Wm M. Darlington

A

DICTIONARY

OF

ARTS, MANUFACTURES,

AND

MINES;

CONTAINING

A CLEAR EXPOSITION OF THEIR PRINCIPLES AND PRACTICE.

BY

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PERFUMERY, ART OF (*Parfumerie*, Fr.; *Wohlriechende-kunst*, Germ.), consists in the preparation of different products, such as fats or pommades, essential oils, distilled spirits, pastes, pastilles, and essence.

Fats ought to be pounded in a marble mortar, without addition of water, till all the membranes be completely torn; then subjected to the heat of a water-bath in a proper vessel. The fat soon melts, and the albumen of the blood coagulating, carries with it all the foreign substances; the liquid matter should be skimmed, and passed through a canvass filter.

Of pommades by infusion.—Rose, orange-flower, and cassia. Take 334 pounds of hog's lard, and 166 of beef suet. These 500 pounds are put into a pan called *bugadier;* and when melted, 150 pounds of rose-leaves nicely plucked are added, taking care to stir the mixture every hour. The infusion thus prepared is to remain at rest for 24 hours; at the end of this time, the pommade is again melted, and well stirred to prevent its adherence to the bottom of the melting-pan. The mass is now to be poured out into canvass, and made into rectangular bricks or loaves, which are subjected to a press, in order to separate the solid matter from the soft pommade. These brick-shaped pieces being put into an iron-bound barrel perforated all over its staves, the pommade is to be allowed to exude on all sides, and flow down into a copper vessel placed under the trough of the press. This manipulation should be repeated with the same fat ten or twelve times; or in other words, 3000 pounds of fresh rose-leaves should be employed to make a good pommade.

The pommade of orange-flowers is made in the same manner, as also the pommade of cassia.

Of pommades without infusion.—Jasmine, tuberose, jonquil, narcissus, and violet.

A square frame, called *tiame,* is made of four pieces of wood, well joined together, 2 or 3 inches deep, into which a pane of glass is laid, resting upon inside ledges near the bottom. Upon the surface of the pane the simple pommade of hog's lard and suet is spread with a pallet knife; and into this pommade the sweet-scented flowers are stuck fresh in different points each successive day, during two or three months, till the pommade has acquired the desired richness of perfume. The above-described frames are piled closely over each other. Some establishments at *Grasse* possess from 3000 to 4000 of them.

Of oils.—Rose, orange-flower, and cassia oils, are made by infusion, like the pommades of the same perfumes; taking care to select oils perfectly fresh. As to those of jasmine, tuberose, jonquil, violet, and generally all delicate flowers, they are made in the following manner. Upon an iron frame, a piece of cotton cloth is stretched, imbued with olive oil of the first quality, and covered completely with a thin bed of flowers. Another frame is similarly treated, and in this way a pile is made. The flowers must be renewed till the oil is saturated with their odor. The pieces of cotton cloth are then carefully pressed to extrude the oil. This last operation requires commonly 7 or 8 days.

Of distillation.—The essential oils or essences, of which the great manufacture is in the south of France, are of rose, neroli, lavender, lemon thyme, common thyme, and rosemary. For the mode of distilling the essential oils, see OILS, ESSENTIAL.

The essence of roses being obtained in a peculiar manner, I shall describe it here. Put into the body of a still 40 pounds of roses, and 60 quarts of water; distil off one half of the water. When a considerable quantity of such water of the first distillation is obtained, it must be used as water upon fresh rose-leaves; a process of repetition to be carried to the fifth time. In the distillation of orange-flower, to obtain the essence of neroli, the same process is to be followed; but if orange-flower water merely be wanted, then it is obtained at one distillation, by reserving the first fifth part of water that comes over. What is called the essence of *petit-grain,* is obtained by distilling the leaves of the orange shrub. The essences of lavender, thyme, &c., present nothing peculiar in their mode of extraction.

OF SCENTED SPIRITS,

From oil of rose, orange, jasmine, tuberose, cassia, violet, and other flowers.

Into each of three digesters, immersed in water-baths, put 25 lbs. of any one of these oils, and pour into the first digester 25 quarts of spirit of wine; agitate every quarter of an hour during three days, and at the end of this period, draw off the perfumed spirit, and pour it into the second digester; then transfer it after 3 days into the third digester, treating the mixture in the same way; and the spirit thus obtained will be perfect. The digesters must be carefully covered during the progress of these operations. On pursuing the same process with the same oil and fresh alcohol, essences of inferior qualities may be obtained, called Nos. 2, 3, and 4.

Some perfumers state that it is better to use highly scented pommades than oils; but there is probably little difference in this respect.

Esprit de Suave.

7 Eng. qrts. of spirit of jasmine, 3d operation.
7 — cassia, —
3 — wine.
2 — tuberose, —
1½ ounce essence of cloves.
½ ounce fine neroli.
1½ ounce essence of bergamot.
8 ounces essence of musk, 2d infusion.
3 quarts rose water.

Spirit of Cytherea.

1 quart spirit of violets.
1 — jasmine, 2d operation.
1 — tuberose, —
1 — clove gillyflower.
1 — roses, 2d operation.
1 — Portugal.
2 — orange-flower water.

Spirit of flowers of Italy.

2 quarts spirit of jasmine, 2d operation.
2 — roses, —
2 — oranges, 3d —
2 quarts spirit of cassia, 2d operation.
1½ — orange flower water.

The above spirits mark usually 28 alcometric degrees of Gay Lussac. See ALCOHOL.

POMMADES.

No less than 20 scented pommades are distinguished by the perfumers of Paris. The essences commonly employed in the manufacture of pommades, are those of bergamot, lemons, *cédrat*, *limette* (sweet lemon), Portugal, rosemary, thyme, lemon thyme, lavender, marjoram, and cinnamon.

The following may serve as an example:—

Pommade à la vanille, commonly called Roman.

12 pounds of pommade à la rose.
3 — oil à la rose.
1 — vanilla, first quality, pulverized.
6 ounces bergamot.

The pommade being melted at the heat of a water-bath, the vanilla is to be introduced with continual stirring for an hour. The mixture is left to settle during two hours. The pommade is then to be drawn off, and will be found to have a fine yellow color, instead of the brown shade which it commonly has.

