Platinum wire is very well suited to this purpose. It is used for other liquids also. Rough glass and porcelain vessels allow water to boil better than smooth. Water thrown on red-hot surfaces is known not to touch the surface. Boutigny found that it may assume this state at any temperature above 340°. When it falls to 288° it touches the surface and commences boiling. In this state of separation from the surface it assumes a globular form; it seems suspended on a film of steam. The condition is called the *spheroidal*. The boiling of water depends on the pressure of the air as well as temperature, as the following shows:—

Barometer, inches.	Water boils at degs. Fahr.
27·74	208°
28·29	209°
28·84	210°
29·41	211°
29·92	212°
30·6	213°

This change of boiling point is used to ascertain the height of mountains, 550 feet making a difference of 1 degree. In a vacuum water will boil at 67°. In a Papin's digester it is raised to 300 or 400 without boiling.—R. A. S.

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. See MOIRE.

WATER PRESSURE MACHINERY FOR MINES. Considerable attention has been given to the construction of pressure engines by Mr. Darlington, who was actively engaged some years since in effecting the drainage of the Alport Mines, in Derbyshire. *See fig.* 1884.

The first engine erected by him had a cylinder 50 inches diameter, and a stroke of 10 feet; the piston-rod passed through the bottom of the cylinder and formed a continuation with the pump-rod, whilst the valve and cataract gearing was worked by a rod connected with the top of the piston, which gave motion to a beam and plug-rod gearing. The column of water was 132 feet high, affording a pressure on the piston of about 58 pounds per square inch, or more than 50 tons on its area. The water was raised from a depth of 22 fathoms, by means of a plunger 42 inches diameter, and in very wet seasons it discharged into the adit nearly 5000 gallons of water per minute. Water was admitted only on the under side of the piston, and in order to avoid violent concussion in working; two sets of valves were employed, the larger being cylindrically shaped, 22 inches diameter; and the smaller 5 inches diameter. In making the upstroke of the engine the cylindrical valves admitted a full flow of water for about $\frac{7}{8}$ths of the stroke, and then commenced closing, but at this stage the small valve opened, through which passed sufficient water to terminate the stroke. In this way the flow of water in the column was gradually slackened, and finally brought to a state of rest without imparting impact to the machinery. The speed of the engine was regulated by sluice valves, one fixed between the engine and the pressure column, and the other upon the discharge-pipe.

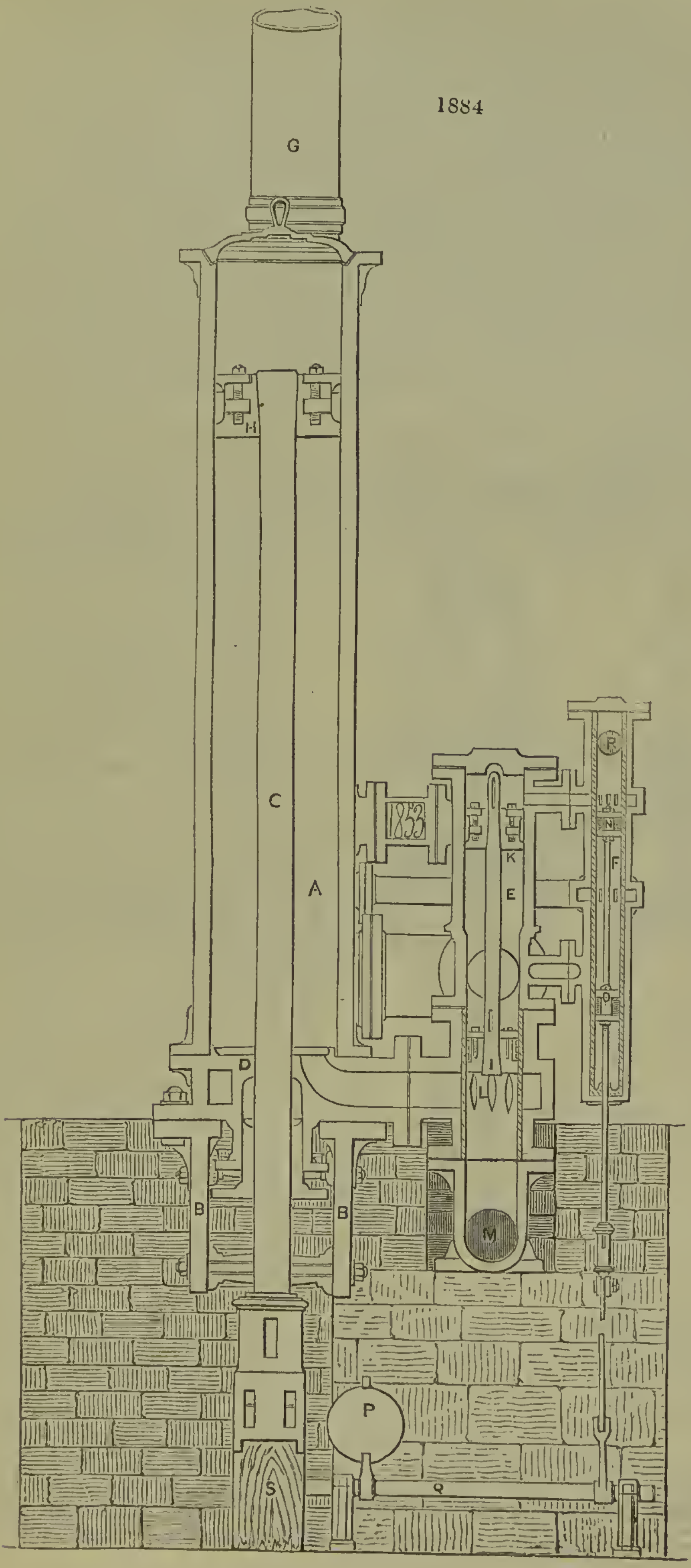
The cylindrical valves were made of brass with a thin feather-edged beat, and kept tight by a concentric boss, projecting from the nozzle, upon which hemp packing was laid. This was pressed down by a projection in the under surface of the valve bonnet. The water thus acted on the exterior of the valves between the zone of packing and the seatings, and when opened passed through the latter. Besides this engine, others of a different construction were designed and erected by Mr. Darlington, but the one to which he gave preference for simplicity, cheapness, and smoothness of action, is illustrated in the following woodcut.

This engine has one main cylinder A, resting on strong cast-iron bearers B B, fixed across the shaft. The piston-rod C, is a continuation of the pump-rod S, and works through the cylinder bottom D. In front of the cylinder A, is a smaller one E, with differential diameters for the admission and emission of water, and right and left are sluice valves not shown for regulating the speed of the engine. Connected with the second cylinder is a small 3-inch auxiliary cylinder F, provided with inlet and outlet regulating cocks.

In starting this engine the sluice valves and regulating cocks are opened, the water then flows from the pressure-column G, into the main cylinder A, through the nozzle cylinder E, and acts under the piston H, until the upstroke is completed. The piston I, has a counter piston K, of larger diameter, and when relieved from pressure on its upper surface, the water acting between them forces it upwards, in which case the pressure is cut off from the main piston, and the water contained in the cylinder A, is free to escape under the piston I, through the holes L. With the emission of water from the main cylinder through M, the downstroke is effected. The downward displacement of the pistons I and K, is performed by the auxiliary cylinder F, and pistons N, O; the pressure column is continually acting between these pistons, and by their alternate displacement by the fall-bob P, and canti-arbor Q. The water is either admitted or prevented from operating on the upper surface of the piston K. The water from the top of piston K, escapes through the aperture R. The motion of the canti-arbor Q, is effected by tappets fixed on the pump-rod S.

One of these engines was recently in operation at the Minera Mines, in North Wales. The cylinder was 35 inches diameter; stroke 10 feet, pressure column 227

1884



feet high. Its average speed was 80 feet, and maximum speed 140 feet per minute. The pressure of water under the piston was 98 pounds per square inch, giving a total weight on its area of about 40 tons. This machine required no personal attendance, the motion being certain and continuous, as long as the working parts remained in order, consequently the cost of maintaining it was of the most trifling character.

In 1803, Trevithick erected an engine at the Alport Mines which worked continuously for a period of forty-seven years, or until 1850, when the mines ceased working. The water from the pressure-column acted on alternate sides of the main piston, by means of two piston valves, displaced by a heavy tumbling beam, and tilted by a projection from the pump-rod. The construction and action of this machine will be best understood by the accompanying illustration, *fig.* 1885.

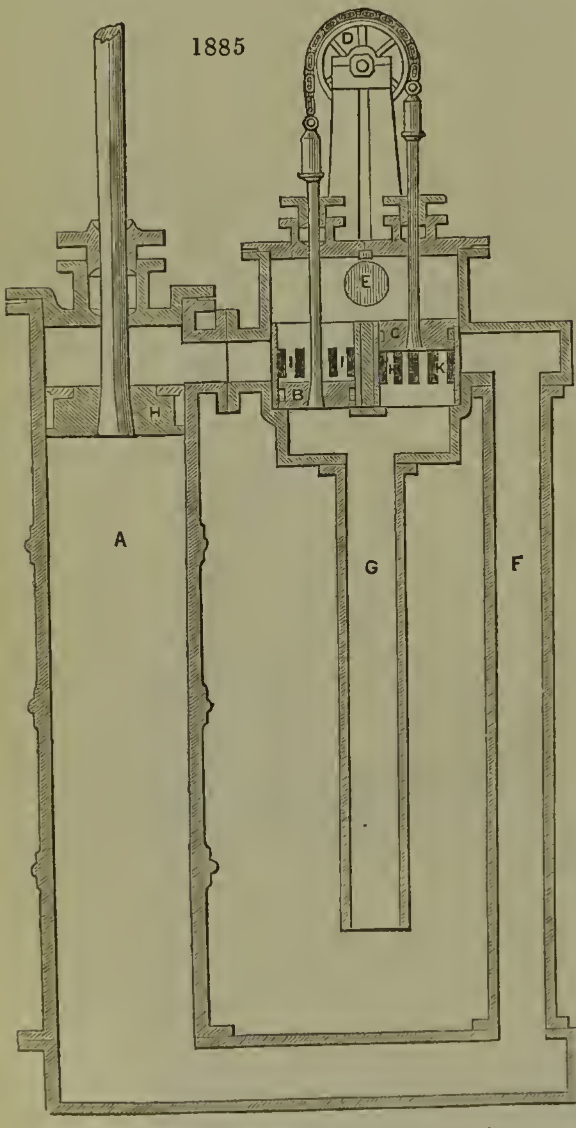
A, main cylinder, B and C, valve pistons; D, chain wheel upon the axis of which is fixed a lever not shown, in connection with a tumbling beam; E, aperture through which water enters from pressure column; F, pipe in communication with main cylinder A, and G, pipe for discharging the water admitted both above and under the main piston H. The position of the valve pistons in the woodcut shows that the pressure column is supposed to be flowing through the holes I, upon the piston H, producing a down stroke, and that the water which has been introduced under this piston in order to make the upstroke is leaving through the pipe F, holes K, and outlet pipe G.

By referring to HYDRAULIC CRANES, the principles adopted by Sir Wm. Armstrong will be understood.

It is not necessary to repeat that part of the subject in this place, but it remains to notice the applications made of the pressure derived from natural falls.

When the moving power consists of a natural column of water, the pressure rarely exceeds 250 or 300 feet; and in such cases he has employed to produce rotary motion, in preference to the original scheme of a rotary engine, a pair of cylinders and pistons, with slide valves resembling in some degree those of a high-pressure engine, but having relief valves to prevent shock at the return of the stroke, as shown in *fig.* 982, already described. Where the engine is single-acting, with plungers instead of pistons, as in the water pressure engine already described, the relief valves are greatly simplified, and in fact are reduced to a single clack in connection with each cylinder, opening against the pressure, which is the same as the relief valve in the valve chest of the hydraulic crane. The water pressure engines erected at Mr. Beaumont's lead mines, at Allenheads in Northumberland, present examples of such engines applied to natural falls. They were there introduced under the advice of Mr. Sopwith, and are now used for the various purposes of crushing ore, raising materials from the mines, pumping water, giving motion to machinery for washing and separating ore, and driving a saw-mill and the machinery of a workshop. In all these cases nature, assisted by art, has provided the power. Small streams of water, which flowed down the steep slopes of the adjoining hills, have been collected into reservoirs at elevations of about 200 feet, and pipes have been laid from these to the engines.

1885



Another application of hydraulic machinery at the same mines is now being made in situations where falls of sufficient altitude for working such engines cannot be obtained, which from its novelty deserves special notice. For the purpose of draining an extensive mining district and searching for new veins, a drift or level nearly six miles in length is now being executed. This drift runs beneath the valley of the Allen nearly in the line of that river, and upon its course three mining establishments are being formed. At each of these power is required for the various purposes above mentioned, and it was desired to obtain this power without resorting to steam engines. The river Allen was the only resource, but its descent was not sufficiently rapid to permit of its being advantageously applied to water pressure engines. On the other hand, it abounded with falls suitable for overshot wheels, but these could not be applied to the purposes required without provision for conveying the power to many separate places. Under these circumstances it was determined to employ the stream through the medium of overshot wheels in forcing water into accumulators, and thus generating a power capable of being transmitted by pipes to the numerous points where its agency was required. In this arrangement intensity of pressure takes the place of magnitude of volume, and the power derived from the stream assumes a form susceptible of unlimited distribution and division, and capable of being utilised by small and compact machines.

A somewhat similar plan is also adopted at Portland Harbour, in connection with the coaling establishment there forming for the use of the navy. The object in that case is to provide power for working hydraulic cranes and hauling machines, and more particularly for giving motion to machinery arranged by Mr. Coode, the present engineer of the work, for putting coal into war steamers. A reservoir on the adjoining height affords an available head of upwards of 300 feet; but in order to diminish the size of the pipes, cylinders, and valves connected with the hydraulic machinery, and also with a view of obtaining greater rapidity of action, a hydraulic pumping engine and accumulator are interposed, for the purpose of intensifying the pressure and diminishing the volume of water acting as the medium of transmission.

Table of Pressure Engines.

Locality.	Engineer.	Diameter of Cylinder.	Length of Stroke.	Speed per Minute.
		inches.	feet.	
Northumberland	Westgarth	10	—	—
Ems	unknown	13½	4	8
Bleiberg	—	7	6¼	100
Chemnitz	—	11	8	48
Ebensee Salzburg	—	9½	1 $\frac{5}{12}$	17
Clausthal	—	16½	6	48
Alte Mordgrube, Saxony	—	18	8	64
Alport Mines, Derbyshire	Trevithick	(double) 25	10	120
Do.	Fairbairn	36	5	70
Do.	Darlington	50	10	140
Do.	do.	18	7	154
Do.	do.	2 Cyl. each. 24	10	120
Do.	do.	2 Cyl. each. 24	10	120
Lisburn, Wales	do.	2 Cyl. each. 20	6	96
Cwmystwyth ,,	do.	2 Cyl. each. 24	10	140
Talargoch ,,	do.	50	10	140
Minera ,,	do.	35	10	140
South Hetton Colliery	Armstrong	* 4 Cyl. each. 3	12	200
Allenheads	do.	do. 6	18	180

WATER-PROOF CLOTH. See Caoutchouc.

WATER, SEA — *rendered fresh.* (*Communicated by Dr. Normandy.*) The analyses of sea water which have been made at various times, and the results of which will be found elsewhere, prove that that liquid contains from 3½ to 4 per cent. of saline substances, two-thirds at least of which are common salt, and also a certain quantity of organic matters, all of which substances impart to it its well-known taste and odour, and render it unfit for drinking or other domestic purposes.

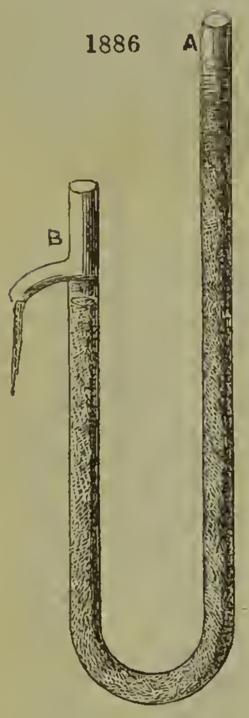
To render sea water drinkable, and thus avoid the accidents resulting from an insufficient supply, or from an absolute want of fresh water, in sea voyages, is a

* Rotary Engines

problem which may be said to have engaged the attention of men from the very moment they ventured to lose sight of the friendly shore and became navigators; gradually, as the enlargement of commercial operations extended the length of sea voyages, the difficulty of preserving in a pure state the fresh water taken in store, the necessity of putting up at stations for procuring a fresh supply of it when it is exhausted, the great gain to be realised by being enabled to devote to the stowage of cargo the valuable space occupied by water-tanks and water-casks, have induced many people at various times, and for many years past, to contrive apparatus by means of which sea water would be rendered fit to drink, or by means of which good fresh water could be obtained therefrom.

Fresh water can be obtained from sea water in two ways; the one by distillation, the other by passing it through a layer or column of sand, or of earth, of sufficient thickness or length. In effect, if sea water be poured at A, in a pipe 15 feet high, and full of clean dry sand, the water, which will at first flow at B, will be found pretty fresh and drinkable, but as the operation is continued, the water which flows at B soon becomes brackish; the brackishness gradually augmenting, until, in a very short time, the water which flows at B is actually more salted than that poured at A; because the latter dissolves the salt which had been first retained by the sand, which must then be renewed, or washed with fresh water, a process evidently useless for the purpose in question. This phenomenon, according to Berzelius, is due to the interstices between the grains of sand acting as capillary tubes; and as, at the beginning of the operation, the effect depends more on the attraction than on the pressure of the liquid poured in one of the branches of the tube, the salt is partly separated from the water which held it in solution, the latter lodging itself into the interstices of the sand, and filling them; if, when the mass of the sand is completely wetted, a greater quantity of sea water is poured upon it, the weight of the said sea water first displaces and expels the fresh water; but as soon as the interstices of the sand have thus been forcibly filled up with sea water, the water flowing at B becomes more and more salted; wherefore this filtration cannot yield more fresh water than can be contained in the interstices of a column of sand of a certain length and proportionate to the saltness of the sea water.

1886



Howbeit, the removal of the salt from sea water, so as to obtain fresh water therefrom, is, practically speaking, an impossibility, except by evaporation.

At first sight one would think that it is sufficient to submit sea water to distillation to convert it into fresh water, and that the solution of the problem is altogether dependent upon a still constructed so as to produce, by evaporation, a great quantity of distilled water, with a consumption of fuel sufficiently small to become practicable.

Distillation at a cheap rate is doubtless an important item, and fuel being a cumbrous and expensive article *on board ship*, it is superabundantly evident that, supposing all the apparatus which have hitherto been contrived for the purpose to answer equally well, that one would clearly merit the preference which would produce most at least cost; but there are, besides, other desiderata of a no less primary importance, and it is from having neglected, ignored, or been unable to realise them, that all the apparatus for obtaining fresh water from sea water, which have been from time to time brought before the public, have hitherto, without exception, proved total failures, or, after trial, have been quite discarded, or fulfil the object in view in a way so imperfect or precarious, that, practically speaking, the manufacture of fresh water at sea, or from sea water, may be said to have been, until quite lately, an unaccomplished feat. In order to understand the nature of the difficulties which stood in the way of success, a few words of explanation become necessary.

When ordinary water, whether fresh or salt, is submitted to distillation, the condensed steam, instead of being, as might be supposed, pure, tasteless, and odourless, yields on the contrary a liquid free from salt, it is true, but of an intolerably nauseous and empyreumatic taste and odour which it retains for many weeks; it is, moreover, insipid, flat, and vapid, owing to its want of oxygen and carbonic acid, which water in its natural state possesses, and of which it has been deprived by the process of distillation. In the absence of ordinary fresh water, this distilled water, however disagreeable and objectionable it may be, is of course of use so far as it is fresh, but the crews invariably refuse it as long as they can obtain a supply from natural sources, even though this may be of so bad a quality as to endanger their health or their lives, as evidenced by the report of *The Times'* Own Correspondent in reference to the water supplied to the crews of our ships in the Baltic during the Crimean war.

With a view to remedy the defects just alluded to, various means have from time to time been proposed and employed; such as the addition of alum, sulphuric and other acids, chloride of lime, &c.; but it is evident that chemical reagents cannot effect the object; but if even they did, their use is always unsafe, for their continuous and daily absorption might, and doubtless would, cause accidents of a more or less serious nature, not to speak of the trouble and care required in making such additions. Liebig said with both authority and reason, that, as a general rule, the use of chemicals should never be recommended for culinary (or food) purposes, for chemicals are seldom met with in commerce in a state of purity, and are frequently contaminated by poisonous substances. On the other hand, the percolation through perforated barrels or coarse sieves, porous substances, plaster, chalk, sand, &c., the pumps, ventilators, bellows, agitators, which have been proposed to aërate the distilled water obtained, and render it palatable, are slow in their action, of a difficult, inconvenient, or impossible application; and as to leaving the distilled water to become aërated by the agitation imparted to it in tanks or casks by the motion of the ship, this must be continued for a length of time, proportioned of course to the vigour of the oscillations imparted to the ship by the violence of the waves, and the time thus required is always considerable; yet in this way, and finally by pouring the water several times from one glass to another before drinking it, it may become fully aërated, but without entirely losing its vapid and nauseous taste and odour, and in fact the report of the correspondent of *The Times*, above alluded to, shows that this method is attended with but indifferent success. I shall presently explain why no system or method of aëration whatever could be attended with success, in the production of *perfect* fresh water from salt water, notwithstanding the great ingenuity displayed in their endeavours to realise the object in view by persons who, some of them at least, though of consummate skill as engineers or philosophers, or as men of general knowledge, were not, it would appear, sufficiently well acquainted with the exact nature of the difficulties which stood in the way, or were not fitted for the investigation and conquest thereof. In reality the failures in this respect have been due to the fact that the aëration of the distilled water, instead of being, as everybody thought, the whole problem, is only a part of it; and we shall see, moreover, that the said aëration, to be effective, must be practised under certain conditions, in a certain manner, and is only a preparatory step though an all-important one, to the final production of *perfect* fresh water.

But before proceeding further, it may not be amiss to say a few words respecting another condition in the construction of marine condensing machines, which, from not being sufficiently taken into account, frequently puts them suddenly out of service, or necessitates constant repairs. I am alluding to those condensers the joints of which are made by soldering or brazing, for the different rates of expansion and contraction of metals by heat and by cold, during the intervals of work and of rest of the apparatus, would be sure eventually to cause the soldered parts to crack and give way, an effect which the motion of the ship would of course greatly promote. This in fact was the cause of the accident which about thirty-five years ago put the lives of Captain Freycinet and of his crew in fearful jeopardy. On the other hand, the electro-chemical action which sets up between the metals of the solder and that of the condenser, corrodes the latter, and in either case a leak being started, the sea water penetrates through it into the apparatus, which may thus be at once put out of service after a few months' working, its unsoundness thus creating the most distressing sufferings, and putting the lives of all on board in imminent peril. It may therefore be most truly asserted that any fresh-water distilling apparatus, for marine purposes, in any part of which solder is employed, is *ipso facto* defective, and ought not to be trusted, the soldered parts being sure to give way from the causes just alluded to. Lastly, another condition often lost sight of (although of extreme importance), in the endeavours which have been made to accomplish the object in question, is to obviate or prevent the deposit of saline matter which takes place when the limit of saturation has been attained, and which in a short time interferes, temporarily at least, and often permanently, with the working of the apparatus, renders frequent repairs necessary, and in all cases eventually destroys it.

The question which had hitherto been left unanswered, and yet which must be integrally solved before success could be hoped for, is the following:—

To obtain, with a small proportion of fuel, large quantities of fresh, inodorous, salubrious, aërated water, without the help of chemical reagents, by means of a self-acting and compact apparatus capable of being worked at all hours, under all latitudes, in all weathers and conditions compatible with the existence of the ship itself, and incapable of becoming incrusted, or of otherwise going out of order.

How this complex and difficult problem has been solved I will now proceed to explain:—

It is a known property of steam that it becomes condensed into water again, whenever it comes in contact with water at a temperature lower than itself, no matter how high the temperature of that condensing water may be.

It is known that the sea and other natural waters are saturated with air containing a larger proportion of oxygen and of carbonic acid than the air we breathe. In effect, 100 volumes of the air held in solution in water contain from 32 to 33 volumes of oxygen, whereas 100 volumes of ordinary atmospheric air contain only 24 volumes of oxygen. Again, ordinary atmospheric air contains only $\frac{1}{4000}$ of carbonic acid, whereas the air held in solution in water contains from 40 to 42 per cent. of carbonic acid. The experiments which I undertook in 1849–50, with a view to determine the amount of these gases present in water, showed me that this amount varied with the state of purity of the water; that whilst ordinary rain-water contains, on an average, 15 cubic inches of oxygenised air per gallon constituted as follows:—

Carbonic acid	6·26
Oxygen	5·04
Nitrogen	3·70
	15·00;

sea water, owing to the various substances which it holds in solution, contains only on an average 5 cubic inches of gases, more than one half of which is carbonic acid; or, in other words, 1 gallon of sea water contains about two-thirds less gases than ordinary rain water, and one half less gases than river water.

I have also ascertained that air begins to be expelled from such natural waters when the temperature reaches about 130° Fahr.; and we know that when the temperature reaches 212° Fahr., all the air which it contained has been expelled, and it is for this reason that distilled water contains no air.

At that time I shared the prevalent opinions of all who had interested themselves on the subject, namely, that the flat, disagreeable, and mawkish taste and odour of distilled water were due to its having been deprived of air, and knowing that the various methods adopted or resorted to for aërating distilled water by forcing atmospheric air into it had failed, and that the distilled water thus aërated spontaneously or by mechanical means, retained the abominable taste and odour just alluded to, and remained for a long time almost undrinkable, I thought that the defect was possibly owing to the air mixed with it not being of a suitable quality, the experiments which I have related having indeed shown that the composition of air contained naturally in water differed essentially from atmospheric air; and that consequently if I could reintroduce into the distilled water the carbonic acid and oxygen of which ebullition had deprived it, it would then become as sweet as good ordinary water. With this view I contrived the apparatus which forms the subject of the present article.

The apparatus is represented in *figs.* 1887, 1888. It consists of three principal parts, an evaporator, A, a condenser, B, and a refrigerator, C, joined so as to form one compact and solid mass, screwed and bolted, without soldering or brazing of any kind. The evaporator is a cylinder, partly filled with sea-water, into which a sheaf of pipes are immersed, so that on admitting steam at a certain pressure into these pipes it is condensed into fresh, though non-aërated water by the sea water by which the pipes are surrounded, that sea water being thus heated and a portion of it evaporated at the same time; for it is one of the properties of steam to be condensed by water, no matter how high the temperature of that water may be, if it be only inferior to that of the steam. This non-aërated water becomes aërated, as I shall explain presently:—On board steamers, the steam is obtained directly from the boilers of the ship; in sailing vessels it is procured from a small boiler which may, or may not be connected with the hearth, galley, or caboose.

The steam at a pressure being, of course, hotter than ordinary boiling water, serves to convert a portion of the water contained in the evaporator into ordinary or no-pressure steam, which, as it reaches the pipes in the condenser, B, is resolved therein into fresh aërated water. The manner in which it becomes aërated will be explained presently. By thus evaporating water under slight pressure, one fire performs double duty, and thus the first condition, that of economy, is completely fulfilled, for while, in the usual way, 1 lb. of coal evaporates at most 6 or 7 lbs. of water, the same quantity of coals, burnt under the same boiler, but in connection with my apparatus, is thus made to evaporate 12 or 14 lbs. of water, or, in other words, from the same amount of coals or of steam employed, the machine which I am describing will produce double the quantity of fresh water that can be obtained by simple or ordinary distillation; that is to say, double the quantity obtained by the ordinary condensers.

The comparative trials made in 1859 on board H. M. ships the Sphynx, Erebus, and Odin, at Portsmouth, before the Commissioners of the Admiralty, have most conclusively proved the perfect accuracy of that statement.

The steam issuing from the evaporator, and which is condensed by the water in the condenser, imparts, of course, its heat to the sea water in it; and as this water is admitted cold at the bottom, whilst the steam of the evaporator is admitted at the top of the condenser, the water therein becomes hotter and hotter gradually as it ascends, and when it finally reaches the top its temperature is about 208° Fahr.

I have already stated that water begins to part with its air at a temperature of about 130° Fahr., therefore the greater portion of the air contained in the water which flows constantly and uninterruptedly through the condenser is thus separated, and led through a pipe into the empty space left for steam-room within the evaporator, where it mixes with the steam.

Now, as about six gallons of sea water must be discharged for every gallon of fresh water which is condensed, and as each gallon of sea water contains, as we said before, 5 cubic inches of air, and whereas the utmost quantity of it that fresh water can naturally absorb is 15 cubic inches per gallon, it follows that the steam in the evaporator, before it is finally condensed, has been in contact with twice as much air as water can take up, the result being a production of fresh water to the maximum of aëration, that is, containing as much air as in pure rain water.

This aëration of the water to the maximum and with the air naturally contained in the water in its original state, though a condition of the utmost importance, as will be seen presently, having, to my extreme surprise, failed in removing the detestable odour and taste in question, it became necessary to try to discover whence came that flavour which no means of aëration could destroy, except after a considerable length of time, and even then never perfectly. With that view I took 25 gallons of distilled water, possessing the characteristic empyreumatic odour and taste, and having evaporated them slowly at a temperature much below the boiling point, I found, at the end of six weeks, the inside of the little platinum dish into which the experiment had finally been carried, covered with a thin oily film of a most disagreeable odour, and upon rinsing the little dish in 25 gallons of excellent ordinary fresh water, the latter immediately acquired the empyreumatic odour and flavour peculiar to distilled water, which odour and flavour are evidently due to the destructive action of the heated surface of the vessels in which the water is boiled on the organic substances which are always floating in the air, on those indescribable particles of dust which are seen playing or moving about in a sunbeam, and which have been dissolved or taken up by the water before its distillation. That water has the power of absorbing and dissolving organic matter in this way is, of course, well known, but it may be illustrated in a very simple manner, as follows:—If water, from whatever source, be distilled, the distillate will, of course, be fresh water, pure fresh water, but it will have a peculiar, nauseous, and empyreumatic taste and odour, stronger in proportion as the heat applied to evaporate it has been more elevated; it is that smell and taste which render it undrinkable for a while. If, when it has become sweet again by long standing, which period may be hastened by agitation in the atmosphere; if, I repeat it, that distilled water be then re-distilled, the distillate will be found to have acquired again the same empyreumatic taste and odour as when it was first distilled. How is this?—Because it will, by standing or agitation, have re-dissolved a portion of the air in the room in which it was kept, and along with that air it will have absorbed whatever substances were present, dissolved or suspended in it, and those substances by their contact with the heated surfaces of the still, yield an empyreumatic product, which taints the distillate. On board ships, the water which is stored in for the use of crews in the usual way, in the course of about a fortnight becomes putrid and almost undrinkable, because the organic matter which that water contains is undergoing putrefactive fermentation. But about a month or so afterwards the water gradually becomes sweeter and sweeter, until at last it becomes drinkable again; because, eventually, all the organic matter which it contained becomes decomposed, carbonic acid and water being the result, and although the air of the ship's hold is none of the sweetest, such water, as just said, generally remains afterwards perfectly good and palatable; because, the tanks in which it is kept being covered up, it is sheltered from fresh pollutions, and because it is now saturated with pure air, and therefore cannot absorb that of the atmosphere.

When the natural waters supplied to our habitations are obtained from impure sources, as is unfortunately too often the case, the evils resulting from their use may in some degree be remedied by putting in practice the recommendation which has been sometimes made, of boiling such water previous to employing it as a beverage; unfortunately the water being thereby deprived of air is, like distilled water, though in a less degree, unpalatable and vapid and heavy; it is, in fact, of difficult digestion; but there is something worse than that; water which has been boiled, or which has been distilled, by reason of its containing *no air*, has a great tendency to absorb or to take that of the media where it is kept, so that if distilled water which contains no air be kept in a ship's hold, or in an impure and confined place, it will absorb precisely the quantity of air which it can absorb, namely, 15 cubic inches per gallon, and if that air be loaded with organic particles or impure emanations, it will soon become fetid and putrid. The experiments of Dr. Angus Smith have proved that if a stream of air which has already been breathed be passed through water, the latter will retain a peculiar albuminoid matter which undergoes putrefaction with extraordinary rapidity; and the water which condenses on the cold exterior surfaces of vessels in crowded rooms possesses the same character, and acquires in a short time an offensive odour; now this is to a great extent the case with the water of ordinary condensers when allowed to become spontaneously aërated on board ship. Thus water, though distilled, if kept in tainted rooms, will soon become foul. The only condition necessary for distilled water not to become putrid or offensive is to saturate it with *pure air*, because in that case there is no room left for other gases to impregnate it (at least, practically speaking, and in the ordinary conditions of domestic or of ship economy) and to keep it in covered vessels or tanks.

Now, although aëration alone is, as I have just said, powerless to destroy the nauseous odour of distilled water within a time practically useful, this aëration, when effected in the manner which I have described, is of the utmost importance; since if even all the other conditions of the problem had been complied with—all, except that one, the apparatus, economical and perfect though it might have been in all other respects, would have been comparatively useless. I would strongly urge the importance of *aërating the fresh water in the manner which I have described*—that is to say, not with ordinary atmospheric air, but with that which was naturally contained in the water before its distillation; because aërating it mechanically with ordinary atmospheric air, by simple ventilation or agitation, is far from answering the purpose so well, for the reasons which I have already stated. Having thus found that the cause of the odour and taste was due to the presence of empyreumatic products, it became evident that, whereas the fresh water produced by my apparatus was aërated in the same manner and to the same extent as that obtained from the very best sources, and equal to it in every other respect, the removal of these ill-smelling and ill-tasting principles was the last obstacle to the entire success of the operation.