In making odoriferous extracts and waters, the spirits of the flowers prepared by macerating the flowers in alcohol should be preferred to their distillation, as forming the foundation of good perfumery. The specific gravity of these spirits should be always under 0·88.

Extract of Nosegay (bouquet).

2 quarts spirit of jasmine, 1st operation.
2 — extract of violets.
1 — spirit of cassia, 1st —
1 — roses, - 1st —
1 — orange, - 1st —
1 — Extract of clove gillyflower.
4 drms. of flowers of benzoin (benzoic acid).
8 ounces of essence of amber, 1st infusion.

Extract of peach blossoms.

6 quarts of spirits of wine.
6 pounds of bitter almonds.
2 quarts of spirits of orange flower, 2d operation.
4 drachms of essence of bitter almonds.
4 drachms of balsam of Peru.
4 ounces of essence of lemons.

Eau de Cologne.

Two processes have been adopted for the preparation of this perfume, distillation and infusion; the first of which, though generally abandoned, is, however, the preferable one. The only essences which should be employed, and which have given such celebrity to this water, are the following; bergamot, lemon, rosemary, Portugal, neroli. The whole of them ought to be of the best quality, but their proportions may be varied according tc the taste of the consumers.

Thirty different odors are enumerated by perfumers; the three following recipes will form a sufficient specimen of their combinations.

Honey-water.

6 quarts of spirit of roses, 3d operation.
3 do. jasmine.
3 do. spirits of wine.
3 ounces essence of Portugal.
4 drachms flowers of benzoin.
12 ounces of essence of vanilla, 3d infusion.
12 do. musk, do.
3 quarts good orange-flower water.

Eau de mille fleurs.

18 quarts of spirits of wine.
4 ounces balsam of Peru.
8 do. essence of bergamot.
4 do. cloves.
1 do. ordinary neroli.
1 do. thyme.
8 do. musk, 3d infusion.
4 quarts orange flower water.

Eau de mousseline.

2 quarts spirit of roses, 3d infusion.	2 ounces essence of vanilla, 3d infusion.
2 do. jasmine, 4th do.	2 do. musk, do.
1 do. clove gillyflower.	4 drachms of sanders wood.
2 do. orange flower, 4th do	1 quart of orange-flower water.

Almond pastes.

These are, gray, sweet white, and bitter white.

The first is made either with the kernels of apricots, or with bitter almonds. They are winnowed, ground, and formed into loaves of 5 or 6 pounds weight, which are put into the press in order to extract their oil; 300 pounds of almonds affording about 130 of oil. The pressure is increased upon them every two hours during three days; at the end of which time the loaves or cakes are taken out of the press to be dried, ground, and sifted.

The second paste is obtained by boiling the almonds in water till their skins are completely loosened; they are next put into a basket, washed and blanched; then dried, and pressed as above.

The third paste is prepared like the second, only using bitter almonds.

Liquid almond pastes, such as those of the rose, orange, vanilla, and nosegay. The honey paste is most admired. It is prepared as follows;—

6 pounds of honey.	12 pounds oil of bitter almonds.
6 do. white bitter paste.	26 yolks of eggs.

The honey should be heated apart and strained; 6 pounds of almond paste must then be kneaded with it, adding towards the conclusion, alternately, the quantity of yolks of eggs and almond oil indicated.

Pastilles à la rose, orange flower, and vanilla.

Pastilles à la rose.	*Pastilles of orange flower.*
12 ounces of gum.	12 ounces of gum galbanum.
12 do. olibanum, in tears.	12 do. olibanum, in tears.
12 do. storax, do.	12 do. storax, do.
8 do. nitre.	8 do. nitre.
16 do. powder of pale roses.	1 pound of pure orange powder.
3 pounds 14 do. charcoal powder.	3 do. 14 ounces charcoal powder.
1 do. essence of roses.	1 ounce superfine neroli.

Pastilles à la vanille.

12 ounces of gum galbanum.	16 ounces powder of vanilla.
12 do. olibanum, in tears.	3 pounds 14 ounces charcoal powder.
12 do. storax do.	4 drms. essence of cloves.
8 do. nitre.	8 ounces do. vanilla, 1st infusion.
8 do. cloves.	

The above mixture in each case is to be thickened with 2 ounces of gum tragacanth dissolved in 2 pints of rose water. It is needless to say that the ingredients of the mixture should be impalpable powders.

Scented cassolettes.

8 pounds of black amber (ambergris).	1 ounce essence of roses.
4 do. rose powder.	1 do. gum tragacanth.
2 ounces of benzoin.	A few drops of the oil of sanders wood.

These ingredients are pulverized, and made into a cohesive paste with the gum.

ESSENCES BY INFUSION.

Essence of musk.

5 ounces of musk from the bladder, cut small.
1 do. civet.
4 quarts of spirit of ambrette (purple sweet sultan).

The whole are put into a matrass, and exposed to the sun for two months during the hottest season of the year. In winter, the heat of a water bath must be resorted to.

Essence of vanilla.

3 pounds of vanilla in branches, 1st quality, cut small.
4 quarts spirit of ambrette.
2 drachms of cloves.
½ do. musk from the bladder.

The same process must be followed as for the essence of musk.

Essence of Ambergris.

4 ounces of ambergris.
2 ounces of bladder musk.
8 quarts of spirit of ambrette.
Treat as above.

Spirit of ambrette (purple sweet sultan).

25 pounds of ambrette are to be distilled with 25 quarts of spirits of wine, adding 12 quarts of water, so as to be able to draw off the 25 quarts.

PERRY is the fermented juice of pears, prepared in exactly the same way as CIDER.

PERSIAN BERRIES. See BERRIES, PERSIAN.

PETROLEUM. See NAPTHA.

PE-TUNT-SE is the Chinese name of the fusible earthy matter of their porcelain. It is analogous to our Cornish stone.

PEWTER, PEWTERER. (*Potier d'étain*, Fr.) Pewter is, generally speaking, an alloy of tin and lead, sometimes with a little antimony or copper, combined in several different proportions, according to the purposes which the metal is to serve. The English tradesmen distinguish three sorts, which they call plate, trifle, and ley pewter; the first and hardest being used for plates and dishes; the second for beer-pots; and the third for larger wine measures. The plate pewter has a bright silvery lustre when polished; the best is composed of 100 parts of tin, 8 parts of antimony, 2 parts of bismuth, and 2 of copper. The trifle is said by some to consist of 83 of tin, and 17 of antimony; but it generally contains a good deal of lead. The ley pewter is composed of 4 of tin, and 1 of lead. As the tendency of the covetous pewterer is always to put in as much of the cheap metal as is compatible with the appearance of his metal in the market, and as an excess of lead may cause it to act poisonously upon all vinegars and many wines, the French government long ago appointed Fourcroy, Vauquelin, and other chemists, to ascertain by experiment the proper proportions of a safe pewter alloy. These commissioners found that 18 parts of lead might, without danger of affecting wines, &c., be alloyed with 82 parts of tin; and the French government in consequence passed a law requiring pewterers to use 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.

The pewterer fashions almost all his articles by casting them in moulds of brass or bronze, which are made both inside and outside in various pieces, nicely fitted together, and locked in their positions by ears and catches or pins of various kinds. The moulds must be moderately heated before the pewter is poured into them, and their surfaces should be brushed evenly over with pounce powder (sandarach) beaten up with white of egg. Sometimes a film of oil is preferred. The pieces, after being cast, are turned and polished; and if any part needs soldering, it must be done with a fusible alloy of tin, bismuth, and lead.

Britannia metal, the kind of pewter of which English tea-pots are made, is said to be an alloy of equal parts of brass, tin, antimony, and bismuth; but the proportions differ in different workshops, and much more tin is commonly introduced. Queen's metal is said to consist of 9 parts of tin, 1 of antimony, 1 of bismuth, and 1 of lead; it serves also for 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. The English ley pewter contains often much more than 20 per cent. of lead. Under TIN, will be found the description of an easy method of analyzing its lead alloys.

PHOSPHORIC ACID is the acid formed by the vivid combustion of

PHOSPHORUS. This interesting simple combustible, being an object of extensive consumption, and therefore of a considerable chemical manufacture, I shall describe the requisite manipulations for preparing it at some detail. Put 1 cwt. of finely ground bone-ash, such as is used by the assayers, into a stout tub, and let one person work it into a thin pap with twice its weight of water, and let him continue to stir it constantly with a wooden bar, while another person pours into it, in a uniform but very slender stream, 78 pounds of concentrated sulphuric acid.

The heat thus excited in the dilution of the acid, and in its reaction upon the calcareous base, is favorable 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 syphon from the deposite 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 deposite in another, and thereby saves fuel in evaporation.

The collected liquors being put into a leaden, or preferably a copper pan, of proper dimensions, are to be concentrated by steady ebullition, till the calcareous deposite becomes considerable; after the whole has been allowed to cool, the clear liquor is to be run off, the sediment removed, and thrown on a filter. The evaporation of the clear liquor is to be urged till it acquires the consistence of honey. Being now weighed, it should amount to 37 pounds. One fourth of its weight of charcoal in fine powder, that is, about 9 pounds, are then to be incorporated with it, and the mixture is to be evaporated to dryness in a cast-iron pot. A good deal of sulphurous acid is disengaged along with the steam at first, from the reaction of the sulphuric acid upon the charcoal, and afterwards some sulphureted hydrogen. When the mixture has become perfectly dry, as shown by the redness of the bottom of the pot, it is to be allowed to cool, and packed tight into stoneware jars fitted with close covers, till it is to be subjected to distillation. For this purpose, earthen retorts of the best quality, and free from air-holes, must be taken, and evenly luted over their surface with a compost of fire-clay and horse-dung. When the coating is dry and sound, the retort is to be two thirds filled with the powder, and placed upon proper supports in the laboratory of an air-furnace, having its fire placed not immediately beneath the retort, but to one side, after the plan of a reverberatory; whereby the flame may play uniformly round the retort, and the fuel may be supplied as it is wanted, without admitting cold air to endanger its cracking. The gallery furnace of the palatinate (under 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 sulphureted hydrogen makes its appearance, and next phosphureted 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 oxyde gas, along with sulphureted, carbureted, and phosphureted 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 vials 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 color, is nearly transparent, brittle when cold, soft and pliable, like wax, at the temperature of 70° F., crystallizing in rhombo-dodecahedrons out of its combination with sulphur, and of specific gravity 1·77. It exhales white fumes in the air, which have a garlic smell, appear luminous in the dark, and spontaneously condense into liquid phosphorous acid. Phosphorus melts in close vessels, at 95° F., into an oily-looking colorless 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 color 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 oxydized, and burns with great vehemence and splendor.

Inflammable match-boxes (*briquets phosphoriques*) are usually prepared by putting into a small vial of glass or lead a bit of phosphorus, and oxydizing it slightly by stirring it round with a redhot 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-vials. Take one part of fine dry cork raspings, 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 vial half filled with this oil, being shaken and suddenly uncorked, will give light enough to see the dial of a watch by night.

There are five combinations of phosphorus and oxygen:—1. the white oxyde; 2. the red oxyde; 3. hypophosphorous acid; 4. phosphorous acid; 5. phosphoric acid. The last is the only one of interest in the arts. It may be obtained from the sirupy superphosphate of lime above described, by diluting it with water, saturating with carbonate of ammonia; evaporating, crystallizing, and gently igniting the salt in a retort. The ammonia is volatilized, and may be condensed into water by a Woulfe's apparatus, while the phosphoric acid remains in the bottom of the retort. Phosphoric acid may be more readily produced by burning successive bits of phosphorus in a silver saucer, under a great bell jar inverted upon a glass plate, so as to admit a little air to carry on the combustion. The acid is obtained in a fine white snowy deposite; consisting, in this its dry state, of 44 of phosphorus and 56 of oxygen. That obtained from the sirupy solution is a hydrate, and contains 9·44 per cent. of water. If the atom of phosphorus be called 32 upon the hydrogen radix, then 5 atoms of oxygen = 40 will be associated with it in the dry acid, = 72; and an additional atom of water = 9, in the hydrate, will make its prime equivalent 81. Phosphorous acid seems to contain no more than 3 atoms of oxygen.