Now, if a tree, for example, after having been cut down, is left exposed to the action of the air on the spot on which it lies, we know that, in the course of time, its exterior becomes soft and friable, and that it gradually crumbles into dust. The tree, in that case, is said to be decaying; and, in effect, after a greater or less number of years, it will be found to have completely disappeared; all its combustible parts, that is to say, all those parts which would have been burnt off if the tree had been set fire to, have vanished, and been volatilised, nothing being left behind but the incombustible parts, that is to say, the earthy constituents of the tree. Whether the tree is destroyed by actual burning or by *spontaneous decay*, the result is the same; the only difference is, that in the first case the combustion is rapid, and is energetically accomplished, with disengagement of heat and of light, in a few hours; in the second case, the combustion is slow, without sensible elevation of temperature, and a period of thirty, or perhaps forty years may be required to accomplish it, and for the tree to disappear completely: it is only a question of time; whether the tree is burnt in a fire, or allowed to decay in the air, the final result is the same; the carbon and hydrogen of its wood being oxidised, or burnt by the oxygen of the air, give, the one carbonic acid, the other water, both of which disappear, and a fixed residue, namely, *ashes*. But if, instead of leaving the tree whole, it be cut into pieces, into shavings, into fragments of shavings, into shreds—then its combustion in a fire will be completed in a few moments; or spontaneously in a few months, as indeed is the case with farm-yard manures, which are spread on the ground, and of which nothing remains in the ensuing year—nothing but the incombustible part thereof—the earthy portion, *the ashes*, mixed with the soil.—How is it that a corpse which, while putrefying, evolves a revolting odour, becomes inodorous when it is put into a hole in the ground, covered with earth, wherein it continues nevertheless to decay and to rot, so entirely and effectually, that after a certain time nothing remains but bones, or the earthy matter of those bones?—What has become of the muscles, of the fat, of the nerves, tendons, tissues of all kinds?—They have been burnt, oxidised, converted into carbonic acid and water; the sulphur thereof has been converted into sulphuretted hydrogen, and that again into sulphuric acid and water; the nitrogen has been converted into ammonia, &c. &c. Whence it is seen, that all dead organic matter is eventually burnt up by the oxygen of the air; and that this combustion, whether rapid or slow, is accelerated by the greater or less degree or state of division in which it is exposed to the action of that gas.

Now, Dr. Stenhouse several years ago, I believe, found that the power which charcoal possesses of purifying *tainted air* is owing to its burning in an insensible manner the substances to which the bad odour was due; and acting, therefore, upon this discovery, I conceived that in order to burn a substance spontaneously in that manner, it mattered not whether the oxygen of the medium into which the said substance was placed was a mixture of oxygen and nitrogen, (atmospheric air,) or a mixture of oxygen and water, (water aërated by my process,) since *oxygen alone* was the supporter of combustion, the *nitrogen* having nothing to do with the burning of the substance, any more than the *water* of the aërated water. And accordingly, on experimenting in that direction, I found that charcoal has the power of destroying the empyreuma of distilled water *when such water is* AERATED, that is to say, when it contains free oxygen. I found by experiments, performed on a somewhat extensive scale for many months, that two cubic feet of charcoal are sufficient to remove entirely the empyreumatic odour and taste of distilled water, produced at the rate of 500 gallons per diem, and that the charcoal *never wants renewing*, because it does not act as a *filter*, but as a *fire grate*, the substance burnt being the empyreumatic product, and the result of the slow combustion thereof being the ordinary products of combustion, to wit, carbonie aeid and water. I have every reason to believe, from the length of time during which several of my apparatus have been in operation, both on board a large number of ships and on land, that such a filter once made will last for ever, because the charcoal disinfects the water, so to speak, as it does air, not by mechanical separation, but by actual, though insensible combustion. The water as it issues from the apparatus is perfectly sweet, tasteless, inodorous, and saturated with its proper and normal quantity of oxygenised air and carbonic acid; it is of sparkling clearness, and being refrigerated in traversing the sheaf of pipes of the refrigerator, C, surrounded by cold sea water at the lower part of the apparatus, it is fit for immediate use.

These qualities I sincerely affirm are not in the slightest degree exaggerated, and a multitude of testimonials establish in an incontrovertible manner that such is truly the case.

And thus is the second condition that of aëration, of digestibility, of wholesomeness accomplished, whereby the fresh water produced is rendered *at once* not only drinkable, but so sweet, limpid, and fresh, that it cannot be distinguished from the very best spring water.

During the experiments or comparative trials which took place at Portsmouth in 1859 before the Committee of the Admiralty, between my apparatus and that of the late Sir Thomas Grant, with which all H. M steam ships were then provided, a very curious phenomenon took place, which corroborated in a startling manner the explanation which I have given of the nauseous odour of ordinary distilled water. The circumstances under which the phenomenon was produced were as follows:—

On the 20th of October, 1859, steam having been got up in one of the boilers of H. M. ship "Odin, that steam was turned in precisely equal quantity to each of the apparatus under trial (Sir T. Grant's and mine). The first experiment was completed about 3·30 of the ensuing morning. The fire was then "banked up" for the rest of the night; the general steamcock supplying the steam to both apparatus was turned off; both apparatus of course became quite cold, and the residuary steam in the boiler was used by the engineer for working his donkey-pump. Towards 12 o'clock of the ensuing day the experiments were resumed; steam again got up for the purpose, and an equal quantity of it turned as before into each apparatus.

When, however, a boiler is not at work, or has been even a few hours without working, its steam room as well as the steam pipe is of course filled with common air instead of with steam; wherefore the steam which is *at first* generated in the said boiler instead of being steam only, is a mixture of steam and air. Accordingly when steam is at first turned into my apparatus, a small cock with which the latter is provided is simultaneously opened for the purpose of allowing an escape for that air which otherwise would to a certain extent interfere with the condensation of the steam, and retard the boiling of the sea water in my evaporator. In conformity with this practice, as soon as the steam from the ship's boiler was turned into both apparatus (Sir T. Grant's and mine), the small cock above alluded to was opened, whereupon a rush of air escaped through it as usual, but I then observed for the first time that this air escaping from my *cold* apparatus (for no steam had as yet come into it), instead of being merely atmospheric air, was an inflammable gas, which being brought in contact with a lighted lamp burnt with a thin bluish flame, due evidently to the presence of carburetted gases resulting from the decomposing action exercised by the heated surfaces of the boiler, not only on the organic matters naturally contained in all natural waters, as discovered by the experiments which I made in 1850, and to which I have already alluded, but also on the fatty matters of the packings of the pistons, and introduced into the boiler by the feed pump, but in all probability principally from the decomposition of the melted tallow which is generally forced into it by means of a syringe *ad hoc*, for the purpose of preventing "priming," which introduction, in my humble judgment, is not under certain circumstances altogether free from danger.

I believe that most of the boiler explosions unsatisfactorily explained or absolutely unaccounted for are referable to the presence of the gases above alluded to, and of atmospheric air in such proportions as to form a detonating mixture, which is then inflamed *possibly* by the unduly heated surfaces of the boiler *above* the water level, but in my opinion much more probably by the electricity resulting from the friction of the vesicular steam against the steam pipe and other surfaces. In effect it is well known that the steam which issues from a boiler is always highly charged with electricity, and that electric sparks several inches in length may and have been drawn from it, especially when the boiler happens accidentally or otherwise to be isolated. On the other hand, a mixture of these gases may be exploded when mixed with atmospheric air in certain proportions varying between 1 of the former and from 6 to 16 of the latter, the maximum effect being when 1 of carburetted hydrogen is mixed with 8 of atmospheric air. Given, therefore, the conditions of a sufficiently insulated boiler, and a mixture therein of the above-mentioned gas and atmospheric air in proportions ranging between one of the first, and six, seven, eight, or nine of the second, an explosion of the boiler, of a more or less formidable nature, may take place.

I have already stated that sea water contains salt in the proportion of about 1 lb. to 33 lbs. of water. Now when sea water is evaporated, all the steam produced therefrom being of course fresh water, all the salt which that water contained is left behind, that is to say, the salt previously contained in the evaporated portion is left in that portion which is not yet evaporated, and which is therefore more impregnated with salt than before. If this salt be not removed, and the evaporation is continued, it goes on accumulating, furring and incrusting the vessel, and very soon destroys it. This is, in fact, an inconvenience common not only to all the sea-water stills hitherto contrived, but to the boilers of marine engines; for no boiler is safe from incrustation as soon as about one-half of the sea water admitted into it has been evaporated; that is, as soon as the sea water has been saturated by concentration so as to contain 1 lb. of salt in about 16 lbs. of water.

My apparatus is not liable to these incrustations or deposits of salt, because the sea water circulates in it in a constant and uninterrupted manner, a discharge taking place at the same time through cock 45 (see *fig.* 1887) so as to leave the sea water in the apparatus superabundantly diluted to hold in perfect solution the whole of its salt; in fact the sea water discharged through that cock contains only about one-half per cent. more salt than it did when it first entered the apparatus, which is a perfectly insignificant increase.

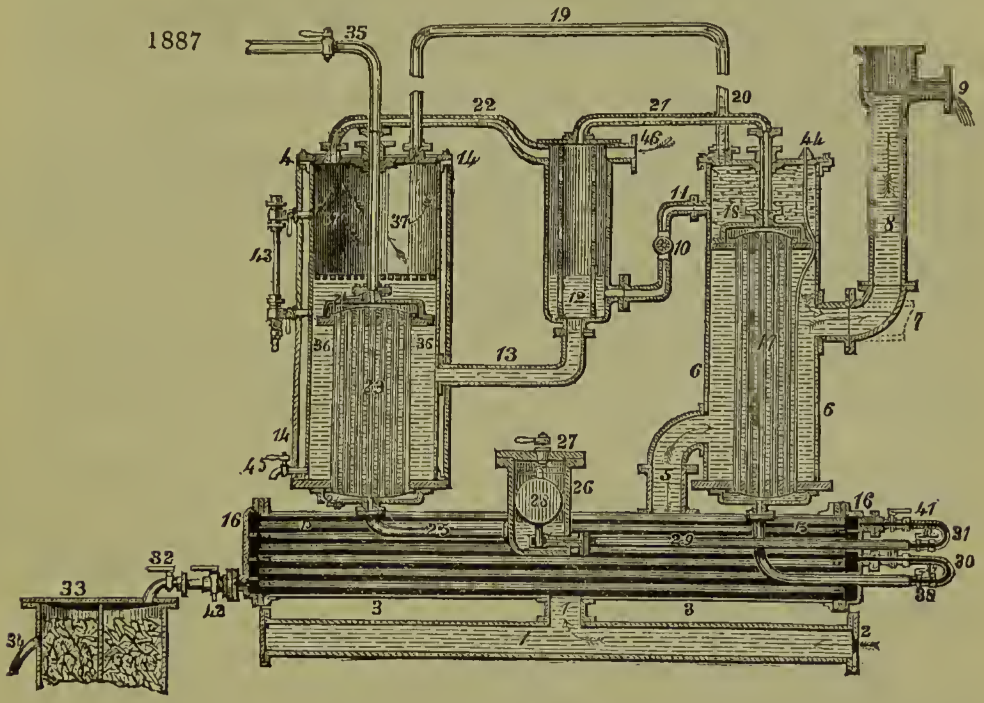
The different parts of the apparatus being made of sheet, riveted, galvanised iron plates and of cast iron, connected in a substantial manner by screws and bolts, without soldering or brazing of any kind or in any part, it is perfectly impossible that it should go out of order by any accident short of those cases of *force majeure* which, unfortunately, are too often the cause of the ruin or wreck of the ship itself.

I shall now give a description of the *figs.* 1887 and 1888, in which the same numbers represent the same organs. *Fig.* 1887 is a section on the same plane, showing the mode of action of the apparatus, without reference to the real position of its constituent parts. *Fig.* 1888 is a correct front elevation of the apparatus.

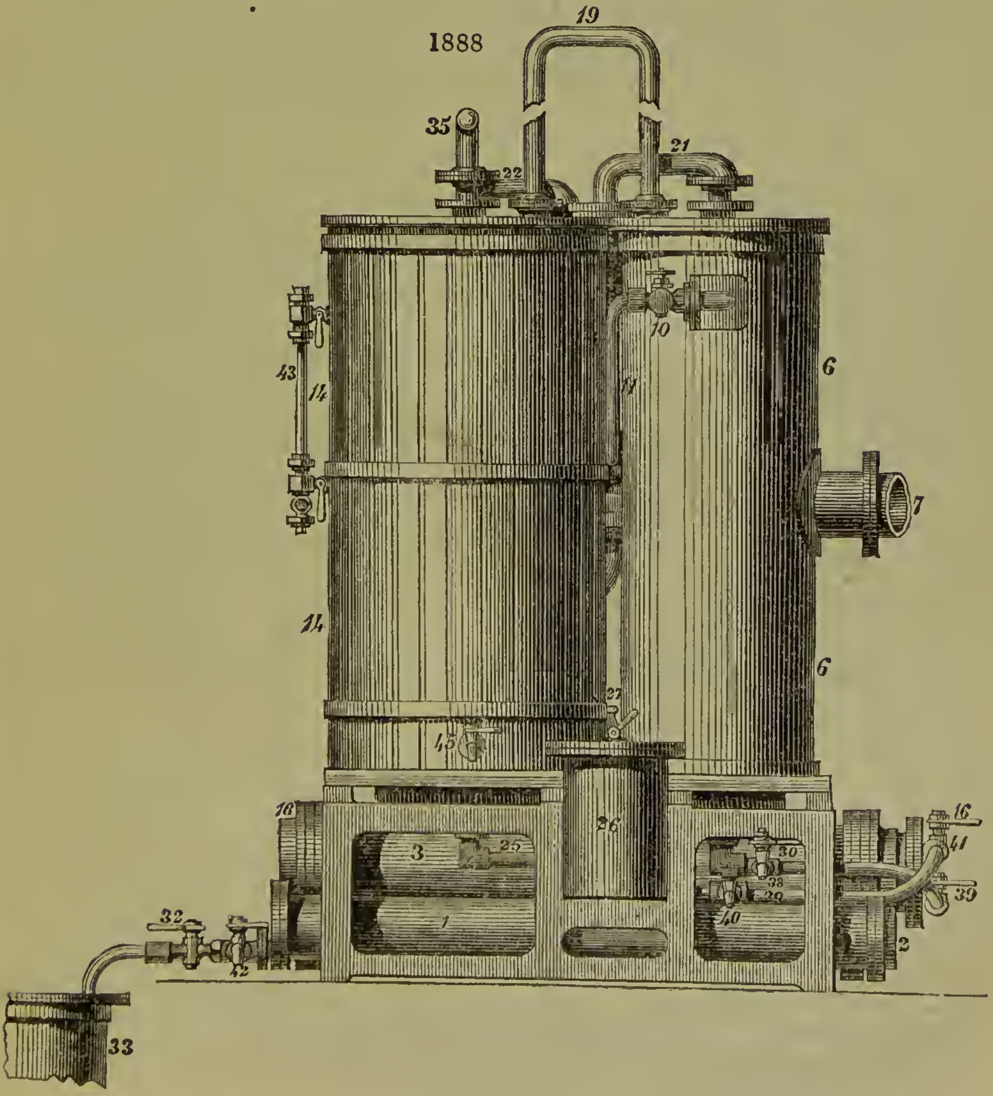
1 shows the large entrance tube for the sea water: this tube is connected to a large cock, communicating with the sea through the side or bottom of the ship; or else flanged to a much smaller pipe connected with a pump, by means of which the apparatus is supplied with water from the sea, which thus penetrates into the refrigerator 3, through the tube of communication 4, and thence passes round the sheaf of pipes 15, in the said refrigerator, through another communication tube 5, into the condenser 6, as shown by the arrows, and up the large vertical tube 8, whence the surplus sea water pumped up flows away through the pipe 9, in the direction indicated by the arrows. The condenser, 6, being thus completely filled up with sea water, on opening the cock 10, the sea water passing through pipe 11 falls into the feed and priming box 12, and thence through pipe 13 into the evaporator 14, filling it up to a certain level, regulated by opening or shutting the cock 10 so as to maintain the sea water at the proper level in the evaporator 14.

3, *Refrigerator.* It is a horizontal case pervaded with pipes 15, placed horizontally in it. The sea water being introduced into this refrigerator, circulates round a sheaf of pipes 15, held between the caps 16, at each end of the said refrigerator, so that the fresh water which has been condensed in the pipes 23, of the evaporator 14, and in the pipes 17 of the condenser 6, is thereby cooled down to the temperature of the sea water outside.

1887



1888



4, large pipe connecting the pipe 1 with the refrigerator 3.
5, large pipe connecting the refrigerator 3 with the condenser 6.
6, *Condenser.* It is a cylinder containing a sheaf of pipes 17, into which the non-aërated steam from the evaporator is condensed by the sea-water which surrounds them.
7, large outlet tube, used only when the apparatus is put below the level of the sea.
8, large upright tube, which, when the apparatus is placed on deck is turned upwards, and is of such a length that the sea water which is forced through the apparatus by means of the pump, or otherwise, may be raised a few feet above the whole apparatus, so that there may be in the large tube 8, a column of sea water higher than the condenser 6, in order to keep it quite full.
9, overflow pipe for the escape of the excess of sea water.
10, cock of the feed pipe.
11, feed pipe, one end of which is inserted in the condenser 6, and the other end in the feed and priming box 12. It is through this feed pipe 11, that the sea water is led from the top of the condenser into the feed and priming box 12, by opening the cock 10 to a suitable degree, as said before, 1.
12, feed and priming box. It is a box into which, on opening the cock 10, the sea-water supplied from the condenser 6, by pipe 11, passes through pipe 13 into the evaporator 14, which is thus fed with the proper quantity of sea water. This feed box receives also any priming which might be mechanically projected by or carried along with the steam through pipe 22. In such a case the priming is then returned to the evaporator 14, through pipe 13.
13, feed-pipe leading to the sea-water to be evaporated into the evaporator 14.
14, evaporator. It is a cylinder containing a sheaf of pipes 23, with their caps, 24, at each end, immersed in the sea-water, part of which is to be evaporated.
15, sheaf of pipes of the refrigerator 3, for the purpose of cooling the fresh water produced; has already been described under No. 3.
16, caps of the refrigerator 3, so arranged that by means of the divisions reserved in the said caps, the steam from the boiler, and that evolved from the evaporator 14, are both made to travel to and fro through the different pipes 15 consecutively, so as eventually to flow out in a mixed and cold state through the cock 32 into the filter 33, and finally through the tube 34 in a perfect state.
17, sheaf of pipes placed between the two caps 18 of the condenser 6, for the purpose of condensing the aërated steam from the evaporator 14.
18, caps covering the ends of the sheaf of pipes 17 placed in the condenser 6.
19, aërating pipe leading the air which separates from the sea water round the pipes 17 of the condenser 6 into the steam-room or chamber of the evaporator 14. It is by means of this aërating pipe that the fresh water condensed in the condenser 6 becomes aërated, and this aëration is accomplished as follows:—

As the steam from the evaporator 14 enters the pipes within the condenser 6 at the top thereof, through the pipe 21, it follows that the sea water at the top of the condenser 6 is brought, as was already said under No. 11, to a temperature which, at the top of the said condenser, is as high as 206° or 208° Fahr.; this temperature, as we also said, No. 11, gradually diminishes from the top downwards, but at a zone corresponding to about the point marked by No. 7, the temperature of the sea-water round the sheaf of pipes 17 is reduced to about 140° Fahr. As the air naturally contained in sea-water begins to separate therefrom at about 130° Fahr., that in the sea water round the sheaf of pipes 17, between No. 7 and the top of the condenser, becoming entirely liberated, ascends, by virtue of its lighter weight, to the top of the said condenser 6; it then passes through the aërating pipe 19, and is then poured into the steam-room 37 of the evaporator 14, wherein it mixes with the secondary steam therein produced by the evaporating pipes 23. This mixture of air and steam passes then through pipes 22 into the feed and priming-box 12, and thence through pipe 21 into the sheaf of pipes 17. The air being there absorbed during the condensation of this secondary steam, with which it was mixed, the condensed fresh water resulting therefrom becomes thus super-aërated, and in passing subsequently through the cock 39 of pipe 30 into a portion of the pipes 15 of the refrigerator 3, it mixes there with the non-aërated fresh water, resulting from the steam of the boiler, which has condensed in the pipes 23 of the evaporator 14, which condensed water flows through pipe 25 into the steam-trap 26, thence along pipes 29 and 31, and through the cock 41, into the other portion of pipes 15 of the refrigerator 3. The condensed water from the pipes 23 of the evaporator 14 becomes aërated by the excess of air contained in the condensed water of the pipes 17 of the condenser, in its passage with the latter through the pipes 15 of the refrigerator 3, in traversing which the combined waters are cooled down to the temperature of the sea water round the said sheaf of pipes in the refrigerator. And the result is, that after passing through the filter it flows at 34 in the state of perfectly cold fresh water, thoroughly aërated, and of matchless quality.

20, level to which the sea water rises in the aërating pipe 19.

21, pipe conducting the mixture of steam and air from the feed and priming-box 12 into the sheaf of pipes 17 of the condenser 6.

22, pipe leading the mixture of steam and air from the evaporator 14 into the feed and priming-box 12, where any salt water, with which it may be mixed, is arrested and returned to the evaporator 14, through pipe 13, while the pure steam, passing through pipe 21, is next condensed in the sheaf of pipes 17 of the condenser 6.

23, sheaf of pipes immersed in the sea water 36 of the evaporator 14, and in which pipes the steam coming from the boiler through the steam-pipe 35 is condensed, after which it flows as distilled but *non-aërated* fresh water into the lower cap 24, and thence through pipe 25 into the steam-trap 26, thence through pipes 29 and 31 and cock 41 into the sheaf of pipes 15 of the refrigerator 3.

24, upper and lower caps covering the two extremities of pipes 23 of the evaporator 14, into which pipes the steam from the boiler diffuses itself, and is condensed, after which it flows in the state of distilled but non-aërated fresh water, through pipe 25 into the steam-trap 26, and thence through pipes 29 and 31 into the pipes 15 of the refrigerator 3, in which it mixes with the *aërated* water coming through pipe 30, and passing through pipe 32 into the filter 33, finally issues at pipe 34 in the state of cold, matchless, aërated fresh water, *immediately fit for consumption.*

25, pipe for the exit of the condensed non-aërated fresh water from the sheaf of pipes 23, of the evaporator 14, which water, after entering the steam trap 26, issues therefrom through pipe 29, and then enters the refrigerator as already said.

26, steam trap. It is a box containing a float 28, provided with a plunger acting in such a way that when the box contains only steam, or a quantity of condensed water, not sufficient to buoy the float, it (the plunger) closes the exit pipe 29; but as soon as the condensed water has accumulated in quantity sufficient to buoy the float up, the plunger, of course, rising with the float, no longer obstructs the exit pipe 29, and accordingly the condensed water may then escape as fast as it is produced.

27, small pet cock on the top of the cover of the steam trap 26.

28, float already described (26).

29, pipe leading the condensed non-aërated water from the steam trap 26, through pipe 31, into the pipes 15 of the refrigerator 3, in which it mixes with the aërated fresh water from the condenser.

30, pipes leading the condensed aërated water from the pipes 17 of the condenser 6, into the pipes 15 of the refrigerator 3, in which it mixes with the non-aërated water from the steam trap 26. This pipe is provided with two cocks, 38 and 39, for the purpose of cleaning the condenser 6.

31, pipe leading the condensed non-aërated water from pipe 29 into the pipes 15 of the refrigerator, in which it mixes with the aërated water from the condenser.

32, exit-pipe and cock, through which the mixed distilled waters (aërated and non-aërated), after passing through the pipes of the refrigerator, enter the filter, 33.

33, filter for receiving the condensed water from both the evaporator and the condenser, as they issue in a mixed and cold state from the pipes 15 of the refrigerator 3, through cock and pipe 32.

34, pipe for the final exit of the perfect aërated fresh water.

35, steam pipe and cock leading the steam more or less under pressure from any description of boiler to the pipes 23 of the evaporator 14. It is connected at one end with the steam boiler, and at the other with the upper cap 24, of the evaporating pipes 23.

36, sea water, to be evaporated by the steam-pipes 23, of the evaporator 14.

37, steam room, or space into which the air naturally contained in the sea water used for condensation in the condenser 6, is poured through the aërating pipe 19, so as to mix with the steam generated by the pipes 23 of the evaporator.

38 and 39, two cocks on pipe 30, placed between the condenser 6 and the refrigerator 3, for the purpose of clearing the pipes 17 of the condenser 6.

40 and 41, two cocks placed on pipe 31, for the purpose of clearing the pipes 23 of the evaporator 14 and steam trap 26.

42, cock placed between the cap 16 of the refrigerator 3, and the cock 32, for the purpose of cleaning the pipes 15 of the refrigerator 3.

43, glass water-gauge.

44, breathing-pipe. It is a small pipe, one end of which is in communication with the lower cap 18 of the condensing-pipes 17, and the other end is open to the atmosphere. The object of this pipe is not only to remove pressure from the cylinders, but likewise to afford an exit for the excess of air generated.

45, brine cock.

46, opening reserved in the feed and priming-box.

The first thing to be done is, of course, to charge the apparatus with sea water. This is done by establishing a communication between the apparatus and the sea water round the ship. This is easily done by turning on the large cocks, or Kingston valves, connected with the large orifices 2 and 7 (see the figures), whereupon the salt water immediately fills up both the refrigerator 3 through the passage 4 and the condenser 6 through the passage 5, up to a certain point 20 of the aërating pipe.

Opening now the cock 10 of the feed pipe 11 the sea water will pass from the condenser 6 into the feed and priming box 12 and thence through pipe 13 into the evaporator 14, where it should be allowed to rise up to about one-third of the glass gauge, 43, when the cock 10 should be shut up. The apparatus being thus charged with its proper quantity of sea water; the steam-boiler being ready to furnish the necessary steam; and admitting, of course, that the steam pipe 35 is in communication with the said boiler, the next thing to be done is to open the steam cock, 35, shutting at the same time the cocks 39, 41, and 32, and opening cocks 38, 40, and 42, and likewise the small pet cock 27 of the steam trap 26. On opening this small pet cock 27 nothing but air will at first rush out; but, presently, steam will issue from it; it should then be closed more and more gradually as the steam is seen issuing from it with rapidity; and it should eventually be left *almost*, but not altogether, shut up, so as to leave only room for the smallest possible wreath of steam slowly to issue from it. As soon as the steam-cock 35 is open, the steam from the boiler will rush through that cock into the sheaf of pipes 23 of the evaporator 14, in which pipes it will be condensed by the sea water which surrounds them, and it will then flow in the state of condensed non-aërated distilled water through the pipe 25 into the steam trap 26; lift up the float 28, and passing through pipe 29, will flow through cock 40, its further progress being intercepted by cock 41, which is shut, as said before. As soon as the condensed water flows out in a clear state from cock 40, shut it, and open cock 41, so that it may pass into the pipes 15 of the refrigerator 3, and out at cock 42. In a few moments the condensed water will flow out in a clear state from that cock, 42, which should then be closed, opening at the same time cock 32, so that it may pass into the filter 33.

But the steam within the sheaf of pipes 23 of the evaporator 14 soon brings the sea water round them to the boiling point, and converts part of it into steam. This pure secondary steam from the evaporator, issuing then from the priming-box 12, passes through pipe 21 into the pipes 17 immersed in the salt water of the condenser 6, and being condensed in the said pipes, is allowed to flow out at the cock 38 (which has been opened at starting), as long as it is not clear. In a short time, however, it will flow out from that cock, 38, in a perfectly clear state; when this takes place shut this cock 38, and open cock 39, whereupon it will flow into the pipes 15 of the refrigerator 3, in which pipes it will mix with that coming from the pipes 23 of the evaporator 14, and flow with it through the said pipes 15, and thence into the filter 33 through the cock 32, the whole issuing finally from the filter 33 through pipe 34, in the state of perfect aërated fresh water.

From this brief description of my marine fresh-water apparatus it may be seen that a quantity of fresh water is produced *always double* that which can be evaporated from any boiler whatever, and indeed by increasing the number of evaporators 1 lb. of coals may thus be made to yield 30 or 40 lbs. of fresh water of matchless quality. That the small volume of the apparatus, the large quantity of fresh aërated water which it produces*, at an extremely small cost, its perfect safety, permanent order, and the ease with which it can be disconnected and all its parts reached, not only render it pre-eminently suited to naval purposes, but likewise to such stations or places as are deficient in one of the first necessaries of life, salubrious fresh water, or where it cannot be obtained at all, or only in an insufficient, precarious, or expensive manner.—A. N.

The following letters were addressed to the Editor in reply to an inquiry made by him as to the value of Dr. Normandy's invention.

"Government Emigration Board,
"8, Park Street, Westminster, 1st March, 1860.

"Sir,—I am directed by the Emigration Commissioners to acknowledge the receipt of your letter of the 28th ultimo, requesting to be furnished with any evidence they may possess as to the good or ill effects of the use of Dr. Normandy's distilled water on board emigrant ships.

"In reply, I am to acquaint you that the Commissioners have placed on board several of their emigrant ships Dr. Normandy's apparatus for distilling fresh from salt water, and that the reports which

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* An apparatus 4 ft. 6 in. high, 5 ft. long, and 2 ft. wide, produces at least 24 gallons of fresh water per hour.

they have as yet received from their surgeons in those vessels (who are instructed to pay particular attention to the matter) are uniformly of a favourable character — one gentleman only having mentioned that the water had at first an insipid taste which subsequently went off. This probably arose from some accidental circumstance in the particular machine, as freedom from insipidity is one of the main characteristics of the water.

"I enclose, for your information, extracts from the official reports made to this Board by their surgeons and the colonial emigration agents, respecting the quality of the water and its effects.

"I have the honour to be, sir,
"Your obedient servant,
"S. WALCOTT, *Secretary*."

"Robert Hunt, Esq."

Extract from the report of Dr. Duncan, Immigration Agent, on the ship "*Confiance*" *dated Port Adelaide*, 10*th Jan.* 1859:—

"A distilling apparatus, invented by Dr. Normandy, was sent out in the 'Confiance' to test its efficiency.

"There are two great objections to water distilled in the ordinary manner; the first is, that water thus obtained is without air, is unpalatable and indigestible; the second is, that it contracts, while in the process of distillation, an empyreumatic odour and taste; in fact, ordinary distilled water is said to be indigestible and nauseous.

"These two objections appear to be perfectly met by Dr. Normandy's invention; the water obtained by his process is perfectly palatable, well aërated, and devoid of smell.

"During the passage of the 'Confiance,' nearly eleven thousand gallons of water were distilled, and is reported by the surgeon superintendent to have been of most excellent quality, and preferred by the emigrants to the water shipped on board in casks."

Extract from the Report of Dr. Carroll on the ship "*Conway*," *dated Melbourne*, 20*th Sept.* 1858:—

"The quality of the water produced was, in my opinion, excellent, and most agreeable in taste; and, so far as my observation went, most wholesome; in fact, during the hot weather I considered it quite a luxury; and I regretted much that the quantity produced was not greater. It was also preferred by the passengers to ship's water."

Extract from the Report of Dr. Crane on the ship "*Forest Monarch*," *dated Sydney, Jan.* 5*th*, 1859:—

"The condensed water was very good, excelling in clearness and purity, and much more palatable than any water I had ever previously seen on board ship, being not unlike the rain-water so much esteemed in the West Indies. The water, as it came from the apparatus, possessed a slight peculiar taste, which varied in degree with the purity of the sea water employed in its production, and which disappeared on exposure to the air. This peculiar taste I attribute partly to the excessive aëration of the condensed water, as I have noticed a similar taste in soda-water that has been adulterated for cheapness' sake, with common air, and partly to empyreumatic products obtained from the destructive distillation of organic impurities contained in the sea water subjected to distillation."

Extract from the Report of Dr. Rivers on the "*Morayshire*," *dated Calcutta*, 18*th May*, 1859:—

"The emigrants did not at first like the distilled water, but gradually got accustomed to it, and afterwards to prefer it to the ordinary water. Those drinking it seemed better in health than the people using the other water, and more free from bowel complaints. I would, therefore, strongly recommend that the water prepared from Dr. Normandy's apparatus be generally used in all ships carrying Coolies, as, in my opinion, it is not only wholesome, but perfectly free from all impurities, besides not so liable to disorder the bowels as the common water."

Extract from the Report of Mr. James Crosby, Immigration Agent at British Guiana, on the ship "*Queen of the East*," *dated British Guiana*, 19*th Oct.* 1859: —

"I found also Dr. Normandy's admirable distilling apparatus in full operation. It is almost impossible to speak in too favourable terms of this apparatus, capable of producing five hundred gallons a day—with the consumption, I think, of only eight bushels of coals—of water apparently as pure and wholesome as could be drunk, and taken from alongside the ship, from the muddy and impure water of the Demerara river."

Extract of a letter from Dr. L. S. Crane, surgeon superintendent of the ship "*Devonshire*," *dated Coconada*, 27*th December*, 1859:—

The "Devonshire" was dismasted in a hurricane, by which the apparatus on deck was injured.

"Since the water apparatus was broken, the health of the Coolies has deteriorated. After careful observation I can find no other cause for the dysentery and diarrhœa prevailing than the water they drink. The ventilation is excellent, the between-decks have been kept beautifully clean and dry—the food is good and well cooked. The rice, cargo, has been steaming to a certain extent, but the diseases that arise from bad air,—low fevers and cholera,—have not made their appearance. Besides the crew have suffered very much more than the Coolies, and the only condition common to both is the water they drink."