The only salts of this acid much in demand, are the phosphate of soda, and the ammonia phosphate of soda. The former is prepared by slightly supersaturating superphosphate of lime with crystals of carbonate of soda; warming the solution, filtering, evaporating, and crystallizing. It is an excellent purgative, and not unpalatable. The triple phosphate is used in docimastic operations; and is described under METALLURGY.

PICAMARE, is a thick oil, one of the six new principles detected by M. Reichenbach, in wood-tar. See CREOSOTE and PARAFFINE. Picamare constitutes 1-6th of beech-tar.

PICROMEL, is the name given by M. Thenard to a black bitter principle which he supposed to be peculiar to the bile. MM. Gmelin and Tiedemann have since called its identity in question.

PICROTOXINE, is an intensely bitter poisonous vegetable principle, extracted from the seeds of the *Menispermum cocculus*, (Cocculus Indicus). It crystallizes in small white needles, or columns; dissolves in water and alcohol. It does not combine with acids, but with some bases, and is not, therefore, of an alkaline nature, as had been at first supposed.

PIGMENTS, VITRIFIABLE, belong to five different styles of work: 1. to enamel painting; 2. to painting on metals; 3. to painting on stoneware; 4. to painting on porcelain; 5. to stained glass.

PIMENTO (*Myrtus pimenta*, or Jamaica pepper) consists, according to Bonastre's complicated analysis, of—

	Shells or capsules.	Kernels.
Volatile oil	10·0	5·0
Soft green resin	8·0	2·5
Fatty concrete oil	0·9	1·2
Extract containing tannin	11·4	39·8
Gum	3·0	7·2
Brown matter dissolved in potash	4·0	8·0
Resinoid matter	1·2	3·2
Extract containing sugar	3·0	8·0
Gallic and malic acids	0·6	1·6
Vegetable fibre	50·0	16·0
Ashes charged with salts	2·8	1·9
Moisture and loss	4·1	4·8

Pimento imported for home consumption, in	1835.	1836.
Duty—British possessions, 5*d.*; foreign, 1*s.* 3*d.*	Lbs. 344,458.	400,914.

PINCHBECK is a modification of brass; see that article and COPPER.

PINE-APPLE YARN and CLOTH. In Mr. Zincke's process, patented in December, 1836, for preparing the filaments of this plant, the *Bromelia 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 be obtained, which are to be freed by washing from the green fecula. The fibrous part must next be laid straight, and passed between wooden rollers. The leaves should be gathered between the time of their full maturity and the ripening of the fruit. If earlier or later, the fibres will not be so flexible, and will need to be cleared by a boil in soapy water for some hours; after being laid straight under the pressure of a wooden grating, to prevent their becoming entangled. When well washed and dried, with occasional shaking out, they will now appear of a silky fineness. They may be then spun into porous rovings, in which state they are most conveniently bleached by the ordinary methods.

Specimens of cambric, both bleached and unbleached, woven with these fibres, have been recently exhibited, which excited hopes of their rivalling the finest flax fabrics, but in my opinion without good reason, on account of their want of strength.

PINEY TALLOW is a concrete fat obtained by boiling with water the fruit of the *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 alkalis, and forms excellent candles. Dr. Benjamin Babington, to whom we are indebted for all our knowledge of piney tallow, found its ultimate constituents to be, 77 of carbon, 12·3 of hydrogen, and 10·7 of oxygen.

PIN MANUFACTURE. (*Fabrique d'épingles*, Fr.; *Nadelfabrik*, Germ.) A pin is a small bit of wire, commonly brass, with a point at one end, and a spherical head at the other. In making this little article, there are no less than fourteen distinct operations.

1. *Straightening the wire.* The wire, as obtained from the drawing-frame, is wound about a bobbin or barrel, about 6 inches diameter, which gives it a curvature that must be removed. The straightening engine is formed by fixing 6 or 7 nails upright in a waving line on a board, so that the void space measured in a straight line between the first three nails may have exactly the thickness of the wire to be trimmed; and that the other nails may make the wire take a certain curve line, which must vary with its thickness. The workman pulls the wire with pincers through among these nails, to the length of about 30 feet, at a running draught; and after he cuts that off, he returns for as much more; he can thus finish 600 fathoms in the hour. He next cuts these long pieces into engths of 3 or 4 pins. A day's work of one man amounts to 18 or 20 thousand dozen of pin-lengths.

2. *Pointing* is executed on two iron or steel grindstones, by two workmen, one of whom roughens down, and the other finishes. Thirty or forty of the pin wires are applied to the grindstone at once, arranged in one plane, between the two forefingers and thumbs of both hands, which dexterously give them a rotatory movement.

3. *Cutting these wires into pin-lengths.* This is done by an adjusted chisel. The intermediate portions are handed over to the *pointer.*

4. *Twisting of the wire for the pin-heads.* These are made of a much finer wire, coiled into a compact spiral, round a wire of the size of the pins, by means of a small lathe constructed for the purpose.

5. *Cutting the heads.* Two turns are dexterously cut off for each head, by a regulated chisel. A skilful workman may turn off 12,000 in the hour.

6. *Annealing the heads.* They are put into an iron ladle, made redhot over an open fire, and then thrown into cold water.

7. *Stamping or shaping the heads.* This is done by the blow of a small ram, raised by means of a pedal lever and a cord. The pin-heads are also fixed on by the same operative, who makes about 1500 pins in the hour, or from 12,000 to 15,000 per diem; exclusive of one thirteenth, which is always deducted for waste in this department, as well as in the rest of the manufacture. Cast heads, of an alloy of tin and antimony, were introduced by patent, but never came into general use.

8. *Yellowing or 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 or 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 labor; 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 labor, but several beautiful inventions have been employed to make them entirely or in a great measure by machinery; the consumption for home sale and export amounting to 15 millions daily, for this country alone. One of the most elaborate and apparently complete is that for which Mr. L. W. Wright obtained a patent in May, 1824. A detailed description of it will be found in the 9th volume of Newton's London Journal. The following outline will give my readers an idea of the structure of this ingenious machine:—

The rotation of a principal shaft, mounted with several cams, gives motion to various sliders, levers, and wheels, which work the different parts. A slider pushes pincers forwards, which draw wire from a reel, at every rotation of the shaft, and advance such a length of wire as will produce one pin. A 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.

I believe the chief objection to the raising of the heads by strong mechanical compression upon the pins, is the necessity of softening the wire previously; whereby the pins thus made, however beautiful to the eye, are deficient in that stiffness which is so essential to their employment in many operations of the toilet.

PIPERINE is a crystalline principle extracted from black pepper by means of alcohol. It is colorless, has hardly any taste, fuses at 212° F.; is insoluble in water, but soluble in acetic acid, ether, and most readily in alcohol.

PITCH, MINERAL, is the same as BITUMEN and ASPHALT.

PITCH *of wood-tar* (*Poix*, Fr.; *Pech*, Germ.) is obtained by boiling tar in an open iron pot, or in a still, till the volatile matters be 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. It melts in boiling water, and dissolves in alcohol and oil of turpentine, as well as in carbonated or caustic alkaline leys. For PYRETINE, see the mode of preparing it from birch wood, for the purpose of preparing *Russia* LEATHER.

PITCOAL. (*Houille*, Fr.; *Steinkohle*, Germ.) This is by far the most valuable of mineral treasures, and the one which, at least in Great Britain, makes all the others available to the use and comfort of man. Hence it has been searched after with unremitting diligence, and worked with all the lights of science, and the resources of art.

The Brora coal-field in Sutherlandshire is the most remarkable example in this, or in perhaps any country hitherto investigated, of a pseudo coal-basin among the deeper secondary strata, but above the new sandstone or red marl formation. The Rev. Dr. Buckland and Mr. C. Lyell, after visiting it in 1824, had expressed an opinion that the strata there were wholly unconnected with the proper coal formation below the new red sandstone, and were in fact the equivalent of the oolitic series; an opinion fully confirmed by the subsequent researches of Mr. Murchison. (*Geol. Trans.* for 1827, p. 293.) The Brora coal-field forms a part of those secondary deposites which range along the south-east coast of Sutherlandshire, occupying a narrow tract of about twenty miles in length, and three in its greatest breadth.

One stratum of the Brora coal-pit is a coal-shale, composed of a reed-like striated plant of the natural order *Equisetum*, which seems to have contributed largely towards the formation of that variety of coal. From this coal-shale, the next transition upwards is into a purer bituminous substance approaching to *jet*, which constitutes the great bed of coal. This is from 3 feet 3 inches to 3 feet 8 inches thick, and is divided nearly in the middle by a thin layer of impure indurated shale charged with pyrites, which, if not carefully excluded from the mass, sometimes occasions spontaneous combustion upon exposure to the atmosphere; and so much, indeed, is that mineral disseminated throughout the district, that the shales might be generally termed "pyritiferous." Inattention on the part of the workmen, in 1817, in leaving a large quantity of this pyritous matter to accumulate in the pit, occasioned a spontaneous combustion, which was extinguished only by excluding the air; indeed, the coal-pit was closed in and remained unworked for four years. The fires broke out again in the pit in 1827.

The purer part of the Brora coal resembles common pitcoal; but its powder has the red ferruginous tinge of pulverized lignites. It may be considered one of the last links between lignite and true coal, approaching very nearly in character to jet, though less tenacious than that mineral; and, when burnt, exhaling but slightly the vegetable odor so peculiar to all imperfectly bituminized substances. The fossil remains of shells and plants prove the Brora coal to be analogous to that of the eastern moorlands of Yorkshire, although the extraordinary thickness of the former, compared with any similar deposite of the latter (which never exceeds from 12 to 17 inches), might have formerly led to the belief that it was a detached and anomalous deposite of true coal, rather than a lignite of any of the formations *above* the new red sandstone: such misconception might more easily arise in the infancy of geology, when the strata were not identified by their fossil organic remains.

On the coast of Yorkshire the strata of this pseudo coal formation appear in the follow ing descending order, from Filey Bay to Whitby. 1. Coral-rag. 2. Calcareous grit. 3. Shale, with fossils of the Oxford clay. 4. Kelloway rock (swelling out into an important arenaceous formation). 5. Cornbrash. 6. Coaly grit of Smith. 7. Pierstone (according to Mr. Smith, the equivalent of the great oolite). 8. Sandstone and shale, with *peculiar plants and various seams of coal.* 9. A bed with fossils of the inferior oolite. 10. Marl-stone? 11. Alum-shale or lias. All the above strata are identified by abundant organic remains.

In the oolitic series, therefore, where the several strata are developed in conformity with the more ordinary type of these formations, we may venture to predict with certainty, that no carboniferous deposites of any great value will ever be discovered, at all events in Great Britain. A want of such knowledge has induced many persons to make trials for coal in beds subordinate to the English oolites, and even superior to them, in places where the type of formation did not offer the least warrant for such attempts.

The third great class of terrestrial strata, is the proper coal-measures, called the *carboniferous rocks*, our leading object here, and to which we shall presently return.

The transition rocks which lie beneath the coal-measures, and above the primitive rocks, or are anterior to the carboniferous order, and posterior to the primitive, contain a peculiar kind of coal, called anthracite or stone-coal, approaching closely in its nature to carbon. It is chiefly in the transition clay-slate that the anthracite occurs in considerable masses. There is one in the transition slate of the little Saint Bernard, near the village of *la Thuile* (in the Alps). It is 100 feet long, and 2 or 3 yards thick.

The coal burns with difficulty, and is used only for burning lime. There are several of the same kind in that country, which extend down the reverse slope of the mountains looking to Savoy. The slate enclosing them presents vegetable impressions of reeds or analogous plants. To the transition clay-slate we must likewise refer the beds of anthracite that M. Hericart de Thury observed at very great heights in the Alps of Dauphiny, in a formation of schist and gray-wacke with vegetable impressions, which reposes directly on the primitive rocks.