Extract of a letter from Mr. C. Chapman, surgeon superintendent of the ship "*Euxine*," *to S. Walcott, Esq., dated Madras*, 23*rd January*, 1860:—

"In my opinion, the water it (Dr. Normandy's apparatus) produces is perfectly sweet and wholesome; is far preferable, and preferred by all hands, to the water in tanks or casks."

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 fecula 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-tree* 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 grey 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 alkalies 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 heated to 154½° Fahr.; 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. Professor B. C. Brodie has made an extensive series of researches into the constitution of wax. He applies the name cerotic acid to cerine, and represents its formula as $C^{54}H^{54}O^{4}$. Pure myricine he considers to be represented by $C^{92}H^{92}O^{4}$.

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 2 per cent. of a tallow sophistication may be discovered in this way.

Wax is sometimes adulterated with stearine, which can be detected, according to Lebel, even when only in 1-20th part. It may be recognised by dissolving the specimens in two parts of oil, agitating with water, and adding acetate of lead. The precipitate thus obtained is said to exhibit a very high degree of solidity.

WAX CANDLES.—Wax contains 81·75 parts of carbon in 100, which generate by combustion 300 parts of carbonic acid gas. Now, since 125 grains of wax constitute the average consumption of a candle per hour, these will generate 375 grains of carbonic acid; equivalent in volume to 800 cubic inches of gas. According to the most exact experiments on respiration, a man of ordinary size discharges from his lungs 1632 cubic inches of carbonic acid gas per hour, which is very nearly the double of the quantity produced from the wax candle. Hence the combustion of two such candles vitiates the air much the same as the breathing of one man. A tallow candle, three or four in the pound, generates nearly the same quantity of carbonic acid as the wax candle; for though tallow contains only 79 per cent. of carbon, instead of 81·75, yet it consumes so much faster, as thereby to compensate fully for this difference.

When a tallow candle of 6 to the lb. is not snuffed, it loses in intensity, in 30 minutes, 80 hundredths, and in 39 minutes 86 hundredths; in which dim state it remains stationary, yet still consuming nearly the same proportion of tallow. A wax candle attains to its greatest intensity of light when its wick has reached the greatest length, and begins to bend out of the flame. The reason of this difference is, that only the lower part of the wick in the tallow candle is charged with the fat, so as to emit luminiferous vapour, while the upper part remains dry; whereas, in the wax candle the combustible substance being less fusible and volatile, allows a greater length of the wick to be charged by capillary attraction, and of course to emit a longer train of light.

	Cwts.
Wax, bleached, *imported* in 1858 - -	1964
„ unbleached do. - - -	9679

	Cwts.	Declared real value. £
Wax *exported* in 1858 - - - -	1485	15,672

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. Its specific gravity varies from 0·94 to 0·97. Candles have been made of it 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. It is associated with variegated sandstone, rock salt, and beds of coal (lignite?). It is analogous to *hatchetine*. Ozocerite has been discovered at Urpeth colliery, near Newcastle, 60 fathoms beneath the surface.

WEAVING (*Tissage*, Fr.; *Weberei*, 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 chain of 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,

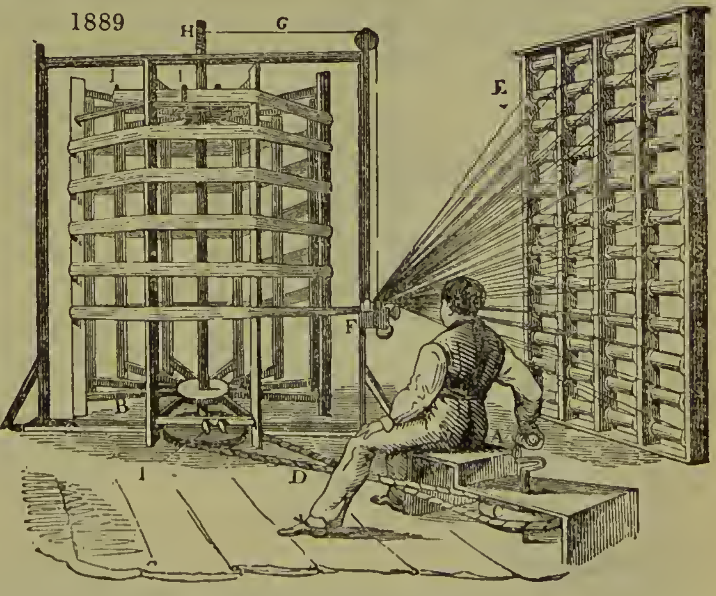
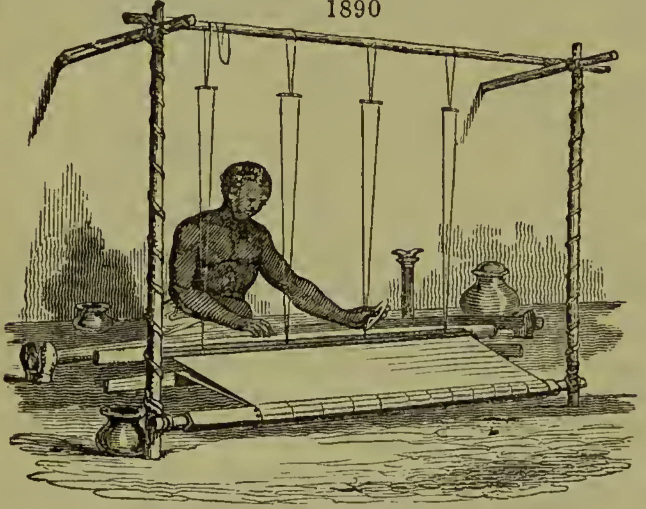


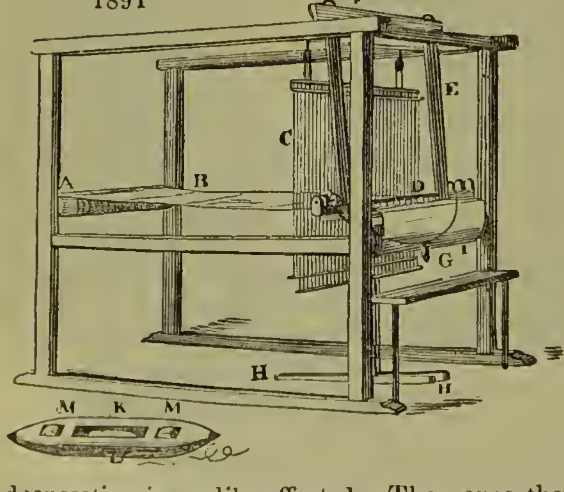
fig. 1889, and causes the reel B to revolve, by turning round with his hand the wheel C, with the endless rope or band D. The bobbins filled with yarn are placed in the frame E. There is a sliding pieee at F, ealled the *heck* box, whieh rises and falls by the eoiling and uneoiling of the cord G, round the eentral shaft of the reef H. By this simple eontrivanee the band of warp-yarns is wound spirally from top to bottom upon the reel. I, I, I, are wooden pins which separate the different bands. Most warping mules are of a prismatic form, having twelve, eighteen, or more sides. The reel is eommonly about six feet in diameter and seven feet in height, so as to serve for measuring exaetly upon its periphery the total length of the warp. All the threads from the frame E pass through the heek F, whieh eonsists of a series of finely-polished, hard-tempered steel pins, with a small hole at the upper part of eaeh to reeeive and guide one thread. The heek is divided into two parts, either of which may be lifted by a small handle below, while their eyes are plaeed alternately. Henee, when one of them is raised a little, a vaeuity is formed between the two bands of the warp; but when the other is raised the vaeuity is reversed. In this way the lease is produeed at eaeh end of the warp, and it is preserved by appropriate wooden pegs. The lease being earefully 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 suffieient number of yarns are eoiled round it to form the breadth that is wanted; the warper's prineipal eare being to tie immediately every thread as it breaks, otherwise defieiencies would be oeeasioned in the ehain, injurious to the appearanee of the web, or produetive of much annoyance to the weaver.

The simplest and probably the most aneient of looms now to be seen in aetion is that of the Hindu tanty, shown in *fig.* 1890. It consists of two bamboo rollers; one for the warp, and another for the woven eloth; with a pair of heddles, for parting the warp, to permit the weft to be drawn aeross 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 eondense eaeh sueeessive thread of weft, against the elosed fabrie. The Hindu earries this simple implement, with his water pitcher, riee pot, and hooka, to the foot of any tree whieh ean afford him a eomfortable shade; he there digs a large hole, to reeeive 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 distanee from eaeh other, with pins, into the sward; he attaehes the heddles to a convenient braneh of the tree overhead; inserts his great toes into two loops under the gear, to serve him for treddles; lastly, he sheds the warp, draws through the weft, and beats it elose up to the web with his rod shuttle or batten.

1890



1891



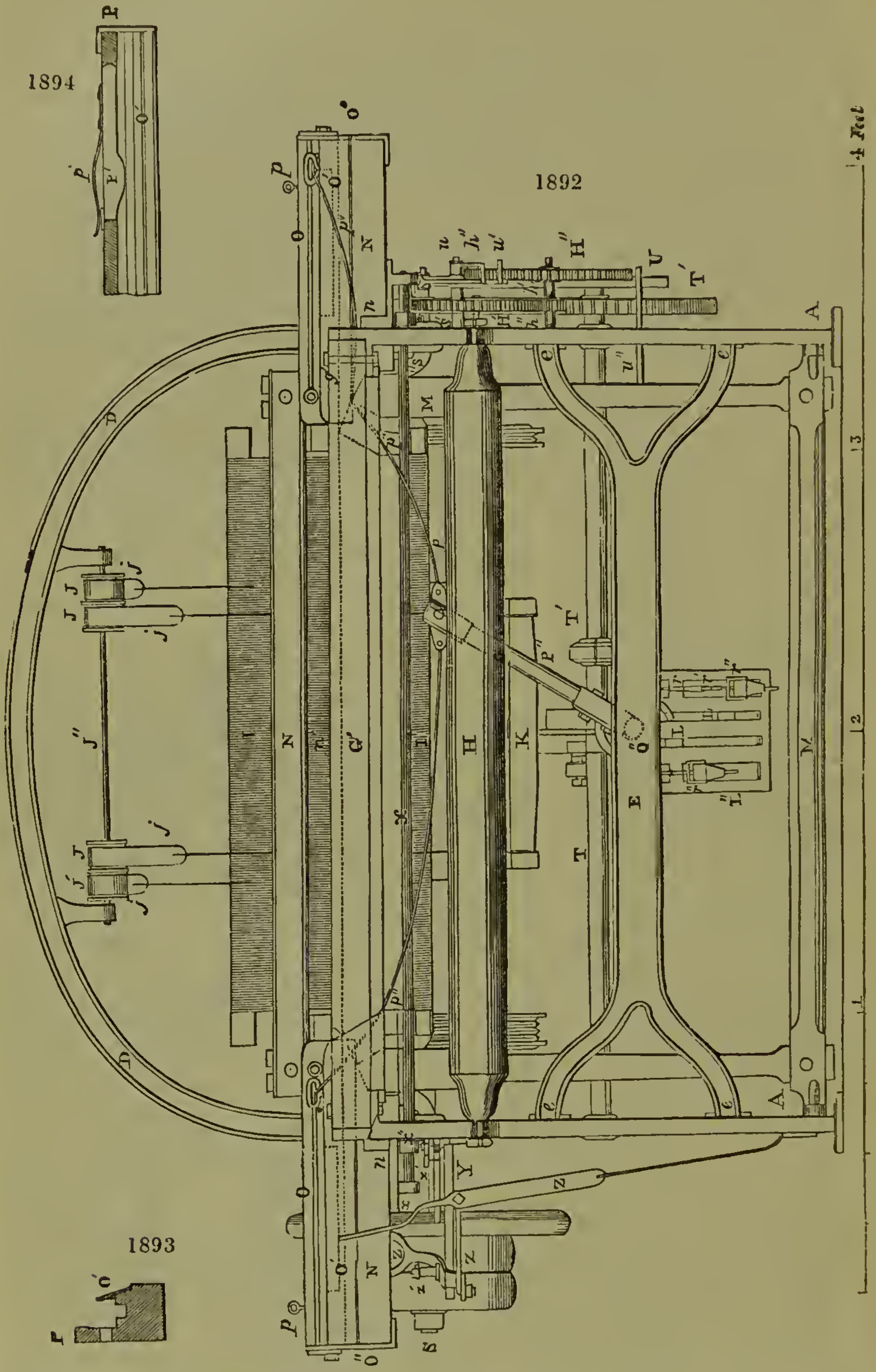
The European loom is represented in its plainest state, as it has existed for several eenturies, in *fig.* 1891. A is the warp-beam, round whieh the ehain has been wound; B represents the flat rods, usually three in number, whieh pass across between its threads, to preserve the lease, or the plane of deeussation for the weft; C shows the heddles or healds, eonsisting 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 baek one; by moving whieh, the decussation is readily effeeted. The yarns then pass through the dents of the reed under D, which is set in a movable swing-frame E, ealled 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.* 1892, 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. E, is the front cross-beam, terminating in the forks *e*, *e*; whose ends are bolted to the opposite standards A, A′, so as to bind the framework most firmly together. G′, 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*′. H, 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 H′. *k*′, is a pinion in geer with H′. H″, is a ratchet wheel, mounted upon the same shaft *h*‴, as the pinion *h*′. *h*′, is the click of the ratchet wheel H″. *h*‴, is a long bolt fixed to the frame, serving as a shaft to the ratchet wheel H″, and the pinion *h*′. I, is the front heddle-leaf, and I′, the back one. J, 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′, J′. K, 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*, *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 hand-loom 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 serve 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; P is the back of them. See *figs.* 1893 and 1894. O″, O″, are iron plates, forming the bottoms of the shuttle-boxes. *p*, small pegs or pins, planted in the posterior faces P (*fig.* 1892) of the boxes, round which the levers P′ turn. These levers are sunk in the substance of the faces P, turned round pegs *p*, being pressed from without inwards, by the springs *p*′. P″, *fig.* 1892, (to the right of K,) 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.* 1892) 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



1894 1892 1893

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 clink *h*″. 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 H″. *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 spring falls into a notch in the bar Y, and is thereby held at a distance from the upright A, as long as the band is upon the loose pulley *z*′; but when the spring bar is disengaged, it falls towards A, 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 E, and the eyes of the heddle leaves I, I′; 2, to throw the shuttle (see *fig.* 1891), by means of the whip lever P″, the driver cord *p*, and the peeker *o*; 3, to drive home the weft 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 H, by the click and toothed wheel mechanism at the right-hand side of the frame.

See COTTON, FLAX, TEXTILE FABRICS, &c.

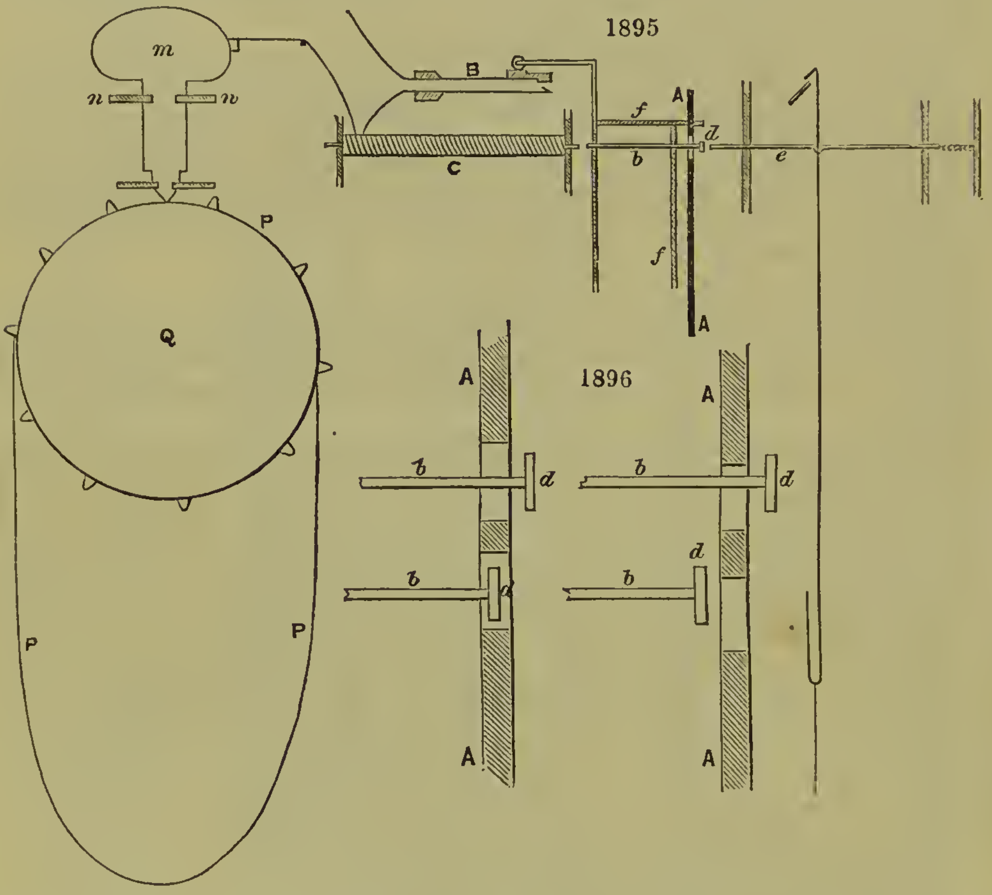
WEAVING BY ELECTRICITY. The article weaving, and those referred to from it, together with the article on the Jacquard loom, will render the conditions necessary to the production of figures in any textile fabric tolerably familiar. A brief notice of a new invention for employing electricity in weaving cannot fail to be interesting.

So long ago as 1852, M. Bonelli constructed an electric loom, which was exhibited at that time in Turin, but the first trial to which the machine was submitted gave but small hope to those who saw it that the inventor would succeed in his object. The public trial at Turin, in 1853, in the presence of manufacturers, was not so successful as to remove all doubts as to the merits of the novel apparatus. In the following year it was submitted to the judgment of the Academy of Sciences at Paris, who appointed a committee to examine it, but it is believed that no report was ever made. In 1855, a model of the loom had a place at the Universal Exhibition at Paris, but the lateness of its arrival there prevented any official report being made in reference to its merits. Since then, M. Bonelli has devoted much time and attention in endeavouring to remedy its defects and to perfect its working, so as to render it capable of holding its place in the factory. This M. Bonelli believes he has at last accomplished, and he has brought over to this country not merely a model, but a loom in complete working order, which he is prepared with confidence to submit to the judgment of manufacturers, as a machine which, from its economy and efficiency, may be put in favourable comparison with the Jacquard loom.

In the first place, it must be understood that the special object of M. Bonelli's machine is to do away with the necessity for the Jacquard cards used to produce the pattern at the present time, the source of delay and very considerable cost, more especially in patterns of any extent and variety of treatment. M. Bonelli uses an endless band of paper, of suitable width, the surface of which is covered with tin-foil. On this metallised surface, the required pattern is drawn, or rather painted with a brush in black varnish, rendering the parts thus covered non-conducting to a current of electricity. This band of paper, bearing the pattern, being caused to pass under a series of thin metal teeth, each of which is in connection with a small electro-magnet, it will readily be conceived that as the band passes under these teeth, a current of electricity from a galvanic battery may be made to pass through such of the teeth as rest on the metallised or conducting portion of the band, and from such teeth, through the respective coils, surrounding small bars of soft iron, thus rendering them temporary magnets, whilst no current passes through those connected with the teeth resting on the varnished portions. Thus, at every shift of the band, each electro-magnet in connection with the teeth becomes active or remains inactive according to the varying portion of the pattern which happens to be in contact with the teeth. In a movable frame opposite the ends of the electro-magnets, which, it should be stated, lie in a horizontal direction, are a series of small rods or pistons, as M. Bonelli terms them, the ends of which are respectively opposite to the ends of the electro-magnets. These pistons are capable of sliding horizontally in the frame, and pass through a plate attached to the front of it. When this frame is moved so that the ends of the pistons are brought into contact with the ends of the electro-magnets they are seized by such of them as are in an active state, and on moving the frame forward, those are retained while the others are carried back with it, and, by means of a simple mechanical arrangement, become fixed in their places; thus there is in front of the frame a plate, with holes, which are only open where the pistons have been withdrawn, and this plate, as will be readily understood, acts the part of the Jacquard card, and is suitable for receiving the steel needles which govern the hooks of the Jacquard in connection with the warp threads as ordinarily used.

The ordinary Jacquard cards are shown in the following wood-cut, *fig.* 1895.

Instead of this arrangement, which will be understood by reference to the article JACQUARD, M. Bonelli, as we have said, instead of the cards prepares his design on metal foil, in a resinous ink, which serves to interrupt the current, and thus effect the object of the machine.



Figs. 1895 and 1896 explain generally the arrangements by which the process is effected.

A, *fig.* 1896, represents the plate pierced with holes, which plays the part of the card. Each of the small pistons or rods, *b*, forming the armatures of the electro-magnets C, have a small head, *d*, affixed to the end, exactly opposite the needles, *e*, *fig.* 1895, of the Jacquard, and are capable of passing freely through the holes of the plate, A, *fig.* 1896. At a given moment the plate is slightly lowered, which prevents the heads of the pistons passing, and the surface of the plate then represents a plain card. The pistons are supported on a frame, *f f*, which allows them to move horizontally in the direction of their length. At each stroke of the shuttle, the frame, carrying with it the plate, A, has, by means of the treddle, a reciprocating motion backwards and forwards, and in its backward movement presents the ends of the pistons to one of the poles of the electro-magnets, and, by means of certain special contrivances, contact with the magnets is secured. When the frame, *f f*, returns with the plate A towards the needles of the Jacquard, the electro-magnets, which become temporarily magnetised by the electric current, hold back the pistons, the heads of which pass through the plate A, and rest behind it. On the other hand, the electro-magnets which are not magnetised, owing to the course of the current being interrupted, permit the other pistons to be carried back, their heads remaining outside the plate and in front of it. At this moment, the plate, by means of an inclined plane beneath it, is lowered slightly, thus preventing the heads of the pistons passing through the holes, by the edges of which they are stopped, so as to push against the needles of the Jacquard;

on the other hand, the heads of the pistons which have passed within and to the back of the plate, leave the corresponding holes of the plate free, and the needles of the Jacquard which are opposite to them are allowed to enter.

The electro-magnets are put into circuit in the following manner: One of the ends of the wire forming the coil of each of the magnets is joined to one common wire in connection with one of the poles of a galvanic battery. The other end of the coil wire of each magnet is attached to a thin metallic plate, *m*, having a point at its lower extremity. All these thin metallic plates are placed side by side, with an insulating material between them, formed like the teeth of a comb, *n n*. At a given time these thin plates rest with their lower extremities on the sheet bearing the design P, which, in the form of an endless band, is wrapped round and hangs upon the cylinder, Q, and according as the thin metal plate rests on a metallised or on a non-conducting portion of the design, the corresponding electro-magnet is or is not magnetised, and its corresponding piston does not or does press against the needle of the Jacquard. The wire from the other pole of the battery of course communicates with the band bearing the design, by being attached to a piece of metal, which lies in constant contact with the metallic edge of the band. At B is a contact-breaker, which is put in motion by the movement of the frame. Besides this, by means of a mechanical arrangement connected with the treddle, which raises or depresses the griff frame, the band bearing the design is carried forward at each stroke, and the rapidity with which it is made to travel can readily be regulated, by means of gearing, at the will of the workman. By regulating the speed of the band, and by the use of thicker or thinner weft, an alteration in the character of the woven material may be made, whilst the same design is produced, though in a finer or coarser material.

Such are the arrangements by which the loom will produce a damask pattern, or one arising from the use of two colours, one in the warp and the other in the weft. I will now shortly explain the method adopted by M. Bonelli for producing a pattern where several colours are required.

The design is prepared on the metallised paper, so that the coloured parts are re presented by the metallised portion of the band, but each separate colour is, by removing a very thin strip of the foil at the margin, insulated from its neighbouring colour. Then all the pieces of foil thus insulated, which represent one colour or shade, are connected with each other by means of small strips of tinfoil, which pierce through the paper and are fastened at the back, and are conducted to a strip of tinfoil which runs along the edge of the band, there being as many such strips of tinfoil as there are colours. Thus each special colour of the pattern, in all its parts, is connected by a conductor with its own separate strip of tinfoil, and by bringing the wire from the pole of the battery successively into contact with the several strips, a current of electricity may be made to pass in succession through the several parts of the design on the band representing the separate colours of the design. Thus, assuming four colours, 1, 2, 3, 4, there would be four strips of tinfoil running the length of the band, insulated from each other, each of which would be in connection with its own separate colour only. At any given moment, the thin plates of metal resting on the pattern would touch it in a line which, as it passes over the width of the pattern, would run through all, or any one or more of the colours, but the electric current would pass only through those plates which rest on the one colour represented by the strip with which the pole of the battery at that instant happened to be in contact.

The inventor claims the following as the results of his invention:—

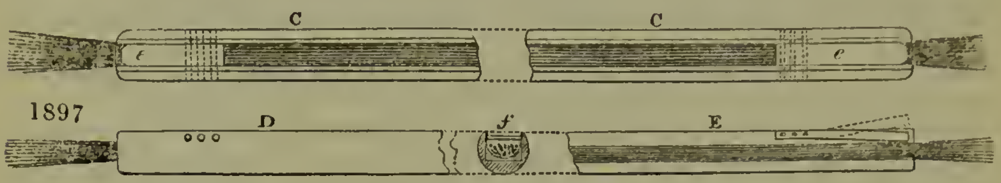
First.—The great facility with which in a very short time, and with precision, reductions of the pattern may be obtained on the fabric by means of the varying velocity with which the pattern may be passed under the teeth.

Second.—That without changing the mounting of the loom or the pattern, fabrics thinner or thicker can be produced by changing the number of the weft, and making a corresponding change in the movement of the pattern.

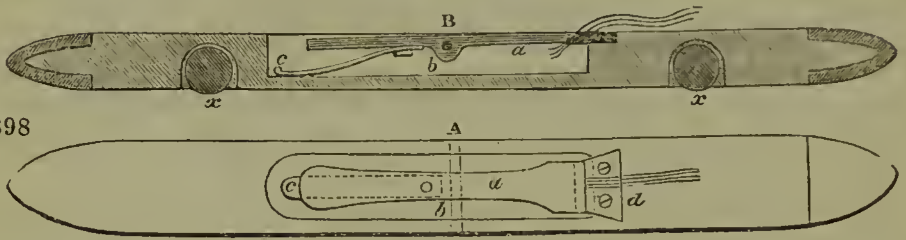
Third.—The loom and its mounting remaining unchanged, the design may be changed in a few minutes by the substitution of another metallised paper having a different pattern.

Fourth.—The power of getting rid of any part of the design if required, and of modifying the pattern.

WEAVING OF HAIR CLOTH, In addition to the description of this art under HAIR, a short notice is required of the best kind of shuttle for weaving hair. *Fig.* 1898 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



1897



1898

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.* 1897. C, C is the view of it from above or the plan; D is a side view; E 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 at each end. They are herein pressed down by elastic slips, *e*, of indiarubber, so that the others remain, when one or more are drawn out by the ends. The ends of the grooves are flat where the indiarubber spring exerts its pressure, as shown by the dotted line *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 E) 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, or DYER'S WEED (*Gande*, Fr.; *Wau*, Germ.) A biennial plant, native of Britain, Italy, and various parts of Europe; the *Reseda luteola* of Botanists. Weld is preferred to all other substances in giving the lively green lemon yellow to silk. Although the quercitron bark has almost superseded it in calico printing, weld is still largely used in dyeing silk a golden yellow, and in paper staining.

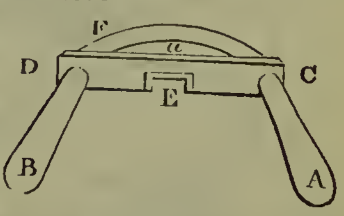
WELDING (*Souder*, Fr.; *Schweissen*, Germ.) is the property which pieces of wrought iron possess when heated to whiteness of uniting intimately under the hammer without any appearance of junction. See IRON.

WELLS, ARTESIAN. See ARTESIAN WELLS.

WHALEBONE (*Baleine*, Fr.; *Fischbeine*, Germ.) is the name of the horny laminæ, 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 scytheshaped 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.* 1899. A, B, are its two handles; C, D, is an iron plate, with a guide-notch E; F, 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 E, 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, B, 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.

1899



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.

Although all the species of Balæna possess this substance, it is furnished in the largest quantities, and of the finest quality, by the *Balæna 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 laminæ are arranged in two series, each containing about 300 in number.

WHALE OIL. See OILS.

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, we 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. 1900, 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. 1901, shows the arm of an axletree, turned perfectly true, with two collars in the solid, as seen at G and H. The parts from G to B are made cylindrical. At K is a screw nail, the purpose of which will be explained in *fig.* 1905.

1900

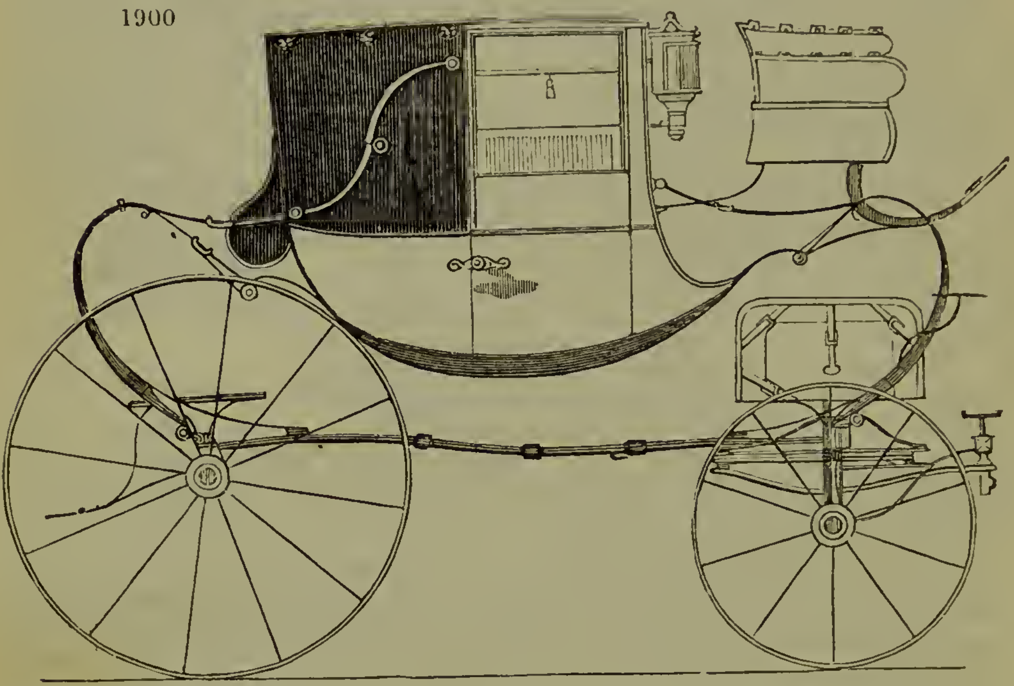
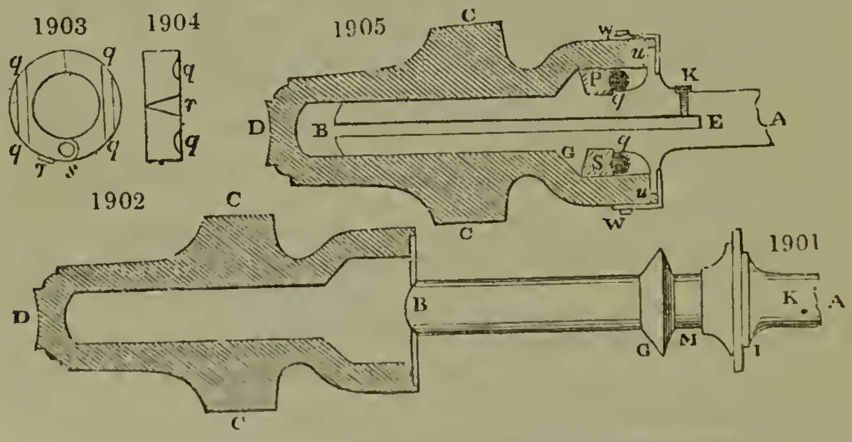


Fig. 1902 is a longitudinal section of a metal nave, which also forms the bush, for the better fitting of which to the axletree, it is bored out of the solid, and made quite air-tight upon the pin; and for retaining the oil it is left close at the out-head D.

Fig. 1903, represents a collet made of metal, turned perfectly true, the least diameter of which is made the same with that part of the axletree M, *fig.* 1901, and its greatest diameter the same with that of the solid collar G, *fig.* 1901. This collet is made with a joint at S, and opens at P. Two grooves are represented at *q q*, *q q*, which are seen at the same letters in *fig.* 1904, as also the dovetail *r*, in both figures.

Fig. 1904 is an edge view of the collet, *fig.* 1903.

Fig. 1905 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 B to E. C C D, the nave



which answers also for the bush. P S, the collet (see *figs.* 1903 and 1904) put into its place; *q*, *q*, 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 *q*, *q*, from getting out of their places. *u*, *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. K, is a screw, the head of which is near the letter K, in *fig.* 1901. 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 B, left by the arm being about 1 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 P, S, and the larger collar. The collet P, S, being movable round the axletree arm, and being made fast to the bush by means of the two pins *q*, *q*, revolves along with the bush, acting against the solid collar G, of the arm, and keeps the wheel fast to the axletree, until by removing the caped hoop W, W, and driving out the pins *q*, *q*, the collet becomes disengaged from the bush.

The dovetail, seen upon the collet at *r*, *fig.* 1904, 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.