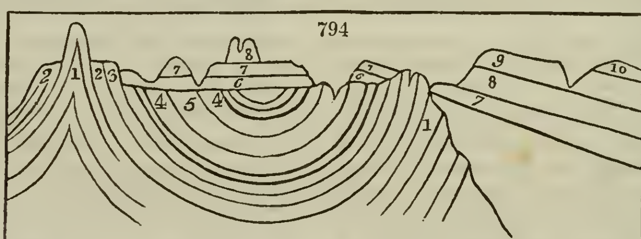
The great carboniferous formation may be subdivided into four orders of rocks: 1. the coal-measures, including their manifold alternations of coal-beds, sandstones, and shales; 2. the millstone grit and shale towards the bottom of the coal measures; 3. the carboniferous limestone, which projecting to considerable heights above the outcrop of the coal and grit, acquires the title of mountain limestone; 4. the old red sandstone, or connecting link with the transition and primary rock basin in which the coal system lies.

The coal-fields of England, from geographical position, naturally fall under the following arrangement:—1. The *great northern district;* including all the coal-fields north of Trent. 2. The *central district;* including Leicester, Warwick, Stafford, and Shropshire. 3. The *western district;* subdivided into *north-western,* including North Wales, and the *south-western,* including South Wales, Gloucester, and Somersetshire.

There are three principal coal-basins in Scotland: 1. that of Ayrshire; 2. that of Clydesdale; and 3. that of the valley of the Forth, which runs into the second in the line of the Union Canal. If two lines be drawn, one from Saint Andrews on the north-east coast, to Kilpatrick on the Clyde, and another from Aberlady, in Haddingtonshire, to a point a few miles south of Kirkoswald in Ayrshire, they will include between them the whole space where pitcoal has been discovered and worked in Scotland.

The great coal-series consists of a regular alternation of mineral strata deposited in a great concavity or basin, the sides and bottom of which are composed of transition rocks. This arrangement will be clearly understood by inspecting *fig.* 794, which represents a section of the coal-field south of Malmsbury.

Mendip hills. Dundry hill. Wick rocks. Fog hill, N. of Lansdowne.



1, 1, old red sandstone; 2, mountain limestone; 3, millstone grit; 4, 4, coal seams; 5, Pennant, or coarse sandstone; 6, new red sandstone, or red marl; 7, 7, lias; 8, 8, inferior oolite; 9, great oolite; 10, cornbrash and Forest marble.

No. 1, or the old red sandstone, may therefore be regarded as the characteristic lining of the coal basins; but this sandstone rests on transition limestone, and this limestone on gray-wacke. This methodical distribution of the carboniferous series is well exemplified in the coal-basin of the Forest of Dean in the south-west of England, and has been accurately described by Mr. Mushet.

The *gray-wacke* consists of highly inclined beds of slaty micaceous sandstone, which on the one hand alternates with and passes into a coarse breccia, having grains as large as peas; on the other, into a soft argillaceous slate. The gray-wacke stands bare on the north-eastern border of the Forest, near the southern extremity of the chain of transition limestone, which extends from Stoke Edith, near Hereford, to Flaxley on the Severn. It is traversed by a defile, through which the road from Gloucester to Ross winds. The abruptness of this pass gives it a wild and mountainous character, and affords the best opportunity of examining the varieties of the rock.

The *Transition limestone* consists in its *lower beds* of fine-grained, tender, extremely argillaceous slate, known in the district by the name of *water-stone,* in consequence of the wet soil that is found wherever it appears at the surface. Calcareous matter is interspersed in it but sparingly. Its *upper beds* consist of shale alternating with extensive beds of stratified limestone. The lowest of the calcareous strata are thin, and alternate with shale. On these repose thicker strata of more compact limestone, often of a dull blue color. The beds are often dolomitic, which is indicated by straw yellow color, or dark pink color, and by the sandy or glimmering aspect of the rock.

The *old red sandstone,* whose limits are so restricted in other parts of England, here occupies an extensive area. The space which it covers, its great thickness, its high inclination, the abrupt character of the surface over which it prevails, and the consequent display of its strata in many natural sections, present in this district advantages for studying the formation, which are not to be met with elsewhere in South Britain. In the neighborhood of Mitchel Dean, the total thickness of this formation, interposed conformably between the transition and mountain limestone, is from 600 to 800 fathoms. The old red sandstone is characterized in its upper portion by the presence of silicious conglomerate, containing silicious pebbles, which is applied extensively to the fabrication of millstones near Monmouth, and on the banks of the Wye. This sandstone encircles the Forest with a ring of very elevated ground, whose long and lofty ridges on the eastern frontier overhang the valley of the Severn.

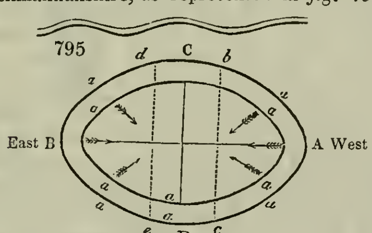
The *mountain limestone*, or carboniferous, is distinguished from transition limestone, rather by its position than by any very wide difference in its general character or organic remains. According to the measurements of Mr. Mushet, the total thickness of the mountain limestone is about 120 fathoms. The zone of limestone belonging to this coal-basin, is from a furlong to a mile in breadth on the surface of the ground, according as the dip of the strata is more or less rapid. The angle of dip on the northern and western border is often no more than 10°, but on the eastern it frequently amounts to 80°. The calcareous zone that defines the outer circle of the basin, suffers only one short interruption, scarcely three miles in length, where in consequence of a fault the limestone disappears, and the coal-measures are seen in contact with the old red sandstone.