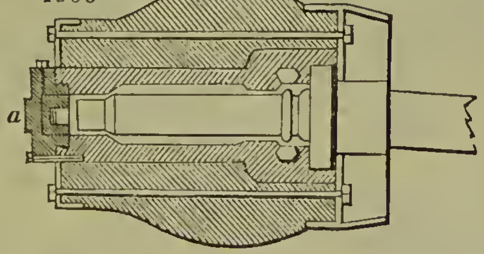
The spokes of the wheel, made of malleable iron, are screwed into the bush or nave at C, C, *figs.* 1902, 1905, all round. The felloes, composed merely of two bars of iron bent into a circle edgeways, are put on, the one on the front, the other on the back of the spokes, which have shoulders on both 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 clasping 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.

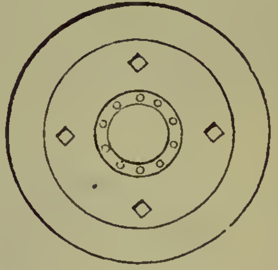
The design of Mr. W. Mason's patent invention, of 1827, is to give any required pressure to the ends of what are called mail axletrees, in order to prevent their shaking in the boxes of the wheels. This object is effected by the introduction of leather collars in certain parts of the box, and by a contrivance, 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. 1906 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.* 1907.

1906



1907



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.

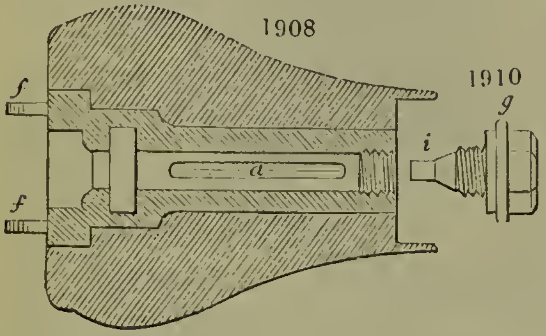
The particular claims of improvement are, the leather collar against the end of the axle; the pin going through one of the holes in the end of the box, to fix it; and the channel for conducting the oil.

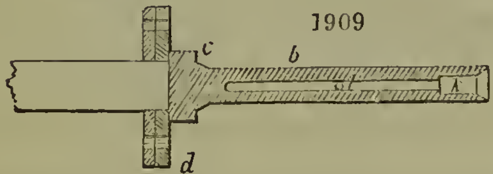
Mr. Mason's patent, of August 1830, applies also to the boxes and axles of that construction of carriage wheels which are fitted with the so-called mail-boxes; but part of the invention applies to other axles.

Fig. 1908 represents the nave of a wheel, with the box for the axle within it, both shown in section longitudinally; *fig.* 1909 is a section of the axle, taken in the same direction; and *fig.* 1910 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.

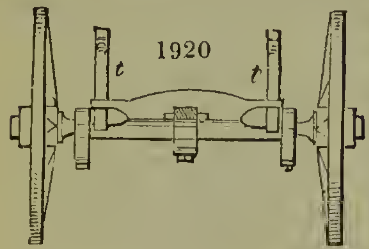
The cylindrical recess *a*, in the box of the nave, is designed to fit the cylindrical part of the axle *b*; and the conical part *c*, of the axle, to shoulder up against a corresponding conical cavity in the box, with a washer of leather to prevent its shaking. A collar *d*, formed by a metallic ring, 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 ends 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 or 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.


1908 1910

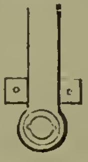

1909

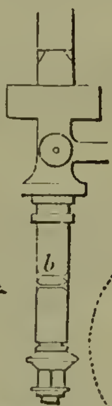
Mr. William Mason's patent invention for wheel carriages, of August 1831, will be understood by reference to the annexed figures. *Fig.* 1911 is a plan showing the four-axletree bed *a*, *a*, of a four-wheeled carriage, to which the axletrees *b*, *b*, are jointed at each end; *fig.* 1912 is an enlarged plan; and *fig.* 1913 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 in the plan view *fig.* 1914, and section, *fig.* 1915.


1920


1916


1915


1914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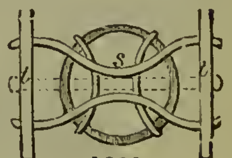
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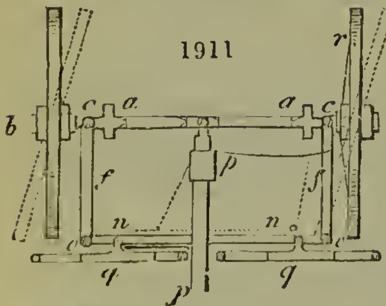
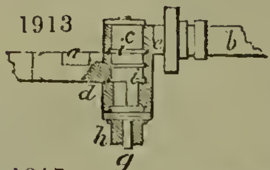

1911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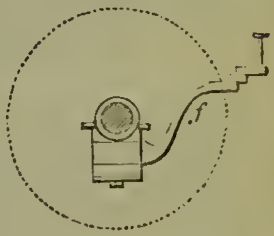
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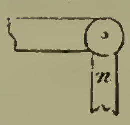
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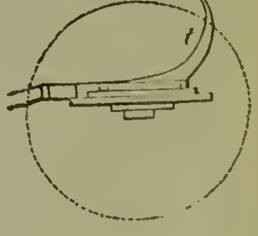
1918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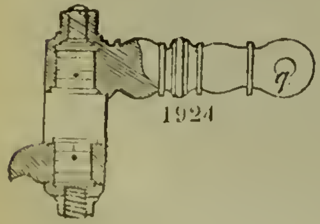
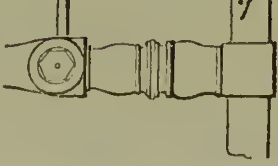

1924


1923

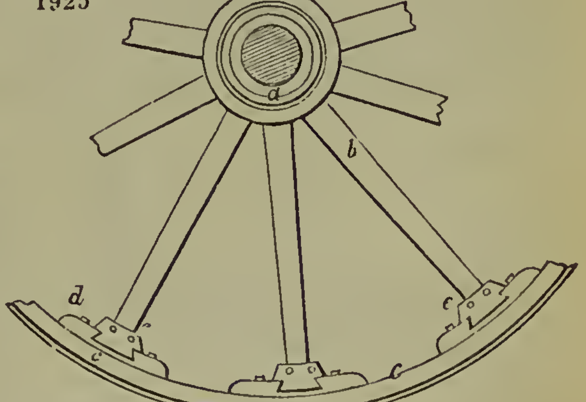
The axletree *b*, is firmly united with the upper end *c*, of the pin or bolt *c*; and to the lower end of it, which is squared, the guide piece *f*, is also fitted, and secured by the screw *g*, and cap or nut *h*, seen in *fig.* 1913, and in section in *fig.* 1916. There are leather washers *i*, *i*, 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.* 1916, 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.* 1914 and 1915. The guide piece *f*, is affixed at right angles with the axletree *b*, as shown in *fig.* 1912, 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.* 1911, 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.* 1915, as follows: — *Fig.* 1917 is a plan, and *fig.* 1918 a section of the joint *o*, in *fig.* 1911, shown on an enlarged scale; a cylindrical pin or bolt *c*, 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.* 1911, are likewise jointed in the same way to the splinter-bar. *Fig.* 1919 is a side view of these parts. The fore-wheels of the carriage, *fig.* 1911, 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, as and shown by dotted lines in the back end view thereof, *fig.* 1920; and the framing *s*, *fig.* 1921, 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.* 1920 and 1921, and likewise in the side view, *fig.* 1922. In certain cases it may be desirable to fix the cylindrical pin or bolt *c*, firmly in the splinter-bar *n*, in the manner shown in *figs.* 1923 and 1924; the swingletrees *q*, *q*, and guide pieces *f*, *f*, turning 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.

1925



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.* 1925 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, intended to be formed by one entire circle of wrought iron; *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.* 1926, by which it will be perceived that the end 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 recess formed in the block, and that it shall be made tight by a wedge driven in. The wedge piece is to be of wood, as *fig.* 1927, 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 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 tyre, 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.

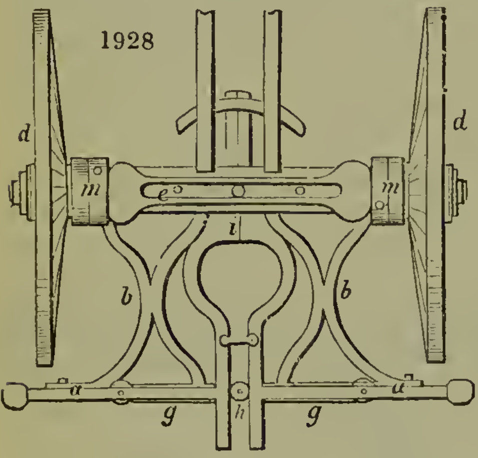
1926

1927

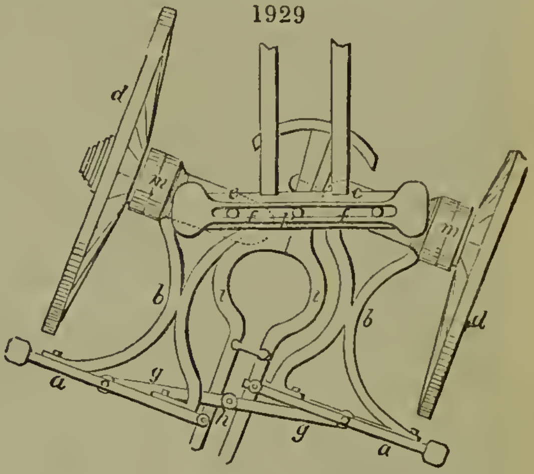
Mr. Reedhead's patent improvements in the construction of carriages are represented in the following figures. They were specified in July, 1833.

Fig. 1928 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.* 1929 is a similar view, showing the wheels as locked, when in the

1928

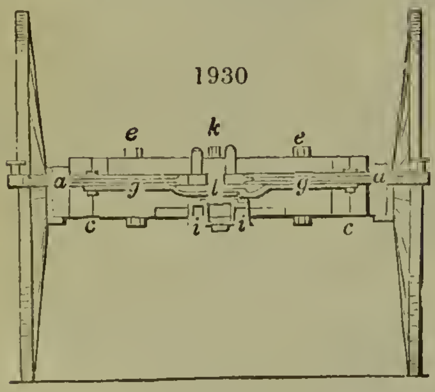


1929

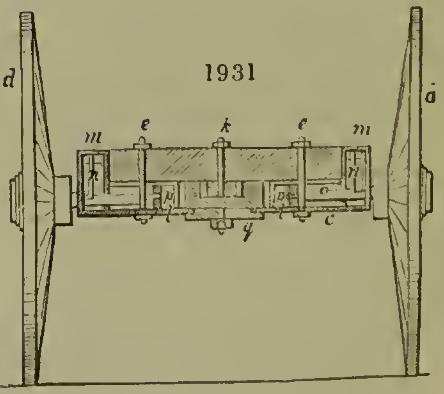


act of turning; *fig.* 1930 is a front end elevation of the same; *fig.* 1931 is a section taken through the centre of the fore axletree; and *fig.* 1932 is a side elevation of the general appearance of a stage coach, with the improvements appended; *a*, *a*, are two splinter-bars with their roller-bolts, 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

1930



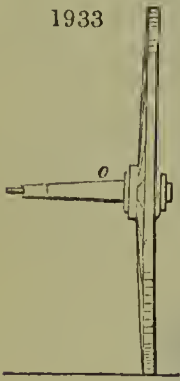
1931



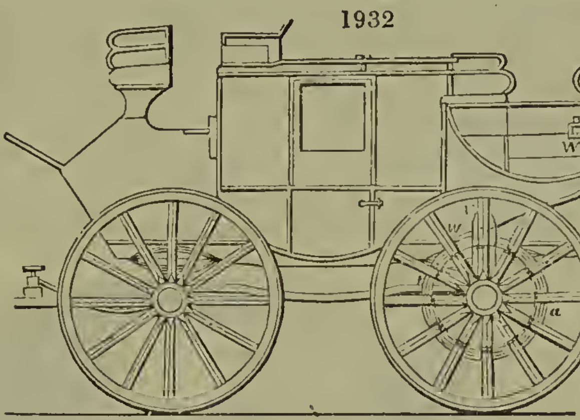
the locking of the wheels, as shown in *fig.* 1929; and in order that the two wheels and their axles and axle-boxes, together with the splinter-bars *a*, *a*, may move simultaneously, the latter are connected by pivots to the end of the links or levers *g*, *g*, which are attached to the arms *i*, *i*, which receive the pole of the coach by a hinge-joint or pin *h*; the arms *i*, *i*, turning on a vertical fulcrum-pin *k*, passed through the main axletree *f*, as the pole 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.* 1934, 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.* 1934 and 1933; 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

1933

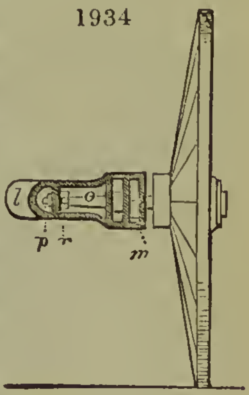


1932



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* 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.* 1934 is a plan or horizontal view of an axle and its box belonging to one of the fore wheels; a piece *q* is attached 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 axletree 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.* 1932, 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.* 1932, 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

1934



the horses in drawing the carriage, by which they are much relieved, and always pull in a direct and equal manner.

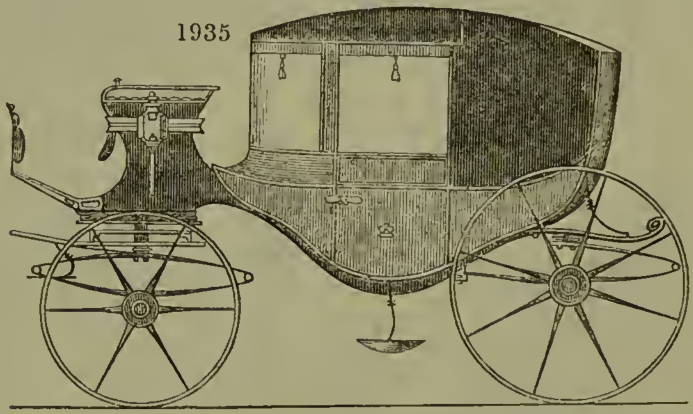
The advantages of these carriages may be thus summed up: — A great diminution of the total weight; a diminution of resistance in draught equal to about one-third; increase of safety to the riders; increased durability of the vehicle; absence of noise and vibration; absence of oscillation.

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.

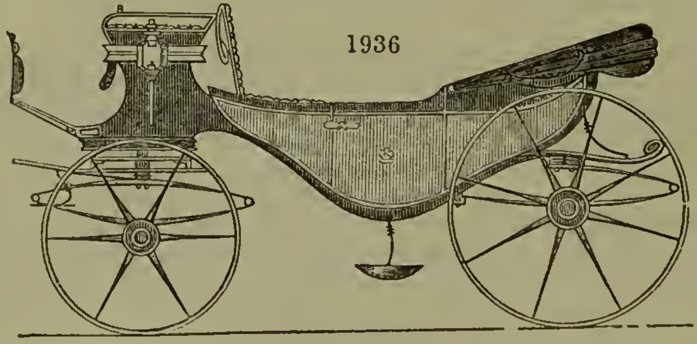
Among the wheel carriages displayed in the Exhibition, one of the most remarkable was the *amempton* (*unblamable*), of E. Kesterton, Long Acre. It is a close double-seated carriage, which by a simple contrivance can be converted into a light, open, step-piece barouche, adapted for summer and winter. *Fig.* 1935, represents the carriage

1935



closed, or what is termed the amempton, which can be readily converted into a step-piece barouche. *Fig.* 1936, is the carriage thrown completely open, and constructed

1936



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-grey 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 whetslate are brought from Turkey, called *hones*tones, which are in much esteem for sharpening steel instruments.

WHEY (*Petit lait*, Fr.; *Molken*, Germ.) is the greenish-grey 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.

WHISKY. A spirit obtained by distillation from corn, sugar, or molasses, though generally from the former. It is extensively manufactured and used in Scotland and in Ireland.

WHITE LEAD, *Carbonate of lead, or Ceruse.* (*Blanc de plomb*, Fr.; *Bleiweiss*, Germ.) This is the principal preparation of lead 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 described with precision by Marcel de Serres. The great white-lead establishments at Krems, whence, though incorrectly, the term *white of Kremnitz* became current, on the continent, have been abandoned.

In Germany the manufacture of white lead is conducted as follows:—

1. The lead mostly 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 a 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 thickness; 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 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.

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 sulphide.

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 20 inches long, and 8 or 9 broad. Several rows of these are placed over cylindrical glazed earthen pots, about 6 or 7 inches in diameter, containiug some wood-vinegar, which are then covered with planks and spent tan; above these pots another range is piled, and so in succession, to a convenient height. The whole are imbedded iu 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 8 or 9 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, has now ceased to be 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 iu a warm humid atmosphere, loaded with carbonic and acetic acids.

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. Brechoz and Leseur contrived the arrangements of this new method, which was subsequently executed on a great scale by MM. Roard and Brechoz.

A subacetate of lead is formed by digesting a cold solution of uncrystallised acetate, over litharge, with frequent agitation. It is said that 65 pounds of purified pyroligneous 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.

It is customary on the continent to mould the white lead into conical loaves, before sending it 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.

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 *infrâ.*

Mr. Ham proposed, in a patent dated June, 1826, to produce white lead with the aid of the following apparatus. *a, a, fig.* 1937, 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. We are not aware of what success has attended this patented arrangement. The heat prescribed is far too great.

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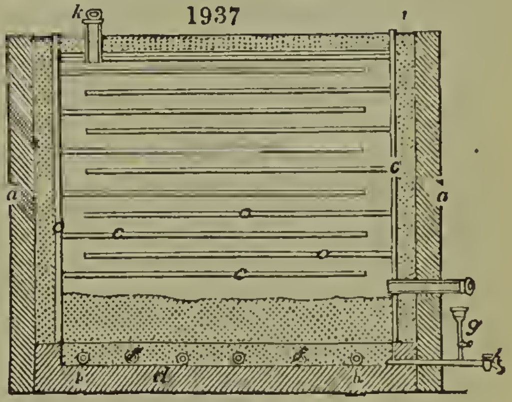


A factory was some years since erected at West Bromwich, near Birmingham, to work a patent lately granted to Messrs. Gossage and Benson, for making white lead by mixing a small quantity of acetate of lead in solution with slightly damped litharge, contained in a long stone trough, and passing over the 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. This 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. It is known 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 oxidised and carbonated. It is said that upwards of 100,000*l.* were expended at Chelsea, by a joint-stock company, in a factory constructed for executing the preceding most laborious and defective process; which had been many years before tried without success in Germany. 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 ten weeks, at less expense of labour than by any other plan.

The composition of the different varieties of white lead has been carefully examined by J. Arthur Phillips.* The result of this investigation shows that those specimens, which are obtained by precipitation from solutions of the nitrate by means of an alkaline carbonate, contain very variable quantities of oxide of lead, whilst in white lead prepared by the ordinary Dutch process, the relations existing between the amounts of carbonate and oxide, although definite, is usually very simple. The most usual composition of the white lead of commerce is represented by the formula $2PbO.CO^2 + PbO.HO$., although specimens represented by the formulæ $3PbO.CO^2 + PbO.HO$, and $5PbO.CO^2 + PbO.HO$ are also occasionally met with.

On examining the ordinary corroded leads in a finely divided state, by the aid of a powerful microscope, no traces of a crystalline structure will be perceived, but when precipitated specimens are subjected to a power of 300 diameters, distinct hexagonal plates become visible. These vary from $\frac{1}{5000}$th to $\frac{1}{10000}$th of an inch in diameter, and appear slightly yellow by transmitted light.

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 1 pound of acetic acid (and water) of spec. grav. 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 spec. grav. 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, but is very inferior to ordinary white lead.

Mr. Leigh, surgeon in Manchester, prepared 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.

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 feet long by $2\frac{1}{2}$ feet 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

* Journal of the Chemical Society, vol. iv. p. 145.

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 spec. grav. 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 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, othewise 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 8½ 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-slaked 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 sexbasic acetate of lead; and the next would be the destruction of this by eremacausis, and the formation of white lead.

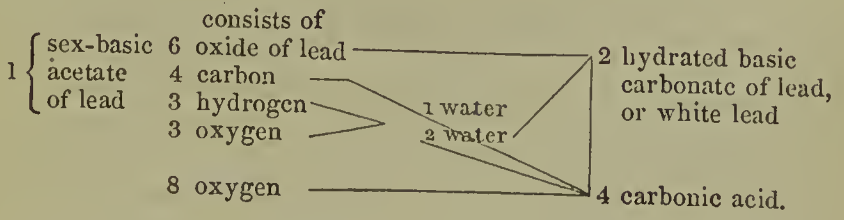
The apparatus employed in the manufacture of white lead is extremely simple, and consists merely of certain large enclosures or spaces, called beds, in which the stacks are built up, together with the earthenware pots needed for holding the vinegar, and the machinery used in casting the lead and grinding 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," 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 secresy 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.

In forming a stack, it is necessary to begin by laying, in the first instance, a bed of spent tanner's bark, 3 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 one foot only 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 substauce; whilst the tan, haviug 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," either by means of rollers or 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 eollected by elutriation and deposition, and dried in stoves, a little below the boiling point 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 30 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, aud 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 solution; and there are many analogous facts in chemistry that warrant the kind of eremacausis or combustion here hinted at. And presuming this to be correct, then one atom of the sex-basic 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 sometimes employed as a substitute for white lead. The oyxchloride 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 was made the subject of a patent by the late Mr. H. L. 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 paint made with an insoluble salt, like carbonate of lead, is preferable to one made with a soluble salt, like the chloride.

WHITING *exported* in 1858:—Cwts. 1485. Declared real value, 6850*l.*

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.

WINCING 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.

WINE is the fermented juice of the grape. This beverage has been in use from the earliest periods of man's history. We have, however, only space to deal with wine in its modern relations.

In the reign of Elizabeth the wines chiefly in use in England were those of Gascony, Burgundy, and Guienne, which with Canary, Cyprus, Grecian Malmsey, Italian Vernage, Rhenish Tent, Malaga, and others, were "accompted of, because of their strength and valure."

In the time of Charles II. "the consumption of French wines was two-fifths that of the whole of England." The favourite wines were then Bordeaux, Burgundy, and hermitage. Champagne, although known in England in the reign of Henry VIII., did not come into use till that of Charles II.

The strong wines of Burgundy, the white wines of Spain (*Sherris-sack* or *Sec*), and the red wines of Portugal, first came into use about 1690 A.D. Port wine was at first a much lighter wine than it afterwards became. According to Baron Forrester the first port wine introduced into this country was not from the Douro, or even shipped at Oporto. It was a wine resembling claret of Burgundy, from the Minho, shipped at Vienna.

The wine-growing countries are especially the more southern states of Europe, where the grapes, being more saccharine, afford a more abundant production of alcohol, and stronger wines, as exemplified in the best Port, Sherry, and Madeira. 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. Everywhere 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. In an essay on the soil and climate of the province of Biscay, by Don L. de Olazabal, an analysis of the soil of the left bank of the Nervion, in the district of Abando, is given.

Argil (silex, alumina, and oxide of iron) - - -	35·15
Broken and small flints - - - - - -	14·20
Carbonate of lime - - - - - -	40·09
Manure and vegetable soil - - - - -	10·16
	100·00

This analysis represents the general character of all the best wine growing districts; and 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.

For the vine, a manure supplying azotised or animal nutriment may be used with great advantage, provided care be taken 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 *animalised black,* of which from $\frac{1}{3}$ to $\frac{1}{2}$ of a litre (old English quart) serves sufficiently to fertilise 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 fruit of the same plant when transferred to a different soil loses its peculiar characteristics ; thus one and the same vine produces Hock upon the Rhine, Bucellas in Portugal, and Sercial at Madeira. It has been found that vines from Germany, France, Portugal, and Spain transplanted to the Cape of Good Hope and Australia have in no one instance produced wine assimilating to the peculiarities of the original plant ; and no European vine has hitherto succeeded when transplanted to the United States, although wine is made at Cincinnati from American grapes.

The finest known wines are the produce of soils the combination and proportions of whose ingredients are extremely rare and exceptional; and co-operating with these they require the agency of peculiar degrees of light, moisture, and heat. The richest wines of France, Italy, Hungary, Madeira, and Teneriffe are grown on the sites of extinct volcanoes. The district of Xeres, which has so long supplied us with Sherry, is mapped out so accurately by the line of its peculiar soil that its dimensions are known by the acre. The vine which produces Port on the hills above the Douro yields a totally different wine in the vicinity of the Tagus. The wine district of the Rhingau, between Mayence and Rudesheim, is but nine miles in length by half as much broad. The south side of a single hill produces Johannisberg; and Steinberg is the vineyard of a suppressed monastery. The numerous wines of Burgundy and the Garonne take their names respectively from circumscribed spots,h and so narrow and apparently so capricious are the respective limits, that a dite divides portions which from time immemorial have been sought with avidity, from others which in the market will uniformly bring but one-fifth the price. The produce of the celebrated vineyard of Lafitte, near Bordeaux, for the year 1848, was sold at 4000 francs per tun, while the wines of the immediate neighbourhood realised only 200 francs. The proprietor of a vineyard which is only separated from that of Lafitte by a narrow gully, a few years since expended a large sum of money in endeavouring, by improved cultivation, to assimilate his wines to that of Lafitte. To some extent he improved the quality, but the wines never approached the peculiar character of the Lafitte, while the expense incurred was so enormous that the enterprising proprietor was ruined. The costly *Clos Vougeot* grows in a farm of eighty acres. *Romanée Conti* is but six and a half, and the famous *Mont Rachet* of the Côte d'Or is distinguished into three classes, of which one sells at one-third less than the other two, "yet these qualities are produced from vineyards only separated from one another by a footpath; they have the same aspect, and apparently the same soil, in which the same vines are cultivated and managed in precisely the same manner."—(*Henderson on Wines.*) One small valley in Madeira alone produces the finest *Malmsey.* See Sir Emerson Tennent *On wine, its uses and taxation.* Art and horticultural science have, he remarks, been applied to extend the limits thus circumscribed by nature, but with such unsatisfactory results, that, as a rule, it may be stated that the higher class wine of any known district has not been successfully reproduced beyond it. The red wines of Portugal grown in the Alto Douro can no more be made in the adjoining provinces of the Minho or Beira than the white wines of Spain could be successfully imitated on the Rhine.

The vine disease.—The *Oidium Tuckeri* is the name given to this disease, Mr. Tucker having first carefully observed the growth of this destructive microscopic fungus. In connection with the cultivation of the vine, and the manufacture of wine, it is necessary that the peculiar characteristics of this disease should be described.

It is stated that the epidemic first showed itself in a hothouse in England in 1845. White efflorescences were remarked, which covered the vine; the grapes were soon after attacked, and, hindered from swelling, the skin burst, and at last they became rotten and fell off. In 1847 it appeared in France; attacking first the hothouses, it spread rapidly to the trellised vines, and to those cultivated near the ground. It then invaded Spain, which it devastated; and finally, in 1851, made its appearance in Italy. This fungus attacks the hinder parts of the vine, and rarely the stems. The leaves and tendrils also become more or less affected, the green colour of those parts becoming paler, and marked with a dark yellow, as if burnt, and emitting an offensive smell. It was fancied at first that the fungus was produced by the puncture of an insect, and its presence was actually ascertained in the seed of the grape, and on the hinder side of the leaf. This insect established itself on the leaves, and formed a cobweb-like film, rising like a blister on the upper part of the leaf. The birth of it is, however, now generally admitted to be posterior to the invasion of the *oidio.*

The *Reports of her Majesty's Secretaries of Embassy and Legation on the Effects of the Vine Disease on the Commerce of the Countries in which they reside,* all point to sulphur as the only reliable remedy for this disease. The most practical method of applying sulphur to the vines was that introduced by Dr. Ashby Price. By boiling sulphur and lime together in water we obtain a brilliant yellow solution, which is a sulphide of lime (*the quadrisulphuret of Dr. Dalton*); with a diluted solution of this the vines are washed over every part. By the action of the carbonic acid of the plant it is speedily decomposed, and over every part a thin white film of sulphur is produced, which effectually destroys the parasite without injuring the vine. See Forrester *on the Vine Disease in the Port-wine Districts of the Alto Douro,* in the *Transactions of the Royal Society for* 1854.

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. Sebille 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° Fahr. 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 spec. grav. 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 six or eight hours, if the temperature be above 50° Fahr., 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, 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, is avoided or rendered of little consequence.

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 alkalies, 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.*

PORTUGAL.— Port wine is the produce of a single well-defined district in the north of Portugal, extending 8 leagues west and east from the Serra do Marão, an elevation of 4400 feet above the level of the sea, to the Quinta da Baleira, near San Joao da Pesqueira, and 4 leagues north and south between Villa Real and Lamego. The return of the vintages in this area, known as the Alto Douro, from 1843 to 1851, show the average production of qualities fit for use in ordinary years to be 63,568 pipes, in addition to which there are 20,633 pipes of refuse, fit only for distillation; in all 84,211 pipes.

The alcoholic contents of port wine, as given by Brande, are:—

Port wine, maximum - - - -	23·92 alcohol.
,, minimum - - - -	19·82 ,,

Christison gives the alcoholic contents in volume as:—

Port wine, weak - - - - - -	18 alcohol.
,, average of seven kinds - - -	20 ,,
,, strong - - - - - - -	21 ,,

Red wine of a good character is grown in the vicinity of Figueira, and sometimes, in peculiar years, shipments have taken place from that port and from Aveiro for the English market.

Portugal, in addition to port wine and its congeners, yields a variety of other wines of a sound and good character; and at one time England consumed, though never very largely, the white wines of *Lisbon* and *Bucellas*, and the red wines of the Minho and Beira; but the taste for them changed; it was transferred to the drier and stronger-bodied wines of Spain, and their importation came to an end.

SPAIN.—The sherries of Spain have long been favourite wines in England and the United States. In 1840, Sir E. Tennent informs us, the consumption attained an average of 2,500,000 gallons, and in 1854 it had risen to 2,741,230 gallons.

Exports of wine from Spain to England.

	Pipes.	Value.		Pipes.	Value.
1850	39,407	£811,841	1854	42,062	£1,192,498
1851	39,493	750,360	1855	38,835	1,149,496
1852	2,809	14,935	1856	42,710	1,217,587
1853	44,943	1,283,316	1857	42,853	1,164,861

In the United States the consumption of sherry is rapidly increasing; and this is the case also in Russia. To meet this demand efforts have of late years been made to introduce Sicilian Marsala.

In the *Basque Provinces* a light wine, called *chacoli*, is produced, but not in large quantities. Mr. Lumley gives the value of the wines of this district as £17,072.

Alicante produced about 21,118 pipes of wine in 1857.

Valencia produced about 150,000 pipes of 100 gallons each.

Cadiz produces annually from 60,000 to 70,000 butts of new wine (*Mosto*) at about £7 per butt. The sherries exported from this district are never under three to four years old.

Barcelona is stated to produce 85,000,000 gallons.

Tarragona exports by sea about 35,000 butts, and a large portion is consumed in the province.

Malaga. Many kinds of grapes are cultivated in this province. The Pedro Ximen, Doradillo, and Don Bueno are cultivated entirely for the manufacture of wine. The Uvas de Parra or trellis vine, the Passa larga or bloom raisin grape, and the Loja, which is shipped green for England for table use, are cultivated for exportation as fruit. Of Malaga wine the annual produce is on the average about 20,000 butts. Three butts of Malaga wine yield one of brandy, while ten butts of French wine are required to produce the same quantity of spirit. This brandy is used to cure the wines.

Aragon produces a large quantity of wine, those which are most preferred being the wines of Campo de Cariñena. Many of the wine districts of Old Castile produce also large quantities of wine.

"At present many of the Spanish wines are not only so badly made that they will not keep for two years, but their quality is much injured from their being kept and transported in pig-skins."—*Correspondent of the Secretary of Legation at Madrid.*

In 1857 the total exportation of Spanish wines was as follows:—

	Pipes.	Value.	
England	42,853	£1,164,861	of which £647,467 was for common wine.
France	100,392	663,661	
Tuscany	22,410	114,285	
Sardinia	3,715	25,535	
Portugal	2,351	17,445	
Total	216,829	£2,602,876	

Spain produces an enormous quantity of wine which is not suitable for the English market. Mr. Porter estimated that, good, passable, and bad, it amounted to 120,000,000 gallons; but (says Sir E. Tennant) the testimony is concurrent that, except in Andalusia and a few other minor localities, its manufacture is so imperfect, its qualities so peculiar, and its flavour so extraordinary, from carelessness, dirt, and other causes, that it is not presentable in the English market. Dr. Gorman, in his evidence before the House of Commons Committee, says:—"No natural sherry comes to this country; no wine house will send it; the article you get is a mixed article; if they gave you the natural produce of Xeres it would not suit you; in all probability you would say it was an inferior wine; our taste is artificial, because we are not a wine-drinking people."

Brande gives the alcohol in sherry 18·37 the maximum, and 17·00 the minimum, while Christison gives the following result from his examination:—

Sherry, weak - - - - - - -	17 in volume.
„ average of 13 old wines - -	18 „
„ strong - - - - - -	20 „
„ Madre de Xeres - - - - -	21 „

The *Montillado* of Spain is a wine which appears to depend for its character on the soil, which is a white soil called *albariza*, containing 70 per cent. of carbonate of lime, with alumina, silica, and a little magnesia. The *Manzanilla* is the produce of the terrains rouges, or red earths, somewhat sandy.