Coal measures.—Their aggregate thickness amounts, according to Mr. Mushet, to about 500 fathoms. 1. The lowest beds, which repose on the mountain limestone, are about 40 fathoms thick, and consist here, as in the Bristol coal-basin, of a red silicious grit, alternating with conglomerate, used for millstones; and with clay, occasionally used for ochre. 2. These beds are succeeded by a series about 120 fathoms thick, in which a gray gritstone predominates, alternating in the lower part with shale, and containing 6 seams of coal. The grits are of a fissile character, and are quarried extensively for flag-stone, ashlers, and fire-stone. 3. A bed of grit, 25 fathoms thick, quarried for hearth-stone, separates the preceding series from the following, or the 4th, which is about 115 fathoms thick, and consists of from 12 to 14 seams of coal alternating with shale. 5. To this succeeds a straw-colored sandstone, nearly 100 fathoms thick, forming a high ridge in the interior of the basin. It contains several thin seams of coal, from 6 to 16 inches in thickness. 6. On this reposes a series of about 12 fathoms thick, consisting of 3 seams of coal alternating with shale. 7. This is covered with alternate beds of grit and shale, whose aggregate thickness is about 100 fathoms, occupying a tract in the centre of the basin about 4 miles long, and 2 miles broad. The sandstone No. 5 is probably the equivalent of the Pennant in the preceding figure.

The floor, or pavement, immediately under the coal beds is, almost without exception, a grayish slate-clay, which, when made into bricks, strongly resists the fire. This fire-clay varies in thickness from a fraction of an inch to several fathoms. Clay-ironstone is often disseminated through the shale.

The most complete and simplest form of a coal-field is the entire basin-shape, which we find in some instances without a dislocation. A beautiful example of this is to be seen at Blairengone, in the county of Perth, immediately adjoining the western boundary of Clackmannanshire, as represented in *fig.* 795, where the outer elliptical line, marked

795



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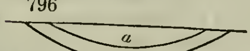

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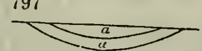

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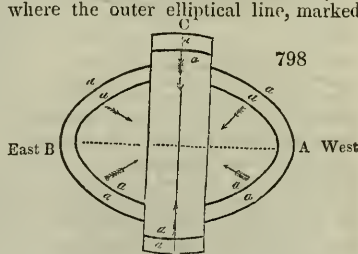

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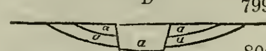

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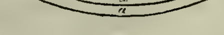

A, B, C, D, represents the crop, outburst, or basset edge of the lower coal, and the inner elliptical line represents the crop or basset edge of the superior coal. *Fig.* 796 is the longitudinal section of the line A B; and *fig.* 797, the transverse section of the line C D. All the accompanying coal strata partake of the same form and parallelism. These basins are generally elliptical, sometimes nearly circular, but are often very eccentric, being much greater in length than in breadth; and frequently one side of the basin on the short diameter has a much greater dip than the other, which circumstance throws the trough or lower part of the basin concavity much nearer to the one side than to the other. From this view of one entire basin, it is evident that the dip of the coal strata belonging to it runs in opposite directions, on the opposite sides, and that all the strata regularly crop out, and meet the alluvial cover in every point of the circumferential space, like the edges of a nest of common basins. The waving line marks the river Devon.

It is from this basin shape that all the other coal-fields are formed, which are segments of a basin produced by slips, dikes, or dislocations of the strata. If the coals (*fig.* 795) were dislocated by two slips *b c* and *d e*, the slip *b c* throwing the strata *down* to the east, and the slip *d e* throwing them as much *up* in the same direction, the outcrops of the coals would be found in the form represented in *fig.* 798, of which *fig.* 799 is the section in the line A B, and *fig.* 800 the section in the line C D.

The chief difficulty in exploring a country in search of coal, or one where coal-fields are known to exist, arises from the great thickness of alluvial and other cover, which completely hides the outcrop or basset edge of the strata, called by miners the *rock-head*; as also the fissures, dikes, and dislocations of the strata, which so entirely change the structure and bearings of coal-fields, and cause often great loss to the mining adventurer. The alluvial cover on the other hand is beneficial, by protecting the seams of the strata from the superficial waters and rains, which would be apt to drown them, if they were naked. In all these figures of coal-basins, the letter *a* indicates coal.

The absolute shape of the coal-fields in Great Britain has been ascertained with surprising precision. To whatever depth a coal-mine is drained of its water, from that depth it is worked, up to the rise of the water-level line, and each miner continues to advance his room or working-place, till his seam of coal meets the alluvial cover of the outcrop, or is cut off by a dislocation of the strata. In this way the miner travels in succession over every point of his field, and can portray its basin-shape most minutely.

Fig. 801 represents a horizontal plan of the Clackmannanshire coal-field, as if the strata at the outcrop all around were denuded of the alluvial cover. Only two of the concentric beds, or of their edges *a*, *a*, are represented, to avoid perplexity. It is to be remembered, however, that all the series of attendant strata lie parallel to the above lines. This plan shows the Ochill mountains, with the north coal-fields, of an oblong elliptical shape, the side of the basin next the mountains being precipitous, as if upheaved by the eruptive trap-rocks; while the south, the east, and the west edges of the basin shelve out at a great distance from the lower part of the concavity or *trough*, as miners call it. Thus the alternate beds of coal, shale, and sandstone, all nearly concentric in the north coal-field, dip inwards from all sides towards the central area of the *trough*. The middle coal-field of this district, however, which is formed by the great north slip, is merely the segment of an elliptical basin, where the strata dip in every direction to the middle of the axis marked with the letter X; being the deepest part of the segment. The south coal-field, formed by the great south slip, is likewise the segment of another elliptical basin, similar in all respects to the middle coal-field. Beyond the outcrop of the coals and subordinate strata of the south coal-fields, the counter dip of the strata takes place, producing the mantle-shaped form; whence the coal strata in the Dunmore field, in Stirlingshire, lie in a direction contrary to those of the south coal-field of Clackmannanshire. O, are the Ochill mountains.

801

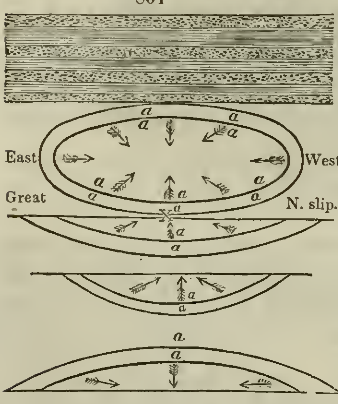

Fig. 802 is intended to represent an extensive district of country, containing a great coal-basin, divided into numerous subordinate coal-fields by these dislocations. The lines marked *b* are slips, or faults; the broad lines marked *c* denote dikes; the former dislocate the strata, and change their level, while dikes disjoin the strata with a wall, but do not in general affect their elevation. The two parallel lines marked *a*, represent two seams of coal, variously heaved up and down by the faults; whereas the dikes are seen to pass through the strata without altering their relative position. In this manner, partial coal-fields are distributed over a wide area of country, in every direction.