Sicily, as producing the celebrated *Sicilian Marsala*, is perhaps next in importance. Marsala resembles ordinary sherry in many respects; it is, when good, a wholesome, and, as it is technically described in the trade, a *clean* wine. Of Marsala, Sicily produces not less than 2,143,370 gallons. Sicily also produces red wine, but of a very coarse quality.

Madeira and the Canaries produce a wine, the former under the name of the place of its production, being well known. Its consumption has never, however, been very large. The produce of the island has rarely exceeded 25,000 pipes. In 1854 we imported 42,874 gallons.

Cape of Good Hope.—*Cape wine* has never found much favour in this country. In 1854 we imported 275,382 gallons, whereas in 1825 we obtained 670,000 gallons. This wine is used to some extent in the manufacture of "British wines."

African port and sherry have lately been introduced to the English market; and, as the price has been remarkably low as compared with the Portuguese and Spanish wines, a large demand has been created; but there appears to be but little chance of any of those South African wines holding a place amongst us.

Before we proceed to the more important wines of France and Germany, we must say a few words on

The Catawba wine of the United States.—About the year 1826, "the Catawba," a native American grape, was first brought into notice by Major Adlum, who had found it growing in a garden at Georgetown, near Washington. This vine, which is derived from the wild fox grape, has gradually supplanted all others, and is now adopted, almost universally, throughout the United States for making wine. It imparts a very peculiar musty flavour to the wine, displeasing when first tasted to many palates; but this dislike is easily removed by habit, and the wine is much relished in Ohio and Missouri, where it sells readily at good prices.

About 3000 acres are cultivated as vineyards in the state of Ohio; 500 in Kentucky; 1000 in Indiana; 500 in Missouri; 500 in Illinois; 100 in Georgia; 300 in North Carolina, and 200 in South Carolina. It is calculated that at least 2,000,000 gallons of wine are now raised in the United States, the value of which may be taken at a dollar and half the gallon.

In the United States the wine-press is constructed much on the same principle as the ordinary screw cider-press. It has an iron screw 3 or 4 inches in diameter, in a strong, upright frame. A box platform, 6 or 7 feet square, of 3-inch plank, is wedged into heavy timbers, and in this a box to contain the mashed grapes is placed, the box being perforated with holes. Bands to fit loosely inside the box, and pieces of scantling to receive the pressure, complete the implement. The power is applied by a strong lever, and the juice runs out through a hole in the floor, and is led into the cellar beneath by means of india-rubber pipes. Before being subjected to pressure, the grapes are bruisedin a small wooden mill. When it is intended to make red wine, the grapes mashed by this process are allowed to stand for two or three days, and are then pressed, in order that the colouring matter in the skins may be absorbed by the grape juice or "must." An analysis of good Catawba wine by Dr. Chapman gave:—

Alcohol	11·5
Water	88·5
	100·0

Large quantities of sparkling wine are made at Cincinnati, and at St. Louis, in imitation of Champagne, and sold as sparkling Catawba.

Germany.—Bavaria, Wurtemburg, and Baden each produce wine in the utmost abundance. Prussia and Nassau supply us with *Rhenish* and *sparkling Moselle*. Hungary has been ever famed for *Tokay* and *Vins de liqueur*; Germany imports for her own use a larger quantity of wine of all sorts than she exports to all the rest of the world.—*Tennent.*

Austria.—The total average vintage in Austria is estimated at 158,986,000 florins =£3,974,650, while the value of the wine production amounts only to 40,000,000 florins, or about £1,000.000 sterling.

The exportations of wine from Austria were as follows for the years named:—

1850	109,713 eimers.	1854	107,803 eimers.
1851	78,840 „	1855	134,921 „
1852	81,793 „	1856	142,991 „
1853	94,329 „	1857	210,214 „

The Vienna eimer is equal to 56·6052 litre, or 1·760 pints English measure.

The Austrian wines are on the average but of middling quality, but there are some which can bear comparison with all but the very best Rhine, French, and Spanish wines. Of Hungarian wine a considerable quantity is sold in England as port wine. The principal wines of Austria are—

"*Red wines*," grown at Erlan, Carlowitz, Szeksard, Buda, Adelsberg, Villau, and St. André;

"*Schiller wines*," a pale, reddish-coloured wine, grown at Erlan and Carlowitz;

"*White wines*," grown at Pesth, Steinbruch-Berg, Totfaln, Moor, Teting, Vöslan, and Rust;

"*Wines of the first press*," grown at Rust and Oedenburg.

France. — The chief wine-growing districts of France are Provence, Languedoc, Roussillon, Auvergne, Bourgogne, Saintonge, and Champagne, the rich valleys of the Gard, Hérault, Garonne, Dordogne, the Loire and the Rhone, and the neighbouring departments as far as the Pyrénées, the Hautes Pyrénées, and the Pyrénées Orientales.

The average production of wine per annum is between 40,000,000 and 42,000,000 hectolitres (of 22·0096 gallons English).

Vinage means in French a certain quantity of brandy added to wine in its natural state: this being necessary to enable wines to resist the effect of removal for exportation, the law allows the addition of 5 litres of brandy to each hectolitre of wine, provided the alcoholic strength of the latter after the mixture does not exceed 21 per cent.; whatever there is above this limit is liable to the scale of taxation applicable to spirits. From experiments made with a view to prevent fraud, it has been ascertained that wines usually furnished to private consumers do not average more than 10 or 11 per cent. of alcohol; that those in the hands of the retail dealer average 16 or 17, while those delivered to wholesale firms contain from 22 to 24 per cent. In order to put a stop to this system, which defrauds both the Government and the consumer, the commissioners proposed to limit the alcoholic force of wines to 18 degrees only, and to authorise the operation of "vinage" only in the Departments of the Pyrénées Orientales, Aude, Hérault, Gard Bouches du Rhone, and Var.

As our Treaty of Commerce with France promises to open out a large trade in French wines, we think the remarks of Sir Emerson Tennent, although made five years since, bear strongly on the probable results of the present:—

"From Bordeaux, it is well known that little or no increase is to be looked for of claret, or of the more generous wines of the Gironde. The strong wines of Burgundy have long since ceased to be brought to England, among other causes from their inability to bear the sea voyage; and even in France their use has been gradually declining from a similar reason. They are easily injured by removal; and a damp cellar, or even the agitation occasioned by the rolling of a carriage along the streets, is sometimes sufficient to turn them sour. The produce of Champagne does not enter into calculation; and on the whole, the portion of France which is most relied on to meet the newly-created demand, is the district of Roussillon, including the departments of the Pyrénées Orientales and Hérault; whence of late years the Masdew, or spurious port, and Picardan, for adulterating sherry, have been imported into England. The vine on this northern side of the Pyrenees seems to participate in the character of the vintages of Portugal and Spain on their southern aspect; and the similarity has suggested the attempt to obtain a place for them in the English market; but failing to establish them in public favour, they have been gradually withdrawn from consumption under their own name, but continue to be introduced for the purpose of *blending* with other wines more familiar and popular.

"Very ample details of those endeavours to bring Masdew into use in this country were given by some wine merchants of experience who were examined as witnesses by the Committee of the House of Commons in 1852. The attempt was first made as a substitute for port-wine, at a moment when the exports were interrupted during the siege of Oporto in 1832; it was taken a little at first, but it obtained no permanent footing, and soon ceased to sell for domestic use.

"Those who have travelled in the south of France, pleased with the abundance of its ordinary wines, and the lowness of their cost, and amused by the novelty of drinking them on the place of growth, frequently return with an impression in their favour, and a supply for future use. But whether it be that they overlook the difference between tasting these low wines at home and under the charming climate in which they ripen, or whether the change which they perceive in their flavour is the result of a sea voyage, the taste proves but transient; their guests do not approve of the new wine; the fancy is soon satisfied; the adventure is not repeated; and the traveller relapses into his accustomed round of stronger wines.

"The evidence taken by the Committee of 1852 abounds in examples of the difficulty before adverted to of introducing a new wine, especially of a light and thin description, into use in the United Kingdom; and the most striking illustrations have been drawn from the wines of France. It was attested by some merchants of large experience that *every attempt made within the last half century to introduce a new wine of this character into use in these countries, has been an almost total failure;* although the experiment has been made with sound and pure wines at a cost greatly below the prevailing prices of port and sherry.

"One gentleman, Mr. Gassiot, stated that in 1825, on the reduction which then took place in the duty, he, firmly relying on the effect of that measure in leading to a consumption of light wines, imported low-priced wines from France, Figueiras and Colares from Portugal, Spanish red wine from Barcelona, and others from Italy and Sicily: but the entire speculation ended in failure and loss.

"Mr. Maxwell, another extensive importer, stated that in 1841 his house had made a large importation of light French wines on speculation; they were sent to Calais, 'after being a long while in the docks, thinking that as the English would not drink them, the French would; but it was a total loss; and the importers did not even get the price of the casks.'

"Mr. Carbonell tried to bring Masdew into use, but failed; and numerous other examples are recorded in the evidence, each singularly unsuccessful, the taste of this country hitherto being decidedly averse from all but wines of high flavours, full body, and strong spirituous character."

Sir E. Tennent concludes his remarks thus: —

"Bearing in mind the very limited area within which the existence of a suitable climate and soil permits the cultivation of those finer wines to be carried on, looking to the comparatively small supply which is capable of being produced, and the increasing demand, not only from the growing population of the old world, but amongst the 23,000,000 of North American citizens, and the new communities which the discovery of gold is distributing over the coasts of the Pacific, and the Continent and Islands of Australia, it is scarcely to be hoped that the reduction of duty in England will lead to a very large increased supply of wines *at present* shipped to us from France."

The following account of the principal French wines is condensed from Viscount Chelsea's Report on the *Effects of the Vine Disease.* He divides France into six principal districts.

1st. The southern, including Corsica, Roussillon, Languedoc, and Provence.

(*a.*) *Corsican.* Corsica produces both dry and sweet wines, but in quantities too small for exportation.

(*b.*) *Roussillon.* These wines are produced exclusively in the Department of the Pyrénées Orientales, which contains about 125,000 acres of vineyards. Sweet, dry, and ordinary wines are equally abundant. Strong, rich in colour, and being generous, they keep long, travel well, and are good for mixing with others. There are three recognised varieties, 1st, those of Banyuls, of Collioure, and of Port Vendres, red wines which generally improve with age; 2nd, those of Rivesaltes; the greater portion being ordinary wines of commerce, deep and brilliant in colour; 200 acres alone produce fine wines, as *Muscat, Manabes, Grenache, Malvoisie,* and *Rancio*; 3rd, Perpignay—the wines of this district will keep an indefinite time, and are sent to North and South America.

(*c.*) *Languedoc.* Under this name are included all the wines of the Hérault, Aude, and a part of Gard. The most important of these districts is that of Hérault, producing two kinds of wine—those for conversion into spirit and ordinary wines, which may be subdivided into red and white ordinary wines, fine red wine, white wines, dry and sweet, and Muscats.

Aude. This district produces a red wine at Limoux, and a white wine known by the name of Blanquette, which is nearly double the value of the preceding. Hérault is the most important wine country in the south of France; it is the largest producer of raw spirits in Europe. The red wines of Hérault are produced in the vineyards of St. George's d'Orques; these are generally heady.

The white wines of Picardan include both dry and sweet.

Muscat, Frontignan, and *Lunel.* The cultivation of these wines has considerably diminished of late years; they have less flavour and do not keep so well as those of Rive-saltes.

The vineyards of St. Gilles (Gard) produce a less delicate wine than those of Roussillon, but which serves to bring up the colour of other wines.

(*d.*) *Provence.* The wines of Provence have not the importance of those of Roussillon or of Languedoc. The chief growths of the region are—

1st. In the Var, that of *Gande* producing a fine wine, at first highly coloured and heady, but becoming dry with age.

2nd. That of Malgue, producing a wine which does not mature, but that bears the sea well.

3rd. That of Bandol, an excellent wine for export, improving much with age: it is sent to India, Brazil, and California.

In the Basses Alpes, the vineyards of Mécs yield a generous wine. In the Bouches du Rhône, Cassis produces the finest wines in the region, both red and white, much sought after by foreigners. The sour and flat wines of Roquevaire are little appreciated. The methods of cultivation are nearly the same in all the districts of the south of France. The soil is generally dug up before the vines are planted; in Roussillon only is this omitted, when the ground has been previously cultivated. In the latter, the operation of planting is carried on in January and February; in Languedoc it is put off until April.

With those varieties of the vine which produce the Muscat, it is the custom to rub off part of the buds. The vines are dressed four times during the first year, but afterwards only twice. They commence bearing in from three to four years. The grapes are pressed by the feet or between channelled rollers without being picked off the bunches. The wine is slightly sprinkled with lime or plaster of Paris when it is intended for commerce. It is allowed to ferment for ten, twenty, or even thirty days.

2nd. The south-eastern region, including Gard, Vancluse, Ardeche, Drôme, and Rhone. This region embraces all the lower part of the basin of the Rhone; the wines produced are generally known as wines of the Côte du Rhône.

(*a.*) That part of *Gard* which is included in this region produces, 1st, the red wine of *Tavel*—very dry and improving much by age—and the red wine of Lirac. 2nd. The sweet wines of *Chuselan*, wines of the finest quality, and those of *Orsan* and *St. Geniez*, of the second. The Gard also produces the ordinary wines of *St. Laurent-des-Arbres* and *Roquemaure.*

(*b.*) *Vaucluse.* The chief growths are the *Châteauneuf-du-Pape*, a very celebrated wine, and the growth of *La Nerthe*, which is decreasing both in quality and quantity; it is sent to Bordeaux and Burgundy, for the purpose of colouring other wines. In Vaucluse also are the vineyards of the *Château-Vieux*, of *Nettes*, and of *Etrel.*

(*c.*) *Ardeche* includes the famous vineyards of *St. Peray.* This white wine, when in a state of effervescence, almost equals Champagne, which, however, has more lightness, delicacy, and softness. It is sent to England, Germany, Belgium, and Holland. The best sparkling sort sells at 2 francs 50 centimes the bottle. There are also the vineyards of St. Jean, Comas, and St. Joseph. The sparkling wine of St. Peray is produced in the same way as Champagne.

(*d.*) *Drôme*. The *Hermitage*, the most famous vineyard in the Côte du Rhône, consists of only 140 hectares. It produces red wine, white wine, and "vins de paille" (straw-coloured); the other vineyards are *Larnage*, *Rochegude*, *Crozes*, and *Mercurol*, all of which wines are esteemed.

(*e.*) *Rhone*. The southern part of the Rhone produces wines very similar to the preceding. The best known are those of *Condrieux* and *St. Michel*.

The vineyards of the Hermitage are managed with great care; the soil is dry to the depth of a metre (39 inches); the leaves are picked off the vine, and it is dressed and tended five times a year during the first two years; the grapes are stripped off the stalks, and the fermentation lasts from fifteen to twenty days.

3rd. The eastern region is formed principally of the valley of the Saône.

(*a.*) *Beaujolais*, the *Mâconnais*, and the *Côte Chalonnaise*. These wines are delicate, light, well-flavoured, but not highly coloured; they are principally consumed in the interior of France. The principal growths are of *Chênas* and that of *Fleury*. The *Mâconnais* produces the highly esteemed white wine of *Ponilly*, a dry wine which keeps badly, and the red wine of *Romanèche*. The wines of *Côte Chalonnaise* are common wines, amongst which the *Mercurey* alone is remarkable.

(*b.*) *Haute Bourgogne*, consisting of the Côte d'Or, produces the most famous wines in Burgundy. The white wines of the Côte d'Or most known are those of *Montrachet*, very superior wines; of *Memsault*, very delicate, light, and with a delicious "bouquet;" and those of Blaquy. It is the red wines, however, which give preeminence to this district. Here grows the renowned *Volnay*, *Pomard*, *Beaune*, *Nuits*, more spirituous than the others, and which require to be kept five or six years in the wood; *Vosne*, *Romanée*, *Clos Vougert*, and *Chambertin*.

(*c.*) *Basse Bourgogne*. The wines of Lower Burgundy are brisk, delicate, and light, but too spirituous. The *Tonnerre* is fit for drinking after the third year, and the wines of *Auxerrois*, which are sooner matured. In Auxerrois also are the vineyards of *Chablis;* these white wines, so much esteemed for their lightness, are made in the early part of October, under the name of *Chablis*. A large quantity of other white wine from the neighbouring vineyards finds its way into the market. The wines of *Avallonais* and those of Joigny are sent into Flanders and Belgium.

(*d.*) *Jura*. The wines of this district are in general dry, heady, brisk, but with some acidity, which arises from their bad cultivation and the unskilful mixture of the vines, and reduces their reputation. In addition to the inferior wines the Jura produces also rose-coloured wines ("*Vins Rosés*"); these are sparkling wines, and the luscious wine known under the name of "*Vin de Garde du Château Chalons*." This vineyard only comprises 96 hectares. The wines produced there require to be kept from twelve to fifteen years in the cask. All these wines are consumed where they are grown, or sent to Switzerland.

(*e.*) *Alsace* produces only common wine, with the exception of the *Turchemi* and *Ribeauviller*.

(*f.*) *Lorraine*. The principal growths are those of *Thiancourt*, *Pagny*, and *Sey*.

(*g.*) *Champagne*. The wines of the Department of the Marne, known under the name of *Champagne*, have a universal reputation, and form one of the principal products of France.

Champagne Wines are divided into four categories —

Sparkling Granot.	*Half Sparkling.*
Ordinary Sparkling.	*Tisane de Champagne.*

The following are the principal growths: —

On the Marne.	By the Avise.	On the Mountains of Rheims.
Mareuil.	*Avise.*	*Bowzy.*
Ay.	*Cramant.*	*Ambonnay.*
Hautvillers.	*Oger.*	*Mailly.*
Epernay.	*Mesnil.*	*Sillery.*
		Romont.

The most esteemed kinds are the *Sillery*, *Ay*, *Cramant*, and *Bowzy*. In good seasons this district does not produce less than 15,000,000 bottles of white wine. The average produce is 7,000,000, of which 6,000,000 are sent to England, Russia, and Germany.

The methods employed in Lower Burgundy and Champagne are nearly the same. It is not as respects the cultivation of the plant, but in the methods adopted in making the wine, that the latter is remarkable.

In the manufacture of Champagne 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 is 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 marc 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 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. Viscount Chelsea says, "The wine is bottled between April and August. Warm weather is necessary to produce the sparkling wine. The effervescence is the result of carbonic acid gas produced by fermentation, which being interrupted in the cask, reproduces and developes itself in the bottles. For this a temperature of from 70° to 75° Fahr. are required. The bottles, as soon as they are filled, which process is effected by women, are handed over to men called 'boucheurs,' who add a certain quantity of a mixture of brandy and sugar candy (in the proportion of 15 to 16 per cent. for those wines intended for the English market), taking care to leave about 2½ to 3 inches space between the cork and the wine; they then introduce by a machine a moistened cork, and pass the bottle on to other men called 'maillochers,' whose business it is to drive the cork home with a mallet, who again transfer them to those who fasten them with a string or wire; sometimes this is done by a machine. It takes an hour to bottle a tun of 88 gallons. The bottles are ranged against the cellar walls in horizontal layers, each being reversed as it regards the previous layer. Eight or ten days afterwards a deposit called '*griffe*' is found at the bottom of the bottle. This indicates the time for removing the bottles to the second or permanent cellar; this is the period also when breakage commences. This loss can neither be foreseen nor prevented, and is often dangerous; it happens mostly at the season when the vine blossoms. The bottles are first placed in the coldest cellars and afterwards removed to warmer temperatures. In the second winter means are taken to remove the deposit formed in the summer; the bottles are placed with their mouths downwards, and are shaken for twenty days, to cause the sediment to fall into the neck. At the end of this time the bottle is uncorked, the sediment thrown out, and a fifth part of the contents replaced by the sweetened liquor, when the bottles are again corked, tied, and stacked as before." 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 from 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.

(4.) *Central Region.* In the five departments comprised in this district the common wines alone are produced; the white wine of *Pouilly* being the only celebrated one.

(5.) *Western Region.* The two departments lying on the banks of the Loire, Indre and Loire, and Maine and Loire, possess 40,000 hectares of vineyards; the principal growths are those of *Joué*, *Bourgueil*, *Vouvray*, and the white wine of *Saumur*. More than 2,000,000 hectolitres of wine are annually devoted in Aunis, Saintonge, and Angoumis, to the distillation of brandy, so well known as *Cognac*. Of the 200,000 hectares of vineyards in the Charente and Charente Inferior, only one third is cultivated for home consumption or exportation, the remaining two-thirds is employed in making brandy. This is divided into two classes, that which is produced in the plain of Champagne in the arrondissement of Cognac, which is again divided according to quality into *Champagne* fine and common *Champagne de Bois*, and *Eau de Vie de Bois*, and that of Annis, produced from the vines on the banks of the river.

(6.) *South-Western District.* The Gironde and Jurançon are the only localities of any special interest. Although the wines of the Gironde have a common origin, they are divided in commerce into five great classes, *Medoc, De Graves, Des Côtes, Palus*, and "*D'Entre Deux-mer.*"

Medoc is the name given to a tongue of land to the north-west of Bordeaux, and lying between Gironde and the ocean. Of all kinds of *Medoc* wines, about 40,000 tuns are made annually: 4500 tuns of superior quality, 4500 tuns of fine wines, 31,000 of common wines. They are distinguished as choice ("grand vins," or "vins classés"), "*Bourgeois,*" and "*Paysan.*"

The "grand vins" are subdivided into five classes, according to their different degrees of delicacy and quality.

The 1st of these comprises only the three famous growths of *Château Margaux, Château Lafitte*, and *Château Latour.*

Medoc wines are sent to all parts of Europe, but chiefly to England and Russia; the first growths are reserved for England, but are mixed before exportation with Hermitage.

The 2nd, "*Vins de Graves,*" produced on the plains around Bordeaux. These wines are more powerful, more highly coloured, and more spirituous than the growths of Medoc; they have a different flavour, and less "bouquet." The white wines of the district have a universal reputation. The principal growth of red wine is *Château-haut-Brion*, which comes immediately after Château Margaux, Lafitte, &c., for richness; *Barjac, Beaumes*, and *Sauterne* are fine transparent white wines much in demand abroad. *Sauterne* produces from 500 to 800 tuns; *Château Yguem* is its best growth.

The 3rd, "*Vins de Côtes,*" is the name given to the wines grown on the left bank of the Garonne.

The most celebrated wine is *St. Emilion.*

The 4th, "*Vins de Palus,*" grown in the moist sands of the Gironde, are very highly coloured and spirituous, but wanting in body and briskness.

The other wines, *Bergerac*, "*Vin de tables,*" the wines of Jurançon, and the red wines of *Gaillac* and "Cahors," require only to be enumerated.

The red wines of Gaillac are high coloured, strong, and spirituous, and are much in demand for mixing with other wines; the red wines of Cahors are used principally for the same purpose.

Such is a somewhat concise statement of the varieties of wines known in commerce. It is not possible to enter into all the details of the manufacture, varying as it does in every locality,—the numerous peculiarities being due in some cases to the conditions of the grape itself, and in others to the methods pursued with regard to the fermentation and the subsequent treatment of the wine.

There are many persons who confound the "flavour" of wine with the "bouquet." The differences are well determined by the writer on wine in the *Penny Cyclopedia.* "The flavour of wine, called by the French *sève*, indicates the vinous power and the aromatic savour which are felt in the act of swallowing the wine, embalming the mouth, and continuing to be felt after the passage of the liquor. It seems to consist of the impression made by the alcohol and the aromatic particles which are liberated and volatilised as soon as the wine receives the warmth of the mouth and stomach. The sève differs from the *bouquet*, inasmuch as the latter declares itself the moment the wine is exposed to the air; it is no criterion of the vinous force or quantity of alcohol present (being in fact greatest in weak wines), and influences the organ of smell rather than of taste."

The *bouquet* of wine is a new product, and in no way dependent on the perfume of the grape from which the wine is made. Red wines scarcely ever retain a trace of the odour of the grapes; the white muscadine wines do in some degree, especially *Frontignan.*

Liebig, in his *Organic Chemistry*, has the following remarks on the *bouquet.* "It is well known that wine and fermented liquors generally contain, in addition to alcohol, other substances which could not be detected before their fermentation, and which must therefore have been formed during that process. The smell and taste which distinguish wine from all other fermented liquids are known to depend upon an ether of a volatile and highly combustible acid, which is of an oily nature, and to which the name of *Œnanthic Æther* has been given." (See *Chemistry of Wine*, by G. J. Mulder, edited by H. Bence Jones, M.D. F.R.S.; and *Ure's Dictionary of Chemistry.*)

On the Rhine an artificial *bouquet* is often given to wine for fraudulent purposes, by hanging orris-root in the casks, or by the use of aromatic herbs.

The volatile substance existing in wine which imparts to it, conjointly with œnanthic ether, its vinous aroma, is partly alcohol. There are other odoriferous substances developed in the course of time; these are compounds of oxide of ethyl, amyl, or propylene, with acetic, propionic, pelargonic, butyric, caproic, caprylic or capric acids.

Acetic ether is present in all aromatic wines, and fraudulent dealers will add acetic ether in small quantities to their artificial compounds.

Butyric ether is much used by confectioners, who call it pine-apple oil. *Caprylic ether* has a similar flavour; these are slowly developed in some wines by time. In Ure's *Dictionary of Chemistry* the other chemical compounds will be fully described. For a very clear account of the processes by which these odoriferous substances are formed in wine, *The Chemistry of Wine*, by G. J. Mulder, edited by Bence Jones, should be consulted.

Wine produced from grape juice alone is perfectly colourless or white; but as the whole mass of the grapes is pressed together, it is impossible but that some admixture of the components of the grape skins should occur. White wine may be prepared from purple grapes, but if the skins are allowed to ferment, red or yellow wine will be obtained. The Italian wine, *Vino Cebedino*, is about the most colourless of wines.

The colour in wines appears to be due to the presence of extractive matter, which, when oxidised, assumes a red or brown colour. This colouring matter has been called *apothema* by Berzelius, but it is, in fact, humic acid, retaining traces of the substance from which it has been derived. Müller supposes the humic acid of the grape to be apocrenic acid. If wine be evaporated before fermentation, apothema will form in it very quickly, and the colour of the wine become actually brown. Boiled wines—so called on account of the evaporation they undergo—such as Malaga, Tinto, &c., are thus rendered brown.

Whilst the juice of grapes ferments, the skins being present, the wine which is in process of formation extracts tannic acid from the skins, and this gives the yellow colour —when by oxidation it is converted into apothema—to Muscadel, Champagne, Teneriffe, and Madeira.

What we call red wines are prepared from either black, purple, or red grapes, the juice of which is colourless, and the skins of which are allowed to ferment. During fermentation the weak spirit which is formed extracts not only tannic acid but blue colouring matter from the skins. This blue colouring matter is tinged more or less red by the tartaric acid of the wine, and may afterwards be rendered more decidedly red by the formation of acetic acid. In the change of colour undergone by red wine, five periods, according to Mulder, must be distinguished. As soon as alcoholic liquid is formed during fermentation, blue colouring matter begins to be extracted from the skins. As the small amount of blue colouring matter is brought into contact with grape juice, which has an acid reaction, it becomes red. The fermentation and formation of alcohol proceed, as does also the solution of blue colouring matter, and the young wine is rather blue than red, and may be called dark violet. This new wine now undergoes fermentation, during which a great deal of colouring matter and red tartar, as well as apothema of tannin and albumen, is precipitated. The loss of the colouring matter causes the wine to become lighter. In the meantime the formation of acetic acid begins, and at a later period increases; the amount of colouring matter is not thereby diminished, but the larger proportion of acid in the liquid reddens its colour. Another period now begins, during which the tannic acid is slowly converted into apothema, whereby red colouring matter is again precipitated out of the liquid, for example, in Port wine; it thus gradually diminishes, and finally, after a length of time, disappears entirely from the wine, which then remains what is called yellow. This will explain the alterations produced by keeping wines.

According to the character of the wine, as already stated, is its power of enduring unchanged, or of improving by age.

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 faucet 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 1000th part of sulphite of lime; and a third, and perhaps the safest, is to introduce $\frac{1}{2}$ a lb. of mustard-seed into each barrel. At anyrate 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 viscidity 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 1 lb., 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.

The quantity of alcohol contained in different wines has been made the subject of elaborate experiments by Brande and Fontenelle, and several others; 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 refrigeratory, 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 100 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 Brande (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 III. on page 1037 gives the alcoholic strength of the Rhine wines.

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 0·825.	Absolute Alcohol.			Alcohol of 0·825.	Absolute Alcohol.
Port Wine	0·97616	21·40	19·82	Frontignac	0·98452	17·79	11·84
Do.	0·97200	25 83	23·92	Cote-Roti	0·98495	12·27	11·36
Mean	0·97460	23·49	21·75	Roussillon	0·98005	17·24	15·96
Madeira	0·97810	19·34	17·91	Cape Madeira	0·97924	18·11	16·77
Do.	0·97333	21·42	22·61	Muscat	0·97913	18·25	17·00
Sherry	0·97913	18·25	17·00	Constantia	0·97770	19·75	18·29
Do.	0·97700	19·83	18·37	Tinto	0·98399	13·30	12·32
Bordeaux, Claret	0·97410	12·91	11·95	Schiraz	0·98176	15·52	4·35
Do.	0·97092	16·32	15·11	Syracuse	0·98200	15·28	4·15
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	17·26	15 98	Raisin wine	0·97205	25·77	23·86
Bucellas	0·97890	18·49	17·22	Drained grape wine	0·97925	18·11	16 77
Red Madeira	0 97899	18·40	17·04	Lachrymæ Christi	—	19·70	18·24
Malmsey	0·98090	16·40	15·91	Currant wine	0·97696	20·55	19·03
Marsala	0·98190	15·26	14·31	Gooseberry wine	0·98550	11·84	10·96
Do.	0·98000	17·26	15·98	Elder wine			
Champagne (rose)	0 98608	11·30	10·46	Cyder	0·98760	9·87	9·14
Do. (white)	0·98450	12 80	11·84	Perry			
Burgundy	0·98300	14·53	13·34	Brown stout	0·99116	6·80	6·30
Do.	0·98540	11·95	11·06	Ale	0·98873	8·88	8·00
White Hermitage	0·97990	17·43	16·14	Porter	—	4·20	3·89
Red do.	0·98495	12·32	11·40	Rum	0·93494	53·68	49·71
Hock	0·98290	14·37	13·31	Hollands	0·93855	51·60	47·77
Do.	0·98873	8·88	8·00	Scotch whisky	—	54·32	50·20
Vin de Grave	0·98450	12·80	11·84	Irish whisky	—	53·90	49·91

TABLE II.

Name of the Wine.	Absolute Alcohol.	Name of the Wine.	Absolute Alcohol.	Name of the Wine.	Absolute Alcohol.
Roussillon (Eastern		Sijeau 8 yrs. old	8·635	Montpellier 5 yrs. old	7·413
Pyrenees.)		Narbonne 8	8·379	Lunel 8	7·564
Rive-saltes 18 yrs. old	9·156	Lezignan 10	8·173	Frontignan 5	7·098
Banyulls 18	9·223	Mirepeisset 10	8·589	Red Hermitage 4	5·838
Collyouvre 15	9·080	Carcassonne 8	7·190	White do.	7·056
Salces 10	8·580			Burgundy 4	6·195
		Department of l'Hé-		Grave 3	5·838
Department of the		*rault.*		Champagne (sprklng.)	5·880
Aude.		Nissau 9	7·896	Do. white do.	5·145
Fitou and		Beziers 8	7·728	Do. rose	4 956
Leucaté 10	8·568	Montagnac 10	8·108	Bordeaux	6·186
Lapalme 10	8·790	Mèze 10	7·812	Toulouse	5·027

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 proeess, as well as during the storing, depend the taste aud principal qualities.

TABLE III.—RHINE WINES.

Place of Growth.	Sort of Grapes.	Spec. Grav.	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 determined	12·10	not determined
Eisler, Kleimberger -	- -	- -	11·90	—
Wiesbaden Neroberg - -	- -	0·9950	10·83	2·78
Wiesloch - - -	- -	0·9945	9·83	2·48

Port is one of the wines which is richest in alcohol. Ginjal has stated that genuine port wines never contain more than 12·75 per cent. of pure alcohol, and is of opinion that those who discover more in such wines, either analysed a wine which had been adulterated with alcohol, or were unable to determine accurately the strength of the alcohol. It is difficult to pronouuce on this opinion out of Portugal. How is it that all who have analysed port wine have found from 17 to 21 per cent. of alcohol? Is there no wine but such as is adultcrated with alcohol exported from Portugal? and does port wine, which is recognised as the strongest wine in the eountry which produces it, really belong to those not very strong wines which only eontain 13 per cent. alcohol?

With regard to alcoholic contents, Madeira ranks next to port wine, in which respect they differ but little from each other. Liquor wines are as a rule stronger than red wines. Jurançon, Lachrymæ Christi, Benicario, and Santerne, all contain from 12 to 15 per cent. alcohol and more. Red French wines eontain less—from 9 to 14 per cent. Good Bordeaux contains 10, 11, 12 per cent. Burgundy 9, 10, 11 per cent. Champagne 10, 11 per eent. Rhine wine from 6 to 12 per cent., generally from 9 to 10 per cent.—*Mulder.*

Under the title of the deacidification of wines, Professor Liebig published in his *Annalen* a proeess 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 eertain 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 vatting; 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 aeid, 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 whieh requires from 180 to 200 parts of water of ordinary temperature for its solution), the free aeid 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°

— 10° C., 2 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 has been withdrawn from the wine."

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 Valencias 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.