The only exception to this general form of the coal-fields in Great Britain, is the inverted basin shape; but this is rare. A few examples occur in some districts of England, and in the county of Fife; but even in extensive coal-fields, this convex form is but a partial occurrence, or a deviation by local violence from the ordinary basin. *Fig.* 803 is an instance of a convex coal-field exhibited in Staffordshire, at the Castle-hill, close to the town of Dudley. 1, 1, are limestone strata; 2, 2, are coal. Through this hill, canals have been cut, for working the immense beds of carboniferous limestone. These occur in the lower series of the strata of the coal-field, and therefore at a distance of many miles from the Castle-hill, beyond the outcrop of all the workable coals in the proper basin-shaped part of the field; but by this apparently inverted basin-form, these limestone beds are elevated far above the level of the general surface of the country, and consequently above the level of all the coals. We must regard this seeming inversion as resulting from the approximation of two coal-basins, separated by the basset edges of their mountain limestone repository.

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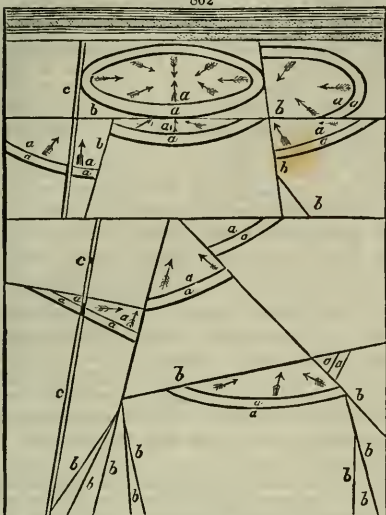

Fig. 804 is a vertical section of the Dudley coal-basin, the upper coal-bed of which has the astonishing thickness of 30 feet; and this mass extends 7 miles in length, and 4 in breadth. Coal-seams 5 or 6 feet thick, are called *thin* in that district.

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Fig. 805 is a very interesting section of the main coal-basin of Clackmannanshire, as given by Mr. Bald in the Wernerian Society's Memoirs, vol. iii. Here we see it broken into three subordinate coal-fields, formed by two great faults or dislocations of the strata; but independently of these fractures across the whole series, the strata continue quite regular in their respective alternations, and preserve nearly unchanged their angle of inclination to the horizon. The section shows the south coal-field dipping northerly, till it is cut across by the great south slip *x*, which dislocates the coal and the parallel strata to the enormous extent of 1230 feet, by which all the coals have been thrown up, not simply to the day, but are not found again till we advance nearly a mile northward, on the line of the dip, where the identical seams of coal, shale, &c. are observed once more with their regular inclination. These coals of the middle area, dip regularly northward till interrupted by the great north slip *y*, which dislocates the strata, and throws them up 700 feet; that is to say, a line prolonged in the direction of any one well-known seam, will run 700 feet above the line of the same seam as it emerges after the middle slip. Immediately adjoining the north slip, the coals and coal-field resume their course, and dip regularly northward, running through a longer range than either of the other two members of the basin, till they arrive at the valley of the Devon, at the foot of the Ochill mountains, where they form a concave curvature, or trough, *a*, and thence rise rapidly in an almost vertical direction at *b*. Here the coals, with all their associate strata, assume conformity and parallelism with the face of the sienitic-greenstone strata of the Ochill mountains *c*; being raised to the high angle of 73 degrees with the horizon. The coal-seams thus upheaved, are called *edge-metals* by the miners.

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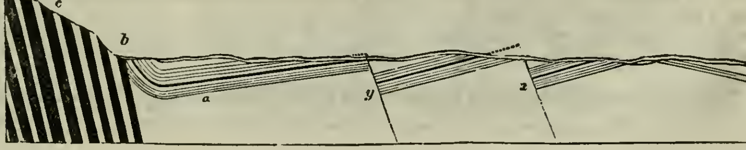

In this remarkable coal-field, which has been accurately explored by pitting and boring to the depth of 703 feet, there are no fewer than 142 beds, or distinct strata of coal, shale, and sandstone, &c., variously alternating, an idea of which may be had by inspecting *fig.* 806. Among these are 24 beds of coal, which would constitute an aggregate thickness of 59 feet 4 inches; the thinnest seam of coal being 2 inches, and the thickest 9 feet. The strata of this section contain numerous varieties of sandstone, slate-clay, bituminous shale, indurated clay, or fire-clay, and clay ironstone. Neither trap-rock nor limestone is found in connexion with the workable coals; but an immense bed of greenstone, named Abbey Craig, occurs in the western boundary of Clackmannanshire, under which lie regular strata of slate-clay, sandstone, thin beds of limestone, and large spheroidal masses of clay ironstone, with a mixture of lime.

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"With regard to slips in coal-fields," says Mr. Bald, "we find that there is a general law connected with them as to the position of the dislocated strata, which is this:—When a slip is met with in the course of working the mines—if when looking to it, the vertical line of the slip or fissure, it forms an acute angle with the line of the pavement upon which the observer stands, we are certain that the strata are dislocated downwards upon the other side of the fissure. On the contrary, if the angle formed by the two lines above mentioned is obtuse, we are certain that the strata are dislocated or thrown upwards upon the other side of the fissure. When the angle is 90°, or a right angle, it is altogether uncertain whether the dislocation throws up or down on the opposite side of the slip. When dikes intercept the strata, they generally only separate the strata the width of the dike, without any dislocation, either up or down; so that if a coal is intercepted by a dike, it is found again by running a mine directly forward, corresponding to the angle or inclination of the coal with the horizon."—*Wernerian Society's Memoirs*, vol. iii. p. 133.*

The Johnstone coal