Our *importations* of wines have been as follows: —

1858.	Red Wine.	White Wine.	Total of all kinds.
	Gallons.	Gallons.	Gallons.
Of British Possessions:—			
South Africa	208,563	445,556	954,119
East Indies	28	46	74
Australia	1,336	2,044	3,380
Other parts	12	223	235
	209,939	447,869	657,808*
Foreign:—			
Russia	68	9,255	9,323
Sweden	5,175	2,684	7,859
Hamburg	28,363	160,646	189,009
Holland	8,367	105,324	113,691
France	345,120	277,921	623,041
Portugal	1,294,035	32,574	1,326,609
Madeira	4	57,262	57,266
Spain	16,056	2,444,354	2,460,410
Canary Islands	2	6,994	6,996
Two Sicilies	1,040	183,020	184,060
Turkey Proper	15	642	657
Channel Islands	57,571	10,096	67,667
Gibraltar	270	7,931	8,201
Malta	275	9,136	9,411
British Possessions in South Africa	252	466	718
British East Indies	1,560	16,301	17,861
Australia	619	3,224	3,843
British West Indies	343	12,376	12,719
Other parts	12,236	22,251	34,487
	1,771,371	3,362,457	5,133,828
Total of Wines	1,981,310	3,810,326	5,791,636†

By "an Act to amend the laws relating to the customs," it was determined that:— In lieu of the duties and drawbacks of customs now charged or allowed on the articles under mentioned, the following duties of customs shall, on and after the twenty-ninth day of February, 1860, be charged thereon, on importation into Great Britain and Ireland, until the thirty-first day of December, 1860, inclusive, that is to say,—

* Duty on all sorts 2*s.* 10*d.* 13-20ths per gallon from the 13th August, 1853.
† Duty 5*s.* 9*d.* 3-10ths per gallon from the 13th May, 1840.

Wine of or from Foreign Countries:

		£	s.	d.
Red - - - - - -	the gallon	0	3	0
White - - - - -	„	0	3	0
Lees of such wine - - -	„	0	3	0

With an allowance for drawback on exportation until the said thirty-first of December, 1860, inclusive, of three shillings per gallon on such wine exported or used as ship's stores, but no drawback shall be granted on lees of wine.

On and after the 1st day of January 1861, and without any allowance for drawback: Wine containing less than the following rates of proof spirit, verified by Sykes's Hydrometer; viz.

	18 Degrees.			26 Degrees.			40 Degrees.			If imported in bottles.		
	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
Wine of or from foreign countries:—												
Red - - - the gallon	0	1	0	0	1	6	0	2	0	0	2	0
White - - „	0	1	0	0	1	6	0	2	0	0	2	0
Lees of such wine „	0	1	0	0	1	6	0	2	0	0	2	0
Wine the growth and produce of any British possession:—												
Red - - - the gallon	0	1	0	0	1	6	0	2	0	0	2	0
White - - „	0	1	0	0	1	6	0	2	0	0	2	0
Lees of such wine „	0	1	0	0	1	6	0	2	0	0	2	0

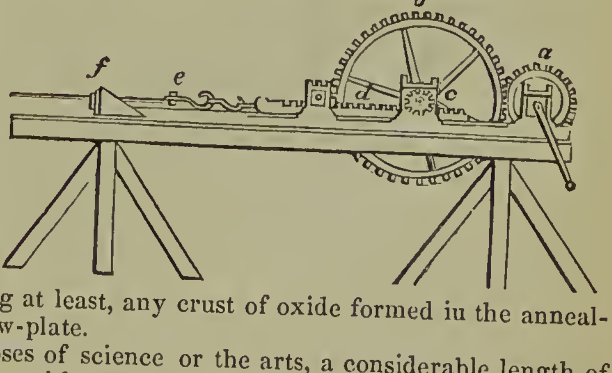
Provided always, that the commissioners of customs may by their order from time to time determine into what ports in Great Britain and Ireland wine may or may not be imported; and all wine imported into any port contrary thereto shall be forfeited or otherwise dealt with as the said commissioners may see fit to direct.

WINE-STONE is the deposit of crude tartar, called argal, which settles on the sides and bottoms of wine casks. See WINE.

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. 1938 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 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 the purpose of clearing off, or loosening at least, any crust of oxide formed in the annealing, before the wire enters the draw-plate.

1938



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 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 $\frac{1}{300}$ of an inch, a wire of platinum of $\frac{1}{3000}$ 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.

WIRE ROPE. The manufacture of ropes made of wire, has, of late years, become a most important one. Not only are ropes of this description now employed in the most extensive coal mines of this country, and for winding generally, but they are used for much of the standing rigging of ships, and for numerous ordinary purposes. Perhaps the most important application of wire rope has been, however, in the construction of the electric cables. See Electro-telegraphy.

The following tables show the relative values of ropes of hemp, iron, and steel.

Table I.

Round Wire Ropes, for inclined planes, mines, collieries, ships' standing rigging, &c.

Hemp.		Iron.		Steel.		Equivalent Strength.	
Circumference.	lbs. weight per fathom.	Circumference.	lbs. weight per fathom.	Circumference.	lbs. weight per fathom.	Working load.	Breaking strain.
						Cwts.	Tons.
2¾	2	1	1	- -	- -	6	2
		1½	1½	1	1	9	3
3¾	4	1⅝	2	- -	- -	12	4
		1¾	2½	1½	1½	15	5
4½	5	1⅞	3	- -	- -	18	6
		2	3½	1⅝	2	21	7
5½	7	2⅛	4	1¾	2½	24	8
		2¼	4½	- -	- -	27	9
6	9	2⅜	5	1⅞	3	30	10
		2½	5½	- -	- -	33	11
6½	10	2⅝	6	2	3½	36	12
		2¾	6½	2⅛	4	39	13
7	12	2⅞	7	2¼	4½	42	14
		3	7½	- -	- -	45	15
7½	14	3⅛	8	2⅜	5	48	16
		3¼	8½	- -	- -	51	17
8	16	3⅜	9	2½	5½	54	18
		3½	10	2⅝	6	60	20
8½	18	3⅝	11	2¾	6½	66	22
		3¾	12	- -	- -	72	24
9½	22	3⅞	13	3¼	8	78	26
10	26	4	14	- -	- -	84	28
		4¼	15	3⅜	9	90	30
11	30	4⅜	16	- -	- -	96	32
		4½	18	3½	10	108	36
12	34	4⅝	20	3¾	12	120	40

Round rope in pit shafts must be worked to the same load as flat ropes.

TABLE II

Flat Wire Ropes, for pits, hoists, &c. &c.

Hemp.		Iron.		Steel.		Equivalent Strength.	
Size in inches.	lbs. weight per fathom.	Size in inches.	lbs. weight per fathom.	Size in inches.	lbs. weight per fathom.	Working load.	Breaking strain.
						Cwts.	Tons.
$4 \times 1\frac{1}{8}$	20	$2\frac{1}{4} \times \frac{1}{2}$	11	- -	- -	44	20
$5 \times 1\frac{1}{4}$	24	$2\frac{1}{2} \times$	13	- -	- -	52	23
$5\frac{1}{2} \times 1\frac{3}{8}$	26	$2\frac{3}{4} \times \frac{5}{8}$	15	- -	- -	60	27
$5\frac{3}{4} \times 1\frac{1}{2}$	28	$3 \times$	16	$2 \times \frac{1}{2}$	10	64	28
$6 \times 1\frac{1}{2}$	30	$3\frac{1}{4} \times$	18	$2\frac{1}{4} \times \frac{1}{2}$	11	72	32
$7 \times 1\frac{7}{8}$	36	$3\frac{1}{2} \times$	20	$\times$	12	80	36
$8\frac{1}{4} \times 2\frac{1}{8}$	40	$3\frac{3}{4} \times \frac{11}{16}$	22	$2\frac{1}{2} \times \frac{1}{2}$	13	88	40
$8\frac{1}{2} \times 2\frac{1}{4}$	45	$4 \times$	25	$2\frac{3}{4} \times \frac{3}{8}$	15	110	45
$9 \times 2\frac{1}{2}$	50	$4\frac{1}{4} \times \frac{3}{4}$	28	$3 \times$	16	112	50
$9\frac{1}{2} \times 2\frac{3}{8}$	55	$4\frac{1}{2} \times$	32	$3\frac{1}{4} \times$	18	128	56
$10 \times 2\frac{1}{2}$	60	$4\frac{5}{8} \times$	34	$3\frac{1}{2} \times$	20	136	60

WOAD (*Vouëde, Pastel*, Fr.; *Waid*, Germ.; *Gualdo*, It. *Isatis tinctoria*, Linn.) is almost the only plant growing in the temperate zone which is known to produce indigo. It is an herbaceous, biennial plant, belonging to the natural order *cruciferæ*, and bears yellow flowers and large flattened seed vessels, which are often streaked with purple. The leaves, which are the only part of the plant employed in dyeing, are large, smooth, and glaucous, like cabbage leaves, but exhibit no external indication of the presence of any blue colouring matter, which indeed, according to modern researches, is not contained in them ready formed. The plant called by the Romans *glastum*, with which, according to Pliny, the Britons dyed their skins blue, is supposed to be identical with woad. Before the introduction of indigo into the dye-house of Europe, woad was generally used for dyeing blue, and was extensively cultivated in various districts of Europe, such as Thuringia, in Germany; Languedoc, in France; and Piedmont, in Italy. To these districts its cultivation was a source of great wealth. Beruni, a rich woad manufacturer of Toulouse, became surety for the payment of the ransom of his king, Francis I., then a prisoner of Charles V., in Spain. The term *pays de cocaigne*, denoting a land of great wealth and fertility, is indeed supposed to be derived from the circumstance that the woad balls, called in French *cocaignes*, were manufactured chiefly in Languedoc.

The woad-leaves were not employed by the dyer in their crude state, but were previously subjected to a process of fermentation, for the purpose of eliminating the colouring matter. The seed having been sown in winter, or early spring, the plants were allowed to grow until the leaves were about a span long, and had assumed the rich glaucous appearance indicative of maturity, when they were stripped or cut off. The cropping was repeated several times, at intervals of five or six weeks, until the approach of winter put a stop to the growth of the plant. The leaves sent up in the succeeding spring yielded only an inferior article (called in German *Komposowaid*), and it was therefore customary to keep only as many plants until the following year as were required for obtaining seed, which, the plant being biennial, is only produced in the second year. The leaves, after being gathered, were slightly dried, and then ground in a mill to a paste. In Germany it was usual to lay this paste into a heap for about twenty-four hours, and then form it by hand into large balls, which were first dried partially in the sun, on lattice work or rushes, and then piled up in heaps a yard high, in an airy place, but under cover, when they diminished in size and became hard. These balls, when of good quality, exhibited, on being broken, a light blue or sea-green colour. They were usually sold in this state to manufacturers, by whom they were subjected to a second process in order to render them fit for the use of the dyer. This process was conducted in the following manner:—The woad balls were first broken by means of wooden hammers, and the triturated mass was heaped up on a wooden floor, sprinkled with water, sometimes with a little wine, and allowed to ferment or putrefy. The mass became very hot, and emitted a strong ammoniacal odour, and much vapour. In order to regulate the process it was frequently turned over with shovels and again sprinkled with water. When the heat had subsided, the mass, which had become dry, was pounded, passed through sieves, and then packed in barrels ready for use. It had the appearance of pigeon's dung.

In France the paste obtained by pounding the woad leaves was taken to a room with a sloping pavement, open at one end, laid in a heap at the higher end of the room, and allowed to ferment for a period of twenty or thirty days. The mass swelled up and often showed cracks or fissures, which were always carefully closed as soon as they appeared, whilst a black juice exuded and ran away in gutters constructed for the purpose. When the fermented heap had become moderately dry, it was ground again and formed into cakes, called in French *coques*, which were then fully dried, and in this state brought to market. In France and Italy a second fermentation was not generally thought essential, but when performed it was conducted exactly in the manner just described.

At the present day woad is nowhere employed alone for the purpose of dyeing blue, since it is found more economical to use indigo, and the cultivation of the plant has therefore declined considerably, and has even become nearly extinct in districts where it was formerly carried on extensively. By woollen dyers, however, it is still used, but only as a means of exciting fermentation, and thus reducing the indigo blue in their vats; indeed, the woad employed by them contains little or no blue colouring matter. See Indigo.

Numerous attempts have been made to extract the blue colouring matter from woad, in the same way that indigo is extracted from the leaves of the indigofera in the East Indies and other countries. At the commencement of the present century, when the price of indigo on the continent of Europe was very high, a prize of 100,000 francs was even offered by the French government for the discovery of a method of obtaining from the *Isatis tinctoria*, or some other native plant, a dyeing material, which, both in regard to price and the beauty and solidity of its colour, should form a perfect substitute for indigo. The experiments which were made in consequence served to prove that it was quite possible to obtain genuine indigo from woad leaves, but that the process could never be carried on profitably on account of the very small proportion of colouring matter contained in the plant. Nine parts of fresh leaves yield only one part of the prepared material or pastel, and the latter does not afford more than 2 per cent. of its weight of indigo. According to Chevreul, the leaves of the *Indigofera anil*, even when grown in the neighbourhood of Paris, contain 30 times as much indigo-blue as those of the *Isatis tinctoria*, and, when cultivated in tropical countries, the amount is probably still higher. The comparatively high price of land and labour would probably itself prove a sufficient obstacle to the successful manufacture of indigo in most European countries, even if the yield were equal to what it is in the tropics.

In 1808 Chevreul published the results of his analysis of woad and pastel. It has more recently been made the subject of chemical investigation, for the purpose of ascertaining the state in which indigo-blue exists in plants and other organisms. See Indigo.—E. S.

WOOD-PRESERVING. Mr. Bethell's invention, which is much employed, 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.

For railway sleepers it is highly useful, as the commonest Scotch fir sleeper, when thus prepared, will last for centuries. 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. The processes which have been introduced for impregnating wood with the protosulphate of iron, corrosive sublimate, chloride of lime, and similar substances, are not much employed, although many of them have been found to be very useful as preservative agents.

WOOF is the same as Weft.

WOOL. 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 sheep-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 not be 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. The filaments of the finer qualities vary in thickness from $\frac{1}{1100}$ to $\frac{1}{1500}$ of an inch; their structure is very curious, exhibiting, in a good achromatic microscope, at intervals of about $\frac{1}{300}$ 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.

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. The Angora, or Angola, or Angona wool, from Agnolia, 39° 53′ N. Lat., 32° 52′ E. Long., owes its beautiful character to the place of its growth. This wool is the same as *Mohair.* 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 *yolk;* 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.

Wool was first imported into this country in 1770. The gradual increase in the importation is shown in the following table:—

Year.	lbs.	Year.	lbs.
1771 - - -	1,829,772	1811 - - -	4,739,972
1781 - - -	2,478,332	1821 - - -	16,622,567
1791 - - -	3,014,511	1831 - - -	31,652,029
1801 - - -	7,371,774	1841 - - -	56,170,974

In the year 1800 a duty of 5*s.* 3*d.* per cwt. was imposed upon the import, which in 1813 was raised to 6*s.* 8*d.* per cwt., and in 1819 to the excessive duty of 6*d.* per lb; in 1824 it was reduced to 3*d.* per lb., and in 1825 to ½*d.* per lb. on wool under the value of 1*s.* per lb., and 1*d.* on wool above that price. The duty was removed in 1844:—

Quantities of Wool (Sheep, Lamb, and Alpaca) imported into the United Kingdom from various Countries.

Years.	Spain.	Germany, viz. Mecklenberg, Hanover, Oldenburg, and Hanse Towns.	Other Countries of Europe.	British Possessions in South Africa.	British Possessions in the East Indies.	British Settlements in Australia.	South America.	Other Countries.	Total.	Years.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	
1844	918,853	21,847,684	15,313.08.	2,197,143	2,765,853	17,602,247	3,760,063	1,308,831	65,713,761	1844
1845	1,074,540	18,484.736	17,606,515	3.512,924	3,975,866	24,177,317	6,468,338	1,513,619	76,813,855	1845
1846	1,020,476	15,888,705	11,733,601	2,958,457	4,570,581	21,789,346	4,890,273	2,404,023	65,255,462	1846
1847	424,408	12,673,814	7,935,697	3,477,392	3,063,142	26,056,815	7,295,550	1,665,780	62,592,598	1847
1848	106,638	14,429,161	7,024,098	3,497,250	5,997,435	30,034,567	8,851,211	924,487	70,864,847	1848
1849	127.559	12,750,011	11,432,354	5,377,495	4,182,853	35,879,171	6,014,525	1,004,679	76,768,647	1849
1850	440,751	9,166,731	8,703,252	5,709,529	3,473,252	39,018,221	5,296,618	2,518,394	74,326.778	1850
1851	383,150	8,219,236	14,263,156	5,816,591	4,549,520	41,810,117	4,850,048	3,420,157	83,311,975	1851
1852	233,413	12,765,253	13,382,140	6,388,796	7,880,784	43,197,301	6,252,689	3,661,082	93,761,458	1852
1853	154,146	11,584,800	26,861,166	7,221,448	12,400,869	47,076,010	9,740,032	4,357,978	119,396,449	1853
1854	424,300	11,448,518	14,481,483	8,223,598	14,965,191	47,489.650	6,134,334	2,954,921	106,121,995	1854
1855	68,750	6,128,626	8,119,408	11,075,965	14,283,535	49,142,306	7,106,708	3,375,148	99,300,446	1855
1856	55,090	8,687,781	14,480,869	14,305,188	15,386,578	52,052,139	8,076,317	3,167.430	116,211,392	1856
1857	397,238	6,088,002	23,802,520	14,287,828	19,370,741	49,209,655	9,306,886	7,287,028	129,749,898	1857
1858	110,510	10,595,186	17,926,859	16,597,504	17,333,507	51,104,560	10,046,381	3,024,216	126,738,721	1858

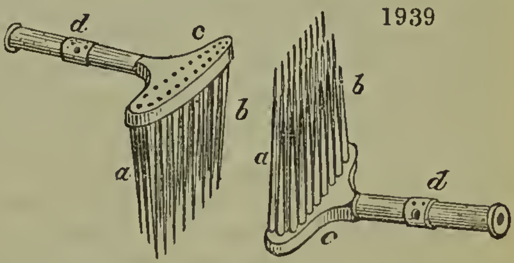
WOOL DYEING. See Dyeing.

WOOLLEN 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.

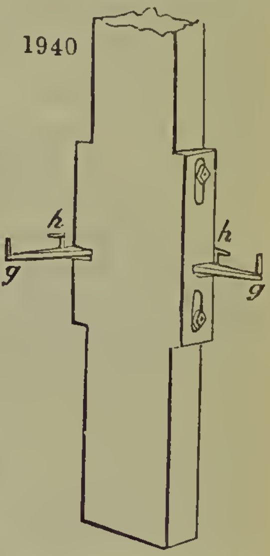
When the long wool is brought into the worsted factory, it is first of all washed by men with soap and water, who are paid for their labour by the piece, and are each assisted by a boy, who receives the wool as it issues from between the drying *squeezers* (see BLEACHING). The boy carries off the wool 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 not found to be at all injured.

The wool, when properly dried, is transferred to a machine called the *plucker*, which is always superintended by a boy 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 webb 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 combs. Each comb is composed either of two or three rows of pointed tapering steel teeth, *b* *fig.* 1939, disposed in two or three parallel planes, each row being a little longer that 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.

1939



1940



In the workshops a post is planted, *fig.* 1940, 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 side, 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 of 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 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 skilfully 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 comber to grasp them in his hand, are called *noyls*. They are unfit for the worsted spinner, and are reserved for the coarse cloth manufacturer.

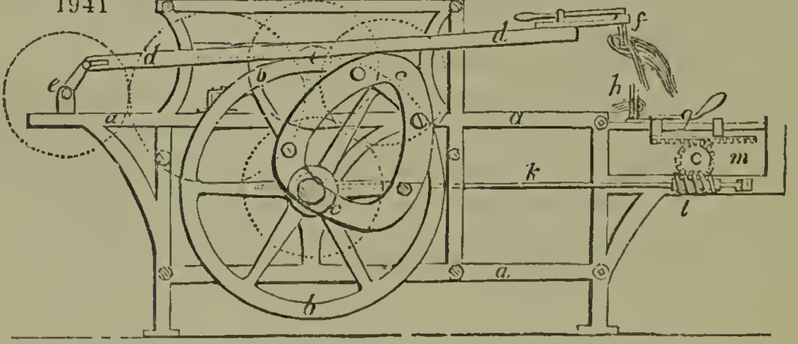
The wool finally drawn off from the comb, though it may form a uniform tress of straight filaments, must yet be combed again at a somewhat lower temperature, to prepare it perfectly for the spinning operation. From ten to twelve slivers are then arranged in one parcel.

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 machine being then thrown out of gear, the teeth are stripped of the tresses by the hand of the attendant; the *noyls*, 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 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.* 1941, the internal structure is exhibited. The frame-

1941



work *a*, *a*, supports the axle of a wheel, *b*, *b*, in suitable earings 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 *c*. By the rotation of the crank *c*, 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 or 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.

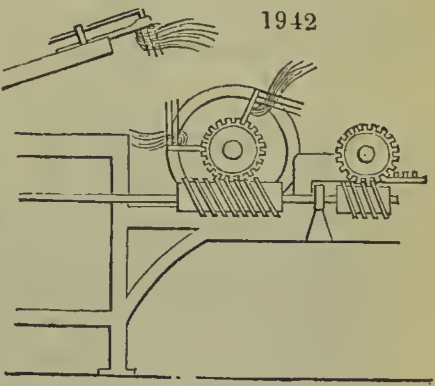
As it is important, in order to prevent waste, that the ends of the wool should be first combed out, and that the needle-points should be made to penetrate the wool progressively, the movable frame *g* is in the first instance placed as far back as possible; and the action of the lever *d*, during the 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 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.

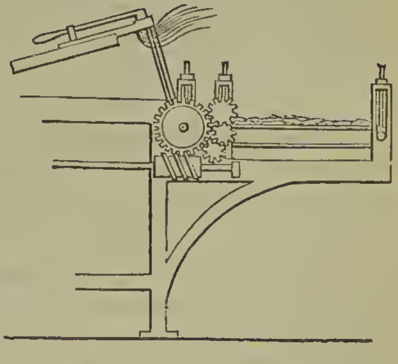
At the end of the axle of the wheel *b*, and cam *c*, a bevel pinion is affixed, which gears into a corresponding bevel pinion on the end of the lateral shaft *k*. The reverse end of this shaft has a worm or endless screw *l*, taking into a toothed wheel *m*; and this last-mentioned toothed wheel gears into the 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.* 1942. 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.

1942



1943



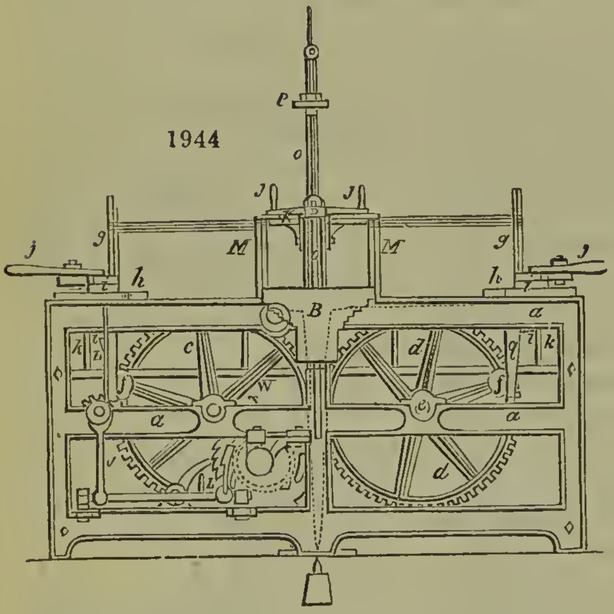
A slight variation in the machine is shown at *fig.* 1943, for the purpose of combing wool of long fibre, which differs from the former only in placing the combs or needle points upon a revolving cylinder or shaft. At the end of the axle of this shaft, there is a toothed wheel, which is actuated by an endless screw upon a lateral shaft. The axle of the cylinder on 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 a half 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. 1944 is an elevation, *fig.* 1945 an end view, and *fig.* 1946 a plan, in which *a*, *a*, is the framing; *b*, the main shaft, bearing a pinion which drives the wheel and shaft *c*, in gear with the wheel *d*, on the shaft *e*. Upon each of the wheels *c* 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 grove *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.

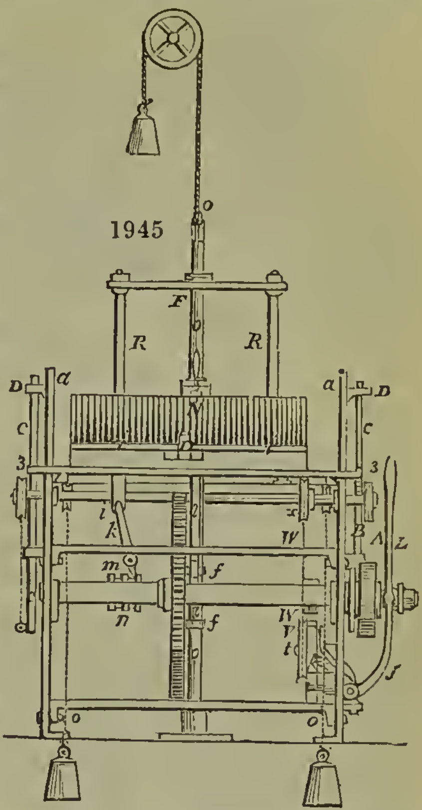
1944



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 A, A, made fast to them, and also to the end of the gauge-plates B, 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 B, are guided up by the bars C, which pass through openings, slots, or guides, made in the framing *a*, as shown by D.

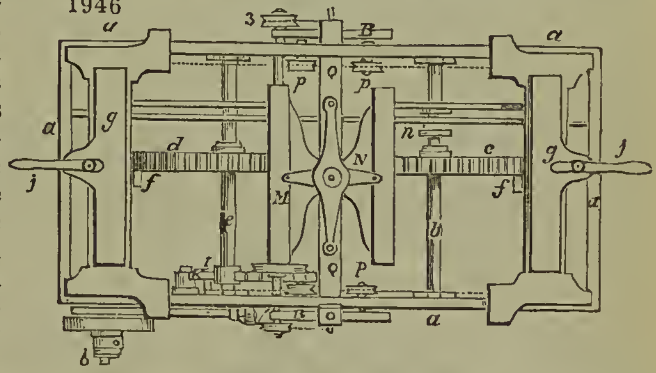
To the ratchet wheel *s*, an inclined projection F, is made fast, which in the course of the rotation of the ratchet wheel, comes under the lever F, fixed to the shaft G, that turns in bearings H. To this shaft the levers I and J, are also affixed; I serving to throw out the click or catch K, from the 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 combining 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 between the frame N, and retained there just as the combs *g*, *g*, are upon the holders *i*, *i*. The framing N, is made fast to the bar or spindle O, which moves vertically through openings in the cross-head P, and the cross-framing of the machine Q; from top of which there is a strap passes over pulleys with a suspended weight to it; the cross-head being supported by the two guide-rods R, fixed to the cross-framing Q. It is by the guide-rods R, and the spindle O, that the frame N 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.

1945



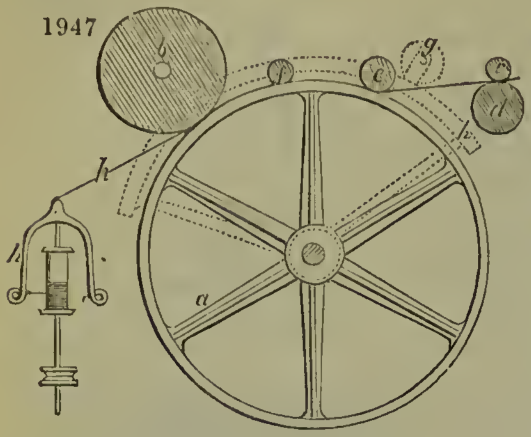
A quantity of wool is to be placed on each of the combs *g*, *g*, and M, M, the machine being in the position shown in *fig.* 1946. When the main-shaft *b*, is set in motion, it will drive by its pinion the toothed wheel *c*, and therefrom the remaining parts of the machine. The first effect of the movement 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 B 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 B, are so much raised as to permit the tables *h* to approach the plates B, below the lowest step or graduation, when the machine will continue to work. Notwithstanding the plates B 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 E, on the ratchet wheel *s*, comes under the lever F, 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.

1946



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 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.

1947



These objects may be effected in several ways; that is, the machinery may be variously constructed, and still embrace the principles proposed. *Fig.* 1947, 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 *h*, where it becomes twisted or spun into a worsted thread.

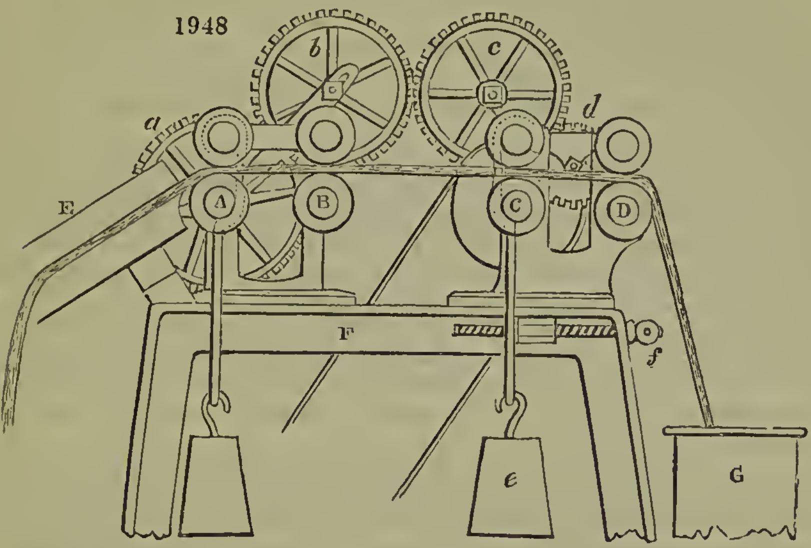
In order to increase or diminish the extent to which the fibres of wool are spread over the periphery of the wheel *a*, a regulating roller is adapted to the machine, as shown at *g*, in place of the tension roller *f*. This regulating roller *g*, is mounted by its pivots in bearings on the circular 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 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.* 1948. It consists of four pairs of rollers A, B, C, D. The first pair A, receives the wool from the inclined trough E, 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 D, 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

1948



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 C is loaded with a heavy weight, similar to the rollers A; but the other rollers, B 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 equalised, 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 E. 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 $2\frac{1}{2}$ times as fast as the rollers A; the third rollers C move 8 times as fast as A; and the fourth rollers E move $10\frac{1}{3}$ times as fast as A. In this case the motion is given to the different rollers by means of beveled 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: but it does not differ from the others, which are called drawing-frames. The slivers which have passed through one system of rollers are collected four or five together and put through the drawing-rollers. In all the slivers pass through three drawings, and the whole extension is seldom less than 1000 times, and for some kinds of wool much greater.

After the drawing of the slivers is finished, a pound weight is taken, and is measured by means of a cylinder, in order to ascertain if the drawing has been properly conducted; if the sliver does not prove of the length proposed, according to the size of worsted which is intended to be spun, the pinions of some of the drawing-frames are changed, to make the draught more or less, until it is found by experiment that one pound of the sliver measures the required length.

Roving-frame.—This is provided with rollers, the same as the drawing-frames: it takes in one or two slivers together, and draws them out four times. By this extension the sliver becomes so small that it would break with the slightest force, and it is therefore necessary to give some twist; this is done by a spindle and flyer. See *Roving*, under COTTON MANUFACTURE.

Spinning-frame.—This is so much like the roving-frame that a short description will be sufficient. The spindles are more delicate, and there are three pairs of rollers, instead of two; the bobbins, which are taken off from the spindles of the roving-frame when they are quite full, are stuck upon skewers, and the roving which proceeds from them is conducted between the rollers. The back pair turns round slowly; the middle pair turns about twice for once of the back rollers; and the front pair makes from twelve to seventeen turns for one turn of the back roller, according to the degree of extension which is required.

The spindles must revolve very quickly in the spinning-frame, in order to give the requisite degree of twist to the worsted. The hardest twisted worsted is called tammy warp; and when the size of this worsted is such as to be 20 or 24 hanks to the pound weight, the twist is about 10 turns in each inch of length. The least twist is given to the worsted for fine hosiery, which is from 18 to 24 hanks to the pound. The twist is from 5 to 6 turns per inch. The degree of twist is regulated by the size of the whirls or pulleys upon the spindle, and by the wheel-work which communicates the motion to the front rollers from the band-wheel, which turns the spindles.

It is needless to enter more minutely into the description of the spinning machinery, because the fluted roller construction, invented by Sir Richard Arkwright, fully described under COTTON MANUFACTURE, is equally applicable to worsted. The difference between the two is chiefly in the distance between the rollers, which in the worsted-frame is capable of being increased or diminished at pleasure, according to the length of the fibres of the wool; and the draught or extension of the roving is far greater than in the cotton.

Reeling.—The bobbins of the spinning-frame are placed in a row upon wires before a long horizontal reel, and the threads from 20 bobbins are wound off together. The reel is exactly a yard in circumference, and when it has wound off 80 turns it rings a bell; the motion of the reel is then stopped, and a thread is passed round the 80 turns or folds which each thread has made. The reeling is then continued till another 80 yards is wound off, which is also separated by interweaving the same thread; each of these separate parcels is called a ley, and when 7 such leys are reeled it is called a hank, which contains 560 yards. When this quantity is reeled off, the ends of the binding thread are tied together, to bind each hank fast, and one of the rails of the reel is struck to loosen the hanks, and they are drawn off at the end of the reel. These hanks are next hung upon a hook, and twisted up hard by a stick; then doubled, and the two parts twisted together to make a firm bundle. In this state the hanks are weighed by a small index-machine, which denotes what number of the hanks will weigh a pound. And they are sorted accordingly into different parcels. It is by this means that the number of the worsted is ascertained as the denomination for its fineness: thus No. 24 means that 24 hanks each containing 560 yards will weigh a pound, and so on.

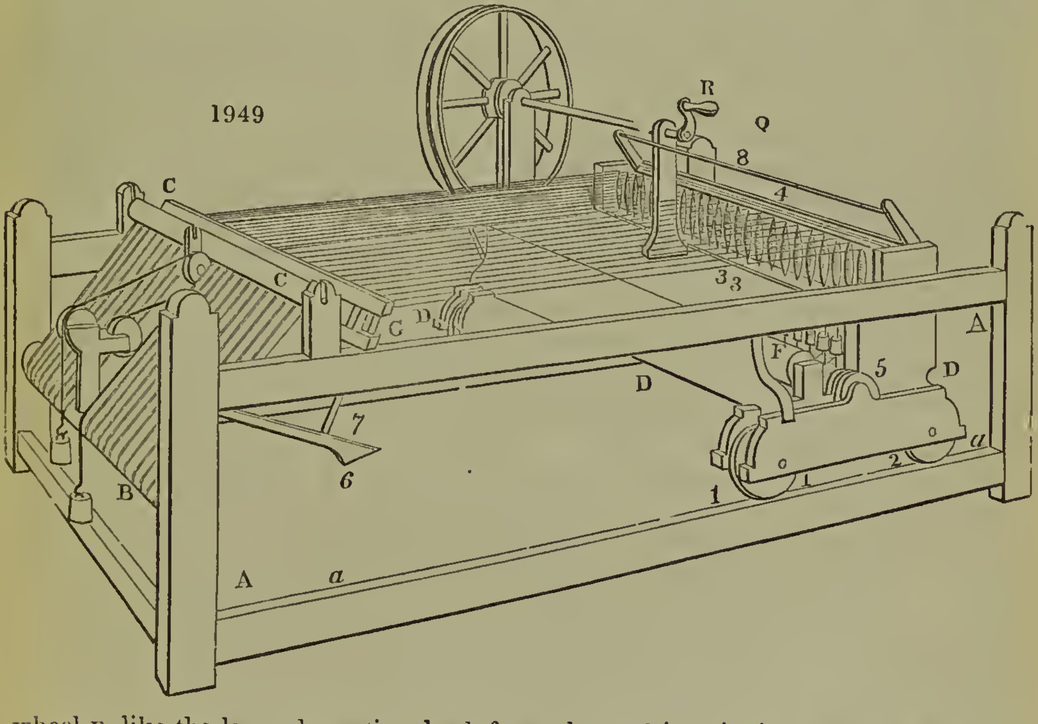
This denomination is different from that used for cotton, because the hank of cotton contains 840 yards instead of 560; but in some places the worsted hank is made of the same length as the cotton.

To pack up the worsted for market, the proper number of hanks is collected to make a pound, according to the number which has been ascertained; these are weighed as a proof of the correctness of the sorting, then tied up in bundles of one pound each, and four of these bundles are again tied together. Then 60 such bundles are packed up in a sheet, making a bale of 240 pounds ready for market.

Of the treatment of short wool for the cloth manufacture.—Short wool resembles cotton not a little in the structure of its filaments, and is cleaned by the *willy*, as cotton is by the *willow*, which opens up the matted fleece of the wool-stapler, and cleans it from accidental impurities. Sheep's wool for working into coarse goods must be passed repeatedly 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.* 1949 is a perspective 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 F, 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

1949



wheel E, 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 R, 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 B, and the other lies behind c. One carding is allotted to a spindle; the total number of each 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 G, 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 aliqnot 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 *clove*, originally used by Hargreaves in his cotton-jenny. The movable upper rail G, is guided between sliders, and a wire 7, descends from it to a lever c. When the spindle carriage D, 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 G, 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 B, C. There is a small catch, which lays hold of the upper bar of the clasp G, 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 D. 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 G, of the clasp to fall, and pinch the carding fast; the wheel E, 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 COTTON 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 fullorum;* 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 Elbœuf, 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

* See this admirable machine fully described and delineated in Dr. Ure's *Cotton Manufacture of Great Britain*, vol. ii.

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.

2. Others conceived that the seesaw motion was not essential, but that it was advantageous to make the teasels or cards act in a rectilinear direction, as in working by hand; this action was attempted by placing the two ends of the teasel-frame in grooves formed like the letter D, so that the teasel should act on the cloth only when it came into the rectlinear part. Mr. Wells, machine-maker, of Manchester, obtained a patent, in 1832, for this construction.

3. It was supposed that the teasels should not act perpendicularly to the weft, but obliquely or circularly upon the face of the cloth. Mr. Ferrabee, of Gloucester, patented, in 1830, a scheme of this kind, in which the teasels are mounted upon two endless chains, which traverse from the middle of the web to the selvage or list, one to the right, and another to the left hand, while the cloth itself passes under them with such a velocity, that the effect, or *resultant*, is a diagonal action, dividing into two equal parts the rectangle formed by the weft and warp yarns. Three patent machines of Mr. George Oldland—the first in 1830, the second and third in 1832—all proceed upon this principle. In the first, the teasels are mounted upon discs made to turn flat upon the surface of the cloth; in the second, the rotating discs are pressed by cork-screw spiral springs against the cloth, which is supported by an elastic cushion, also pressed against the discs by springs; and in the third machine, the revolving discs have a larger diameter, and they turn, not in a horizontal, but a vertical plane.

4. Others fancied that it would be beneficial to support the reverse side of the cloth by flat hard surfaces, while acting upon its face with cards or teasels. Mr. Joseph Cliseld Daniell, having stretched the cloth upon smooth level stones, teasels them by hand.

5. Messrs. Charlesworth and Mellor obtained a patent, in 1829, for supporting the back of the cloth with elastic surfaces, while the part was exposed to the teasling action.

6. Elasticity has also been imparted to the teasels, in the three patent inventions of Mr. Sevill, Mr. J. C. Daniell, and Mr. R. Atkinson.

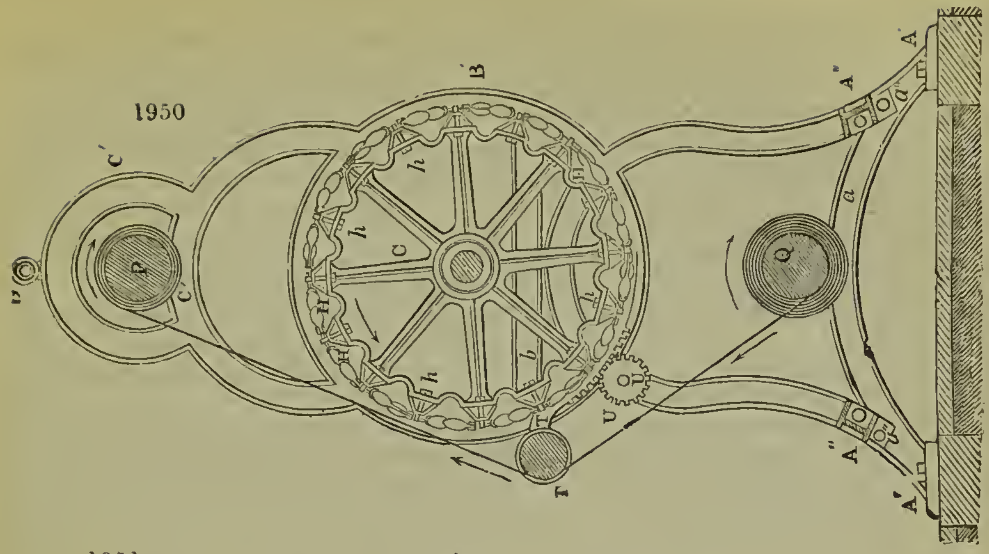
7. It has been thought useful to separate the teasel-frames upon the drum of the gig-mill, by simple rollers, or by rollers heated with steam, in order to obtain the combined effect of calendering and teasling. Mr. J. C. Daniell, Mr. G. Haden, and Mr. J. Rayner, have obtained patents for contrivances of this kind.

8. Several French schemes have been mounted for making the gig-drum act upon the two sides of the cloth, or even to mount two drums on the same machine.

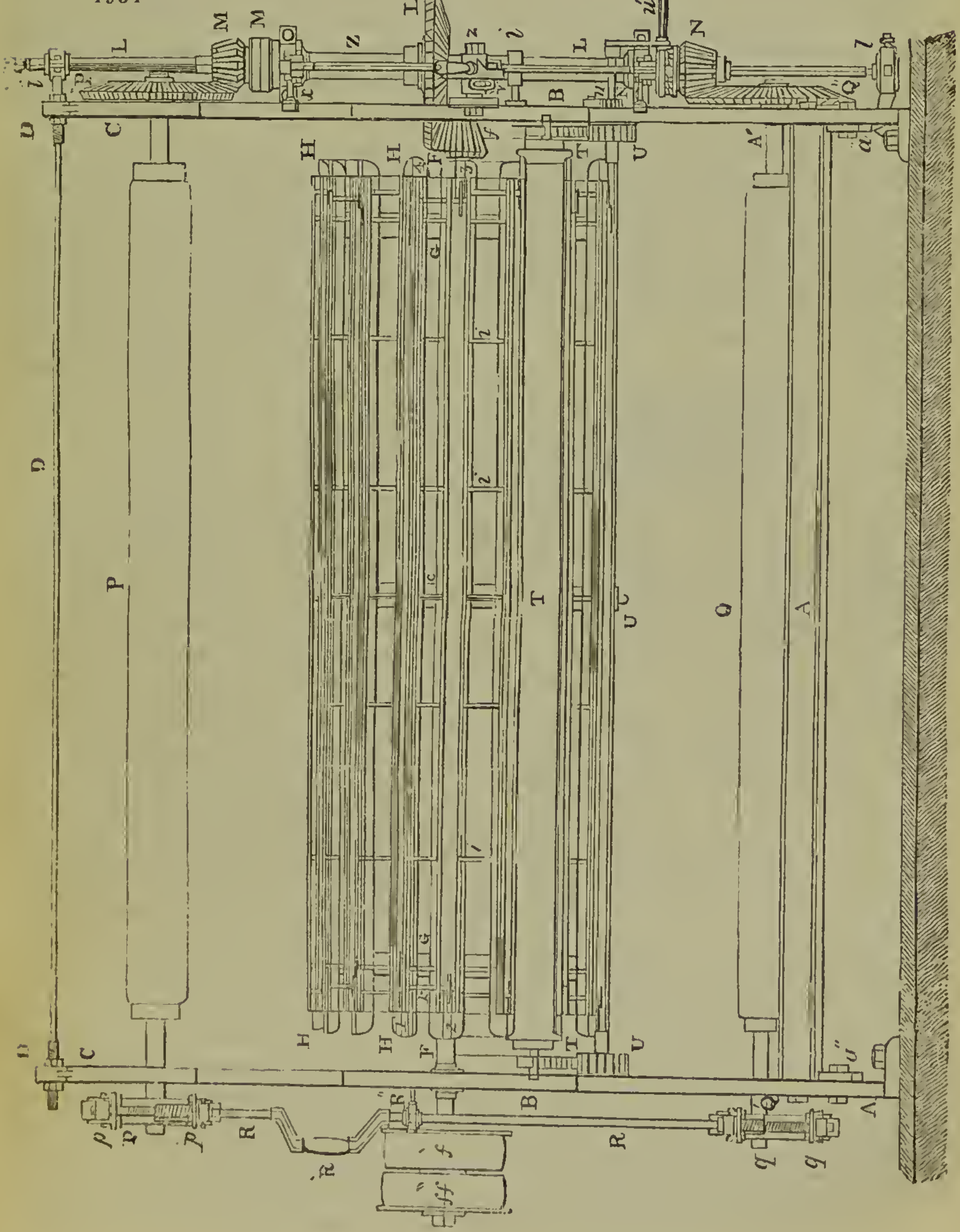
Mr. Jones, of Leeds, contrived a very excellent method of stretching the cloth, so as to prevent the formation of folds or wrinkles. (See *Newton's Journal*, vol. viii. 2nd series, page 126.) Mr. Collier, of Paris, obtained a patent, in 1830, for a greatly improved gig-mill, upon Douglas's plan, which is now much esteemed by the French clothiers. The following figures and description exhibit one of the latest and best teasling machines. It is the invention of M. Dubois and Co., of Louviers, and is now doing excellent work in that celebrated seat of the cloth manufacture.

In the fulling mill, the woollen web acquires body and thickness, at the expense of its other dimensions; for being thereby reduced about one-third in length, and one-half in breadth, its surface is diminished to one-third of its size as it comes out of the loom; and it has, of course, increased threefold in thickness. As the filaments drawn forth by teasling, are of very unequal lengths, they must be shorn to make them level, and with different degrees of closeness, according to the quality of the stuff, and the appearance it is desired to have. But, in general, a single operation of each kind is insufficient; whence, after having passed the cloth once through the gig-mill, and once through the shearing-machine (*tondeuse*), it is ready to receive a second teasling, deeper than the first, and then to suffer a second shearing. Thus, by the alternate repetition of these processes, as often as is deemed proper, the cloth finally acquires its wished-for appearance. Both of these operations are very delicate, especially the first; and if they be ill conducted, the cloth is weakened, so as to tear or wear most readily. On the other hand, if they be skilfully executed, the fabric becomes not only more

1950



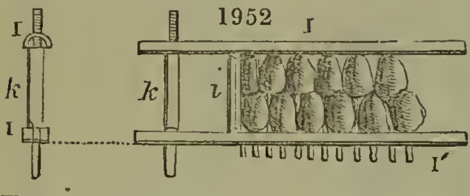
1951



sightly, but it acquires strength and durability, because its face is changed into a species of fur, which protects it from friction and humidity.

Figs. 1950, 1951, represent the gig-mill in section, and in front elevation. A, B, C, D, A′, B′, C′, D′, being the strong frame of iron, cast in one piece, having its feet enlarged a little more to the inside than to the outside, and bolted to large blocks in the stone pavement. The two uprights are bound together below by two cross-beams A″, being fastened with screw-bolts at the ears *a″*, *a″*; and at top, by two wrought-iron stretcher rods D, whose ends are secured by screw-nuts at D, D′. The drum is mounted upon a wrought-iron shaft F, which bears at its right end (*fig.* 1951), exterior to the frame, the usual riggers, or fast and loose pulley, *ff″*, *f′*, which give motion to the machine by a band from the main shaft of the mill. On its right end, within the frame, the shaft F, has a bevel wheel F′, for transmitting movement to the cloth, as shall be afterwards explained. Three crown wheels G, of which one is shown in the section, *fig.* 1950, are, as usual, keyed by a wedge to the shaft F. Their contour is a sinuous 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 F, and the other two, towards its extremities. Their size may be judged of, from inspection of *fig.* 1950. After having set them so that all their spokes or radii correspond exactly, the 16 sides H, 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.* 1950, but rounded off at the end, *fig.* 1951, and each of them is fixed to the three felloes of the wheels by three bolts *h.* 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 wou'd coincide with that of the shaft F.

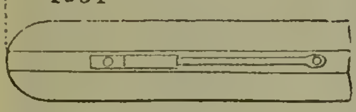
Between the 16 sides there are 16 intervals, which correspond to the 16 hollowings of each of the wheels. Into these intervals are adjusted, with proper precautions, 16 frames bearing the teasels which are to act upon the cloth. These are fitted in as follows:—Each has the shape of a rectangle, of a 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.* 1950). A portion of the frame is represented in *fig.* 1952. The large side I, 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 *i*, which serve to maintain the sides of the frame I, 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 I, I′, ought to be such, that if a frame be laid upon the drum, in the interval of two ribs, the side I will rest upon the inclined plane of one of the ribs, and the side I′ upon the inclined plane of the other (see *fig.* 1950); 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.* 1953, 1954, 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.* 1951 (near the right end of the shaft F), shows the place of the clamp, *figs.* 1953, 1954. 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.

1953

1954



The cloth is wound upon the lower beam Q, *fig.* 1950; thence it passes in contact with a wooden cylinder T, turning upon an axis, and proceeds to the upper beam P, on to which it is wound: by a contrary movement the cloth returns from the beam P to Q, over the cylinder T; 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 teasled, 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.* 1951, 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 *l′*, and top collet *l″*, in the prolongation of the stretcher D. Upon this upright shaft are mounted—1, a bevel wheel L′; 2, an upper bevel pinion M, with its boss M′; 3, a lower bevel pinion N, with its boss N′. 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 F 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 M is independent upon the shaft L; that is to say, it may be slidden 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 M′, which is dependent, by feathered indentations, upon the rotation of L, though it can slide freely up and down upon it. When it is raised, therefore, it comes into gear with M. The pinion N, and its boss, have a similar mode of being thrown into and out of gear with each other. The bosses M′ and N′, ought always to be moved simultaneously, in order to throw one of them into gear, and the other out of gear. The shaft L serves to put the cloth in motion, by means of the bevel wheels P″ and Q″, upon the ends of the beams P and Q, which take into the pinions M and N.

The mechanism destined to stretch the cloth is placed at the other end of the machine, where the shafts of the beams, P, Q, are prolonged beyond the frame, and bear at their extremities P′ and Q′, armed each with a brake. The beam P (*fig.* 1950), turns in an opposite direction to the drum; consequently the cloth is wound upon P, and unwound from Q. If, at the same time as this is going on, the handle R, of the brake-shaft, be turned so as to clasp the brake of the pulley Q′ and release that of the pulley P′, 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 R′ 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 P, to the beam Q, Z must be lowered, to put the shaft L 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 P′ so as to oppose an adequate resistance.

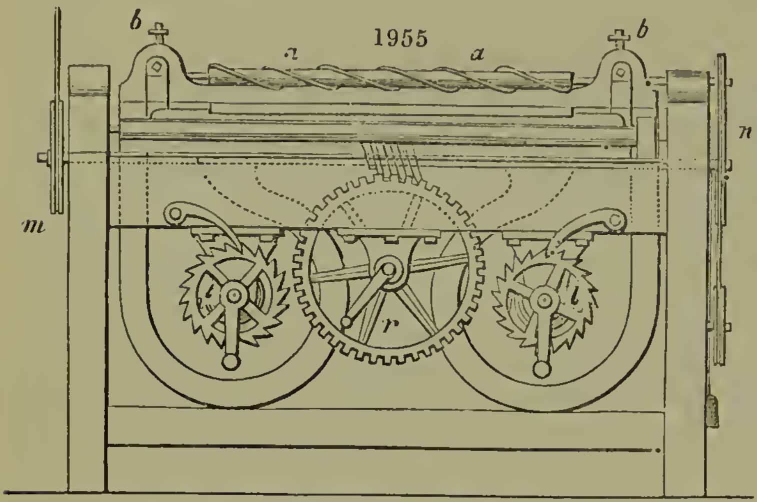
The cloth is brought into more or less close contact with the drum as follows:— There is for this purpose a wooden roller, T, against which it presses in passing from the one winding beam to the other, and which may have its position changed relatively to the drum. It is obvious, for example, that in departing from the position represented in *fig.* 1950, where the cloth is nearly a tangent to the drum, if the roller T′ 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 T″ (*fig.* 1950), 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 slidden upwards or downwards, and consequently raise or depress the roller T. 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 T′, T″: this shaft is extended in front of the frame, upon the side of the head of the machine (*fig.* 1951), and there it carries a ratchet wheel *u*, and a handle *u′*. 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 T, 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.

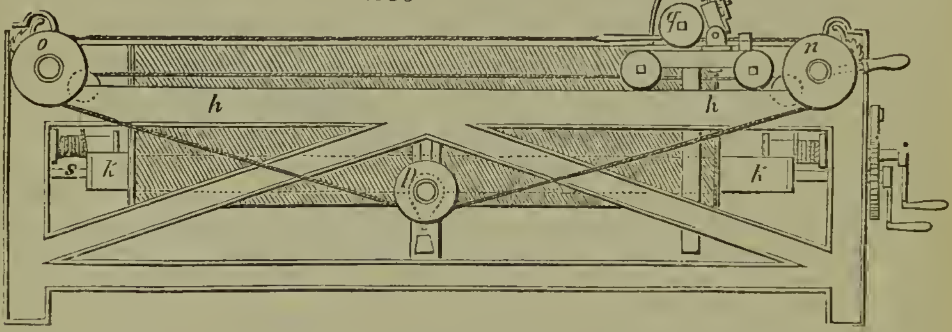
Fig. 1955 is an end view, and *fig.* 1956 is a side view, of Lewis's machine for shearing cloth from list to list. *Fig.* 1957 is an end view of the carriage, with the rotatory cutter detached from the frame of the machine, and upon a larger scale: *a*, is a cylinder of metal, on which is fixed a triangular steel wire; this wire is previously bent round the cylinder in the form of a screw, as represented at *a*, *a*, in *fig.* 1955, and, being hardened, is intended to constitute one edge of the shear or cutter.

1955



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.* 1958 and 1959, as consisting of plates of thin metal cut into narrow slips (*fig.* 1958), or perforated with long holes (*fig.* 1959). Their object is to support the cloth,

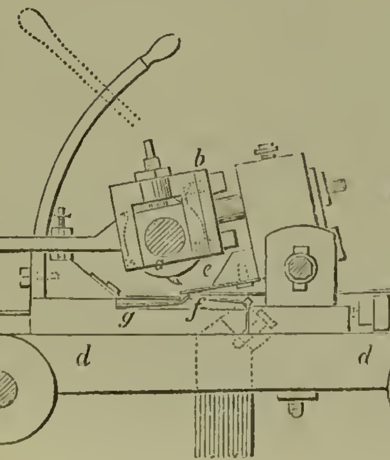
1956



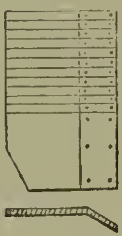
which is intended to pass between them, and operate as a spring bed, bearing the surface of the cloth against the cutters, so that its pile or nap may be cropped off or shorn as the carriage *d* is drawn along the top rails of the standard or frame of the machine *h*, *h*, by means of cords.

1958

1957



1959



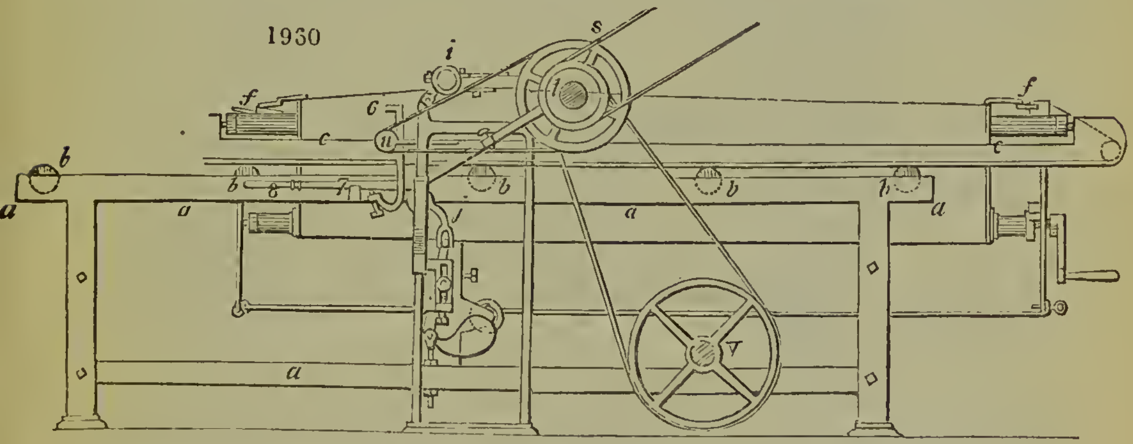
The piece of cloth to be shorn, is wound upon the beam *k*, and its end is then conducted through the machine, between the flat springs *f* and *g* (as shown in *fig.* 1957), to the other beam *l*, and is then made fast; the sides or lists of the cloth being held and stretched by small hooks, called habiting hooks. The cloth being thus placed in the machine, and drawn tight, is held distended 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.* 1957, so 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 *e*, 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. 1960, is a geometrical elevation of one side of Mr. Davis's machine. *Fig.* 1961, a plan or horizontal representation of the same, as seen at top; and *fig.* 1962, 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 runs 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

1930

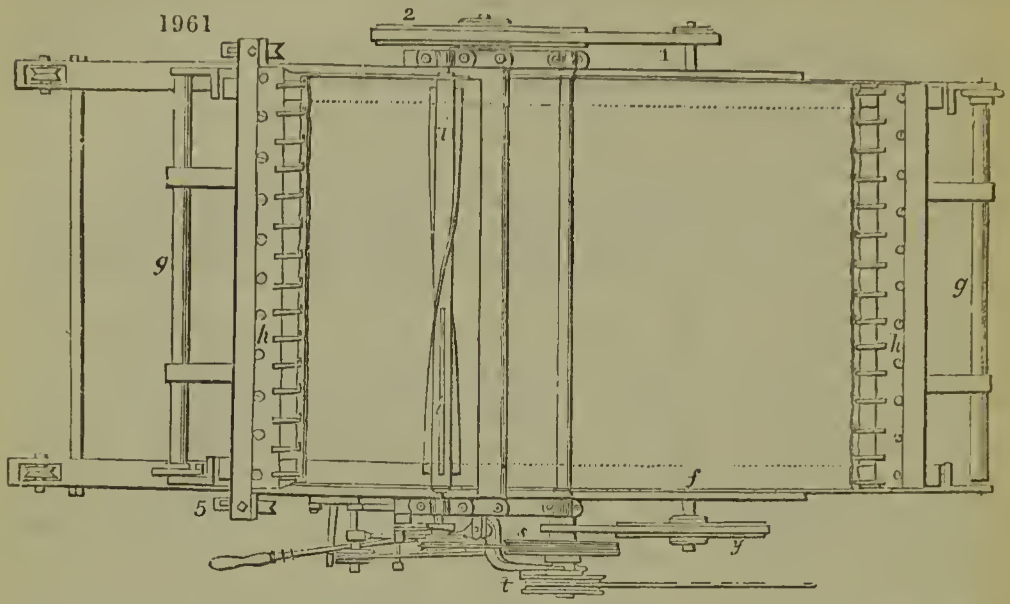


which the cloth intended to be shorn is wound; the two upper lateral rollers *f*, *f*, over which the cloth is conducted and held up; and the two end rollers *g*, *g*, by which the habiting rails *h*, *h*, are drawn tight.

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 hooks 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 slidden along upon the stop 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.

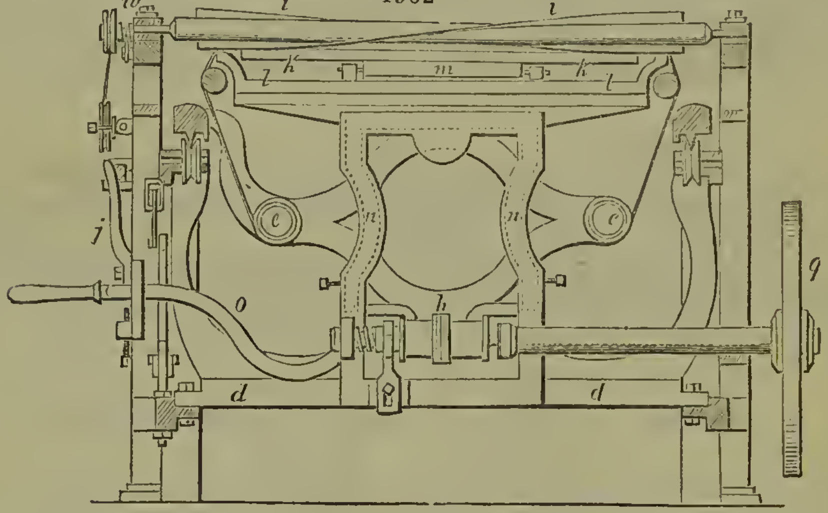
The construction of the bed will be seen by reference to the cross section *fig.* 1962. It consists of an iron or other metal roller, *k*, *k*, turned to a truly cylindrical figure, and covered with cloth or leather, to afford a small degree of elasticity. This roller is mounted upon pivots in a frame, *l*, *l*, and is supported by a smaller roller *m*,

1961



similarly mounted, which roller *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.

1962

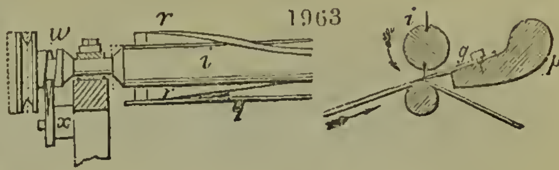


In order to allow the bed *k* to rise and fall, for the purpose of bringing the cloth up to the cutters to be shorn, or lowering it away from them after the operation, the frame *l*, *l*, is made to slide up and down in the grooved standard *n*, *n*, the movable part enclosed within the standard being shown by dots. This standard *n*, 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 rased 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.* 1963.

In this figure is exhibited a portion of the cutters in the same situation as in *fig.* 1957; 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.* 1956. 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.

1963



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 piled 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 the 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 trigger 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.* 1963), 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 1, 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.* 1962. 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.

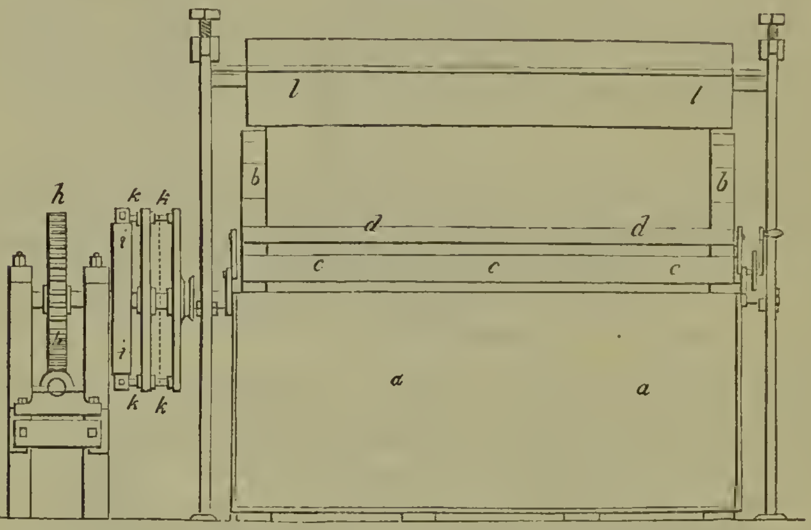
It remains only to point out the contrivance whereby the machinery throws itself out of gear, and stops its operations, when the edge of the cloth or list arrives at the cutters.

At the end of one of the habiting rails *h*, 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 slidden 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.

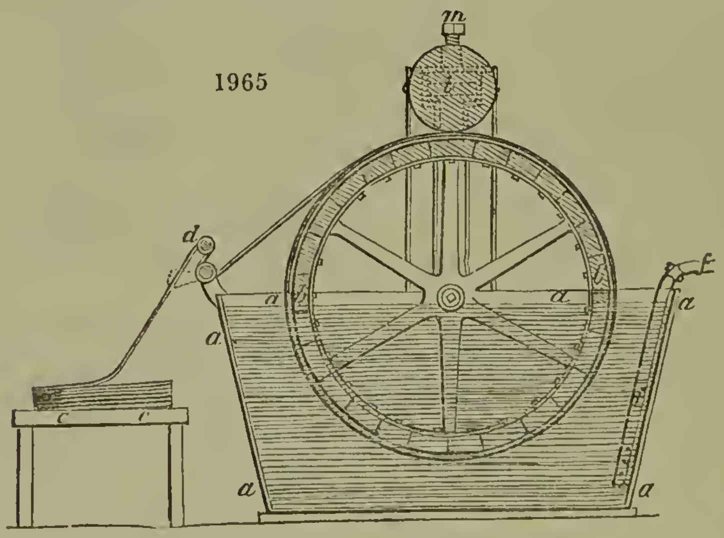
The apparatus which he proposes to employ for carrying on his improved process is shown in the accompanying drawing. *Fig.* 1964, is a front view of the apparatus, complete, and in working order; *fig.* 1965, is a section, taken transversely through the middle of the machine, in the direction of *fig.* 1966; and *fig.* 1966 is an end view of the same. *a*, *a*, *a*, is a vessel or tank, made of iron or wood, or any other suitable

1964



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*, *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.

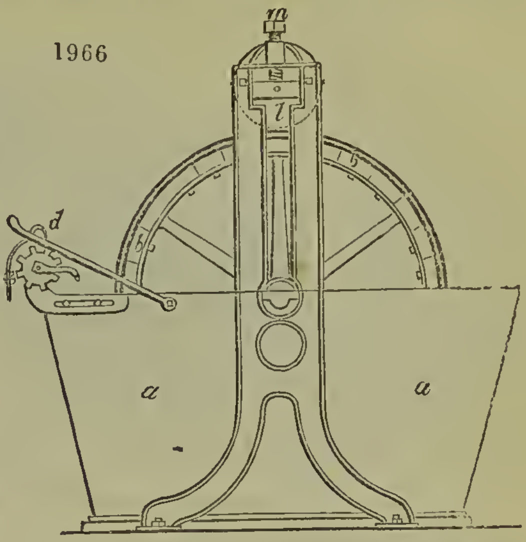
1965



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.* 1965, 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.* 1965, 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.

1966



Uniform rotatory motion to the drum is shown in *fig.* 1964, 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.* 1964, 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.

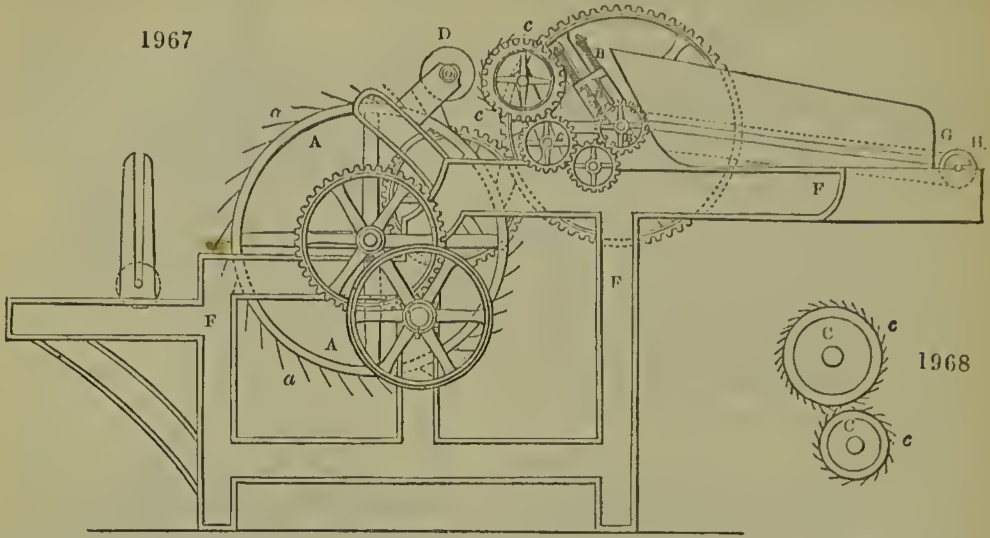
In the cold-water operation he sometimes employs a heavy pressing roller *l*, which being mounted in slots in the frame or standard, revolves with the large drum, rolling over the back of the cloth as it goes round. This roller may be made to act upon the cloth with any required pressure, by depressing 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 pieee 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 consists 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. 1967 is an elevation of a sheeting machine thus constructed:— F F 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

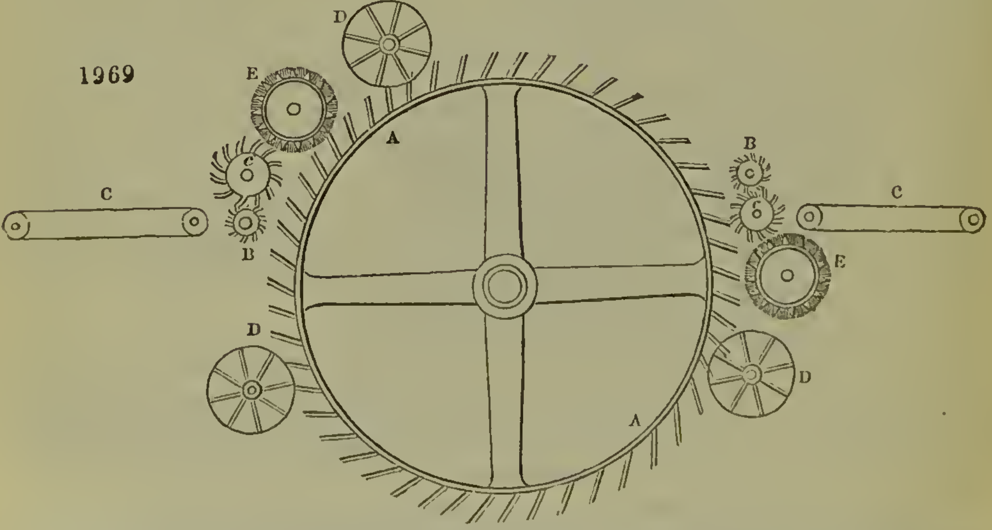
1967



1968

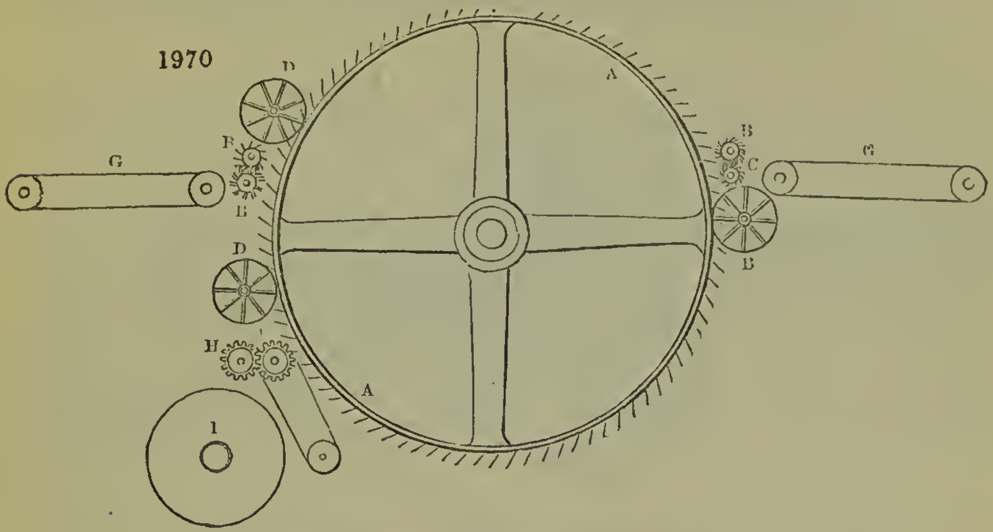
the rows consisting each of a single set of teeth, two, three, or more sets, may be combined together. The number of wires which may be placed on one line should vary with the quality of the wool or other material. In long staple machines, the number may vary from four to ten or more, and in short staple 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.* 1968. 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. D 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 G, which works over the under feed rollers, and a plain roller H, 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.

1969



A modification of this sheeting machine is represented in *figs.* 1969, 1970, 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

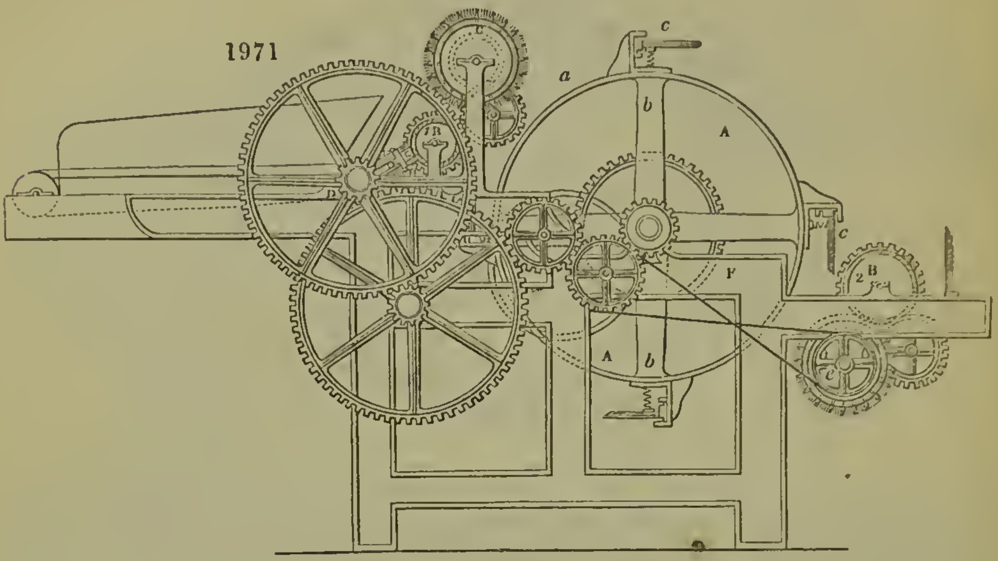
1970



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, in 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.* 1970. H, H, are the drawing or straightening rollers, and I the receiving roller. 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.* 1971 is a side elevation of a comb filling mach ne 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 F, F ; B^1, B^2 are the porcupine combing rollers, and C^1, C^2 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* ; D, D, are the feed-rollers, and E an endless web which runs over the lower feed-roller and the plain roller G, 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 I, I, I, 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 E, 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 B^1 and the brush C^1, the continued revolution of the drum, and combs causes the wool to be brought into contact with the other porcupine combing roller B^2 and brush C^2. 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.

1971



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 heating 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. See Alpaca, Mohair.

WOOTZ, is the Indian name of Steel The Indian wootz is prepared in very rude furnaces, in a most primitive manner, from hematite iron; charcoal being the fuel employed.

WORSTED. Yarns made of wool drawn out into long filaments by passing it, when oiled, through heated combs, as described under Woollen Manufacture, page 1045. Numerous machines have been introduced for combing wool, and they are, for many purposes, very extensively employed; but as far as we can learn there has not yet been introduced a machine which is capable of producing long-fibred wool in any respect equal to that which is prepared by hand.

Of woollen or worsted manufactures our *imports* have been as follows:—

Woollen Manufactures:	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1851.
Cloths of all kinds, coatings, &c. -	2,072,594	2,118,292	1,605,258	1,613,048	1,322,167	1,814,649	2,692,492	2,572,181
Mixed stuffs, flannels, &c.	1,824,525	1,834,350	1,741,839	2,321,692	1,840,038	2,413,625	2,882,607	2,822,961
Worsted stuffs	4,031,704	3,451,165	2,745,666	2,709,639	2,342,911	2,827,933	2,689,042	2,679,003
Other kinds -	275,310	289,117	242,339	251,650	228,712	286,526	324,549	303,038
Total of Woollen Manufactures - -	8,204,133	7,693,310	6,335,102	6,896,038	5,733,828	7,342,723	8,588,690	8,377,183
Woollen and worsted yarn-	958,204	1,066,925	908,270	1,001,364	776,975	1,090,223	1,451.642	1,481,544

Woollen Manufactures:	1852.	1853.	1854.	1855.	1856.	1857.	1858.
Cloths of all kinds, coatings, &c.	2,683,395	2,923,515	3,089,343	2,371,324	2,762,622	3,030,788	2,548,394
Mixed stuffs, flannels &c.	3,015,283	3,641,767	3,050,548	2,503,984	3,220,011	3,699,324	3,388,313
Worsted stuffs	2,733,804	3,106,609	2,565,474	2,368,451	2,833,541	3,325,564	3,326,731
Other kinds -	298,452	500,291	415,403	474,615	684,254	647,699	513,506
Total of Woollen Manufactures - -	8,730,934	10,172,182	9,120,759	7,718,374	9,500,423	10,703,375	9,776,944
Woollen and worsted yarn-	1,430,140	1,456,786	1,557,612	2,026,095	2,889,642	2,941,800	2,966,923

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; also Muriatic Acid.

X.

XANTHINE, the name given by Kuhlmann to the yellow dyeing matter of madder. See Madder.

XYLOIDINE—*Nitramidine*. By acting on starch with fuming nitric acid a transparent jelly is formed, and on adding water xyloidine is precipitated as a white granular substance. Its composition, according to Ballol, is $C^{15}H^{12}O^{16}N$. See Collodion; Gun Cotton.

XYLOLE, $C^{16}H^{10}$, a hydrocarbon found in coal naphtha and in the oils which separate when crude wood-spirit is mixed with water. For a table of its physical properties see Carburetted Hydrogen.

Y.

YARN. (*Fil*, Fr.; *Garn*, Germ.) Wool, cotton, or flax, spun into thread.

YEAST. See Beer, and Fermentation.

YEAST, ARTIFICIAL. Mix 2 parts by weight of fine flour of pale barley malt, with 1 part of wheat flour; stir 50 pounds of this mixture gradually 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 three days. It should be occasionally stirred.

The German yeast imported into this country in large quantities, and employed by our bakers in baking cakes, and other *fancy* bread, is made by putting the *unterhefe* (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 staud 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.) *Annotto dyer's-broom* (*Genista tinctoria*), *fustic*, *fustet*, *Persian* or *French berries*, *quercitron bark*, *saw-wort*, (*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 yttrotantalite, being an oxide of the metal yttrium.

Z.

ZAFFRE. See COBALT. Zaffre *imported* in 1858, 550 cwts.

ZEA. Indian corn or maize.

ZEDOARY. (*Zédoaire*, Fr.; *Zittwer*, Germ.) The root of a plant imported from Ceylon, Malabar, and Cochin-China, employed sometimes medicinally. 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. According to Morin this root contains besides an azotised 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 considerable lustre when broken, 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 process of lamination, at the temperature of from 220° to 300° Fahr., by which it becomes malleable and ductile. 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 degree of condensation to which it has been subjected. It melts under a red heat, at about the 680th or 700th degree of Fahrenheit's scale. When exposed to this temperature 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 this combustion is a white powder, formerly called flowers, but now oxide of zinc; consisting of 32·3 of metal, and 8 of oxygen, being their respective equivalents.

The principal ores of zinc are, the sulphide called *blende*, the silicate called *calamine*, and the sparry calamine, or carbonate.

1. *Blende* crystallises in rhombic dodecahedrons; its fracture is highly conchoidal; lustre, adamantine; colours, black, brown, red, yellow, and green; transparent or translucent; spec. grav. 4. It is a simple sulphide of the metal; and, therefore, consists in its pure state, of 32·3 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 Przibram, remarkable for containing a large proportion of cadmium. Blende is found in great quantities in Derbyshire and Cumberland, as also in Cornwall and many other localities.

2. *Calamine*, or silicate of zinc, is divided into two species; the prismatic or electric calamine, and the rhomboidal; 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 — oxide of zinc, 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 gelatinises on cooling. It emits a green phosphorescent light before the blowpipe. The second species, or rhombohedral calamine, is a carbonate of zinc. Its spec. grav. 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 one equivalent of oxide and one of acid, or $42 + 22 = 64$.

The mineral called *zinc-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 employed in several metallurgic processes, and according to Mitscherlich, occurs crystallised, in six-sided prisms of a yellow colour, in the smelting works of Kœnigshutte, in Silesia.

The zinc ores of England, like those of France, Belgium, 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 considerable quantity of this ore is obtained.

In almost every part of England where 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 mine 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 zechstein 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 4 feet, in consequence of the union of several small ones into a single mass. There were formerly explorations for calamine in the magnesian limestone, 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 Frome. Calamine was chiefly worked in the parishes of Phipham and Roborough, as also near Rickford and Broadfield-Doron, by means of a great number of small shafts. The miners paid for the privilege of working a tax of 1*l.* sterling per annum, to the Lords of the Treasury; and they sold the ores, mixed with a considerable quantity of carbonate of lime, at Phipham, after washing it slightly in a sieve. Very little is at present worked in this district. Calamine is now largely imported into this country from Spain and the United States of America.

Metallurgy of Zinc.

Roasting of Ores.—Blende, or sulphide of zinc is, previous to its treatment for metal, carefully roasted in a reverberatory furnace, over the bottom of which it is spread in a layer of about four inches in thickness. A strong heat is necessary for this purpose, and during the operation the charge is frequently stirred with a strong iron rake, with a view of exposing fresh surfaces to the gases of the furnace. The apparatus most commonly employed in this country for roasting sulphide of zinc consists of a reverberatory furnace about 36 feet in length and 9 feet in width, provided with a fireplace of the usual construction. The sole or hearth of this apparatus is divided into three distinct beds, of which that nearest the fire-bridge is 4 inches lower than that which is next it, which is again 4 inches lower than that nearest the chimney. In addition to the heat derived from the fire-place, the gases escaping from the reducing furnaces are usually introduced immediately before the bridge, and a considerable economy of fuel is thereby effected.

When the furnace has been sufficiently heated a charge of 12 cwt. of raw blende is introduced into the division nearest the chimney and equally spread over the bottom, care being taken to stir it from time to time by means of an iron rake, as before described. After the expiration of about eight hours this charge is worked on to the floor of the compartment forming the middle of the furnace, and a new charge is introduced into the division next the chimney. About eight hours after this charging the ore on the middle bed is worked on to the first, whilst that on the hearth next the chimney is equally spread on the middle one and a new charge introduced into the division next the stack. After the expiration of another period of eight hours the charge on the first hearth is drawn, the ore on the middle and third hearths moved forward, and a fourth charge introduced as before. In this way the operation is continuous and each furnace will effect the calcination of about 36 cwt. of ordinary blende in the course of 24 hours.

Calamine or silicate of zinc is usually prepared for smelting by calcination in a furnace resembling an ordinary lime kiln, the heat being often supplied by means of four fire places arranged externally, and so placed that the heated gases may be drawn into it, and regularly distributed through the interstices existing between the masses of ore. Calamine subjected to this treatment commonly loses abou one-third of its weight, and is at the same time rendered so friable as easily to admit of being reduced to fine powder by an ordinary edge-mill.

Reduction.

Belgian process.—When this method of treating zinc ore is employed the furnace represented in *fig.* 1972 is commonly used.

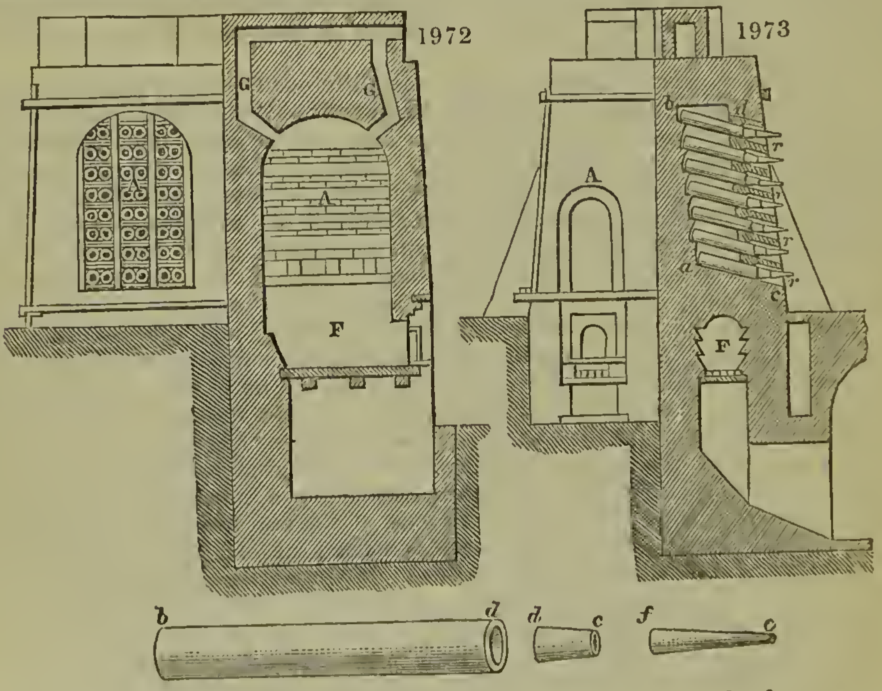


Fig. 1972 represents, on the left hand, a front elevation of the furnace, and on the right a sectional elevation through the ash-pit and fire-place. F is the fireplace, whilst A is the cavity into which are introduced the retorts destined for the distillation of the metal. The products of combustion escape by the openings G into a flue, by which they are conducted into the calciner for the purpose of economising the waste heat. These furnaees are either arranged in couples, back to back, or in groups of four, for the purpose of rendering the structure more solid, and economising heat. In the arched chamber A are placed 48 cylindrical retorts, 3 feet 6 inches in length from *b* to *d*, and 7 inches internal diameter. These are made of refractory fire clay, well baked and supported behind by ledges of masonry *a*, *b*, *fig.* 1973, whilst in front, at *c d*, they rest on fire-clay saddles let into an iron framing. Short conical fire-clay pipes, 10 inches in length from *d* to *c*, are fixed in the mouths of these retorts by means of moistened clay, and project for a short distanc e beyond the mouth of the furnace. To these are adapted thin wrought-iron cones 18 inches in length from *e* to *f*, tapering off at the smaller extremity to an orifice of about three quarters of an inch in diameter. The inclined position of the retorts, the method of adjusting the pipes, and the general arrangement of the apparatus is shown in *fig.* 1973, in which *r*, *r*, *r*, *r*, represent the nozzles of thin wrought iron. When a new furnace is first lighted the retorts are introduced without being previously baked, but care must be taken that they be perfectly dry and seasoned, and for this reason it is necessary to keep a large stock constantly on haud, in a store-house artificially heated by means of some the flues of the establishment. The heat is gradually increased during three or four days, at the end of which period charges of ore are introduced, the clay cones are luted in their places, and the furnaee is brought into full working order. The charge of a furnace consists of 1680 lbs. of roasted blende or calcined calamine and 840 lbs. of coal dust. The ore and eoal dust, after being finally divided and intimately mixed, is slightly damped and subsequently introduced into the retorts by means of a semi-cylindrical scoop, by the aid of which an experienced workman will effect the charging without spilling the smallest quantity of the mixture.

In this country the retorts in the lower tier are usually not charged, as they are extremely liable to be broken, and are therefore only employed to moderate the heat of the furnace. On the Continent, however, the fire-place is frequently covered by a hollow arch, and in that case every retort requires a charge of ore.

The mixture introduced into the retorts varies, to a certain extent, with their position in the furnace, for in spite of every precaution to prevent inequality of temperature, it is found impossible to heat the whole of them alike, and those next the fire, therefore, from being the most strongly heated, are liable to work off first. As soon as the retorts have been charged the clay cones are luted into their places, and earbonic oxide gas, which burns with a blue flame at the mouth of the cones, quickly makes its appearance. The quantity of this gas gradually diminishes, and as soon as the flame assumes a greenish-white hue, and white fumes are observed to be evolved, the sheet-iron cones are put on, and the furnace at once enters into steady action. From time to time, as the iron cones become choked with oxide, they are taken off and gently tapped against some hard substance, so as to remove it, and then replaced. The oxide thus collected is added to the mixture prepared for the next charge. After the expiration of about six hours from the time of charging the wrought iron tubes are suecessively removed, and the metallic zinc scraped from the clay pipes into an iron ladle. This, when full, is skimmed, and the oxide added to that obtained from the nozzles, whilst the pure metal is cast into ingots, weighing about 28 lbs. each. At the expiration of twelve hours from the time of charging the zinc is again tapped, amd the residue remaining in the retorts withdrawn. The retorts are immediately re-charged, and the operation of reduction is conducted as above described.

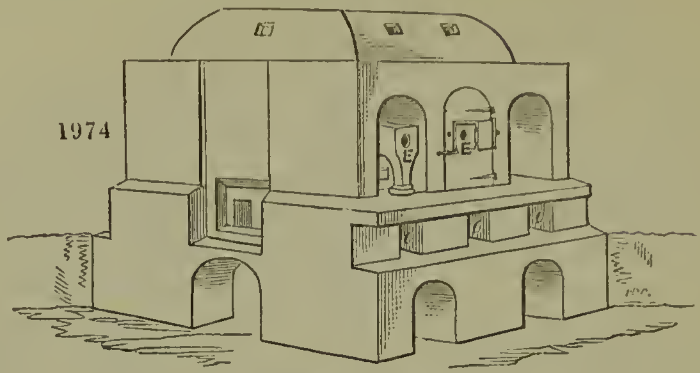
The residues obtained from the retorts, after the first working, are passed through a crushing-mill, mixed with a further quantity of small coal, and again treated for the metal they contain. The carthen adapters or cones, when unfit for further serviee, are crushed and treated as zinc ores.

In order to work these furnaces with economy, it is of the greatest importance that they should be constantly supplied with a full number of retorts, since the amount of fuel consumed, and the general expenses incurred for each furnace, will be the same if the apparatus has its full complement of retorts, or if one half of them are broken and consequently disabled.

It is therefore necessary, in all zinc smelting establishments, to keep a large stoek of well-seasoned retorts, which, before being introduced into the furnace, to make good any defieiency caused by breakage, are heated to full redness in a kiln provided for that purpose. The Belgian process of zinc smelting is that which is at present most employed in this country. The principal localities in which zinc ores are treated are Swansea, Wigan, Llannelly, and Wrexham.

Silesian process.—In the zinc works of Silesia the furnaces employed differ considerably from those used in the Belgian process.

1974



1975

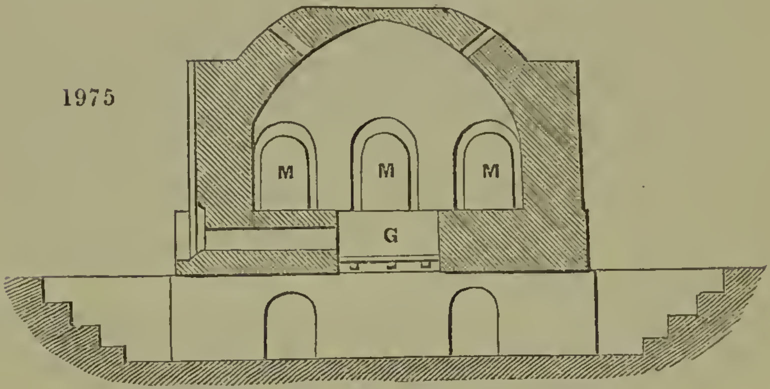
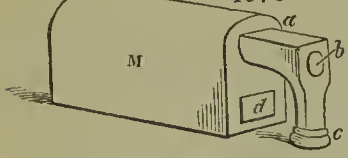


Fig. 1974, represents an elevation, and *fig.* 1975, a vertical section of the Silesian furnace. The distillation is effected in a sort of muffle of baked clay, M, *fig.* 1975, and *figs.* 1976, 1977, about 3 feet 3 inches in length, and 20 inches in height. The front of this muffle is pierced with two apertures. The lower opening, *d*, serves to remove the residues remaining in the retorts after each operation, and is closed during the process of distillation by a small door of baked clay, firmly luted in its place. In the upper opening is introduced a hollow clay arm, bent at right angles, *a*, *b*, *c*, and which remains open at *c*. An opening at *b*, permits of charging the retort by means of a proper scoop, and this, during the operation, is closed by a luted clay plug. From six to ten of these muffles or retorts are arranged in rows, on either side of a furnace provided with suitable apertures for their introduction. They are securely luted in their places, and the openings closed by sheet iron doors, by which the too rapid cooling of the pipe *a*, *b*, *c*, is prevented. The fuel employed is coal, which is burnt on the grate G, situated in the centre of the furnace. The retorts are charged with a mixture of calamine and small coal, or more frequently coke-dust, since, when coal is employed, the products of distillation are found to be liable to choke the pipe *a*, *b*, *c*.

1976

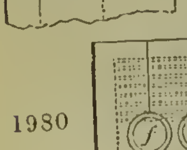


1977

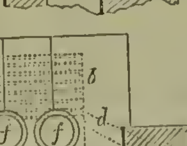
The zinc escapes by the opening *c*, of the adapter, and is received into the cavities *o*, of the furnace.

The furnace shown in *figs.* 1978, 1979, 1980, is for re-melting the metallic zinc. *Fig.* 1979, is a front view; *fig.* 1978, is a transverse section; *fig.* 1980, 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 metal. The heat

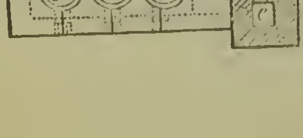
1979



1978



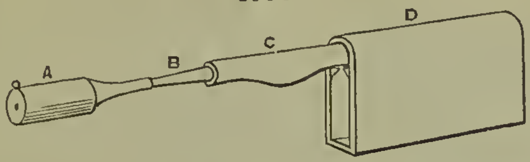
1980



is moderated by the successive addition of pieces of cold zinc. The inside of the pots is sometimes coated with loam, to prevent the iron being attacked by the zinc.

In some establishments, and particularly those at Stolberg in Prussia, the retorts have the form D, represented *fig.* 1981. C is an adapter also of fire clay; B a cone of wrought iron, and A a small vessel of the same material for the collection of the

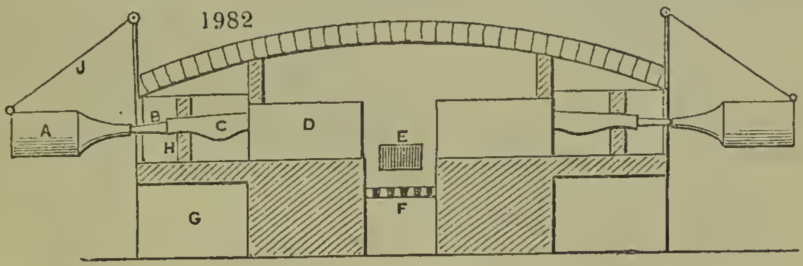
1981



oxide, and furnished in the bottom with an aperture for the escape of the gases generated.

These are arranged on either side of a grate as represented, *fig.* 1982, an internal opening serving for two retorts, and of which there are usually twelve in each furnace. E is the fire-door; F grate; G chamber in masonry of furnace; H diaphragm of fire-brick supporting adapter, in the depressed part of which the metallic zinc is col-

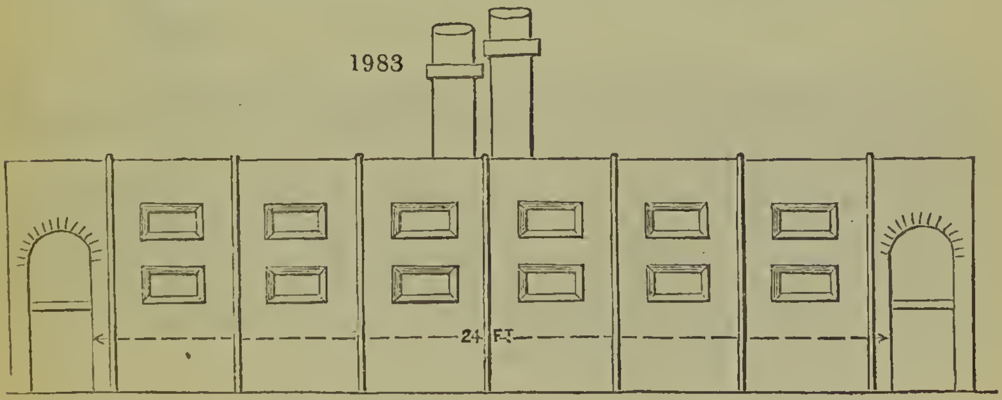
1982



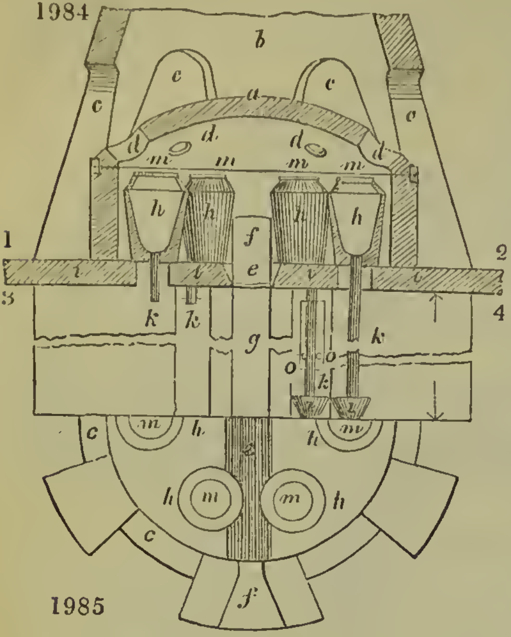
lected and subsequently removed by a scraper, as in the case of the cone of the Belgian retort. The wrought iron vessel A, is supported by a chain or wire J.

Fig. 1983 represents a longitudinal elevation of the roasting furnace employed.

1983



Old English process.—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.* 1984), 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 tongs supported upon two wheels, as is the case with glass-house pots. *c*, is the grate; *f*, the door for 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 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*, *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 pots, when the distillation begins, a long sheet-iron pipe *k*, is joined, which dips at its end into a vessel *l*, for receiving in drops the condensed vapours of the zinc. The pot is charged from above, through an orifice in the lid, which is left open after the firing until the bluish colour of the flames indicates the volatilisation of the metal, immediately whereupon the whole is covered with a fire-tile *m*. The iron tubes are liable to become obstructed during the distillation, and must therefore be occasionally cleared by means of an iron bar. When the operation is terminated the pipes must be removed, and the carbonaceous and other residual matters extracted from the pots.



1984

1985

1, 2 is the level of the upper floor; 3, 4, level of the lower ceiling of the lower floor.

Fig. 1985 ground plan on the level of 1, 2; only one half is here shown. — J. A. P.

The general consumption of Spelter throughout the world is about 67,000 tons per annum, of which about 44,000 tons are made to take the shape of rolled sheets, and these are estimated to be applied as follows, each quantity being somewhat below the truth: —

	Tons.
Roofing and architectural purposes - - -	23,000
Ship sheathing - - - - - -	3,500
Lining packing cases - - - - - -	2,500
Domestic utensils - - - - - -	12,000
Ornaments - - - - - - -	1,500
Miscellaneous - - - - - - -	1,500
	44,000

Fifteen years ago the quantity used for roofing did not exceed 5,000 tons; none was employed for ship sheathing or lining packing cases, and stamped ornaments in zinc date only from 1852.

From the low temperature at which zinc fuses, and from the sharpness of impressions possessed by castings in this metal it is much employed on the continent for the production of statues and statuettes. The uses of this metal in the preparation of alloys has already been noticed under the head of alloys. It is also employed like tin for coating iron, producing what is known as galvanised iron. The *disenfectant liquor* of Sir W. Burnett, is chloride of zinc, and the oxide of this metal is much employed as a pigment in place of white lead.

Zinc or Spelter *imports* in 1858: —

Crude in cakes.	Tons.	
Denmark - - - - - -	271	Computed real value. £470,195.
Prussia - - - - - -	9,034	
Hamburg - - - - - -	8,413	
Holland - - - - - -	1,259	
Belgium - - - - - -	240	
Other Parts - - - - -	302	
	19,519	

Rolled, but not otherwise manufactured.	Tons.	
Denmark - - - - - -	47	Computed real value. £128,738.
Prussia - - - - - -	304	
Belgium - - - - - -	3,818	
Other parts - - - - -	37	
	4,206	

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 Pül, 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 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.

ZINCING 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 zinc 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.

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.

Under the article Crushing and Grinding Machinery will be found descriptions of several crushers. The wood-cut, *fig.* 1986 represents a small high-pressure engine, devised by Mr. T. B. Jordan, for driving crushing apparatus.

1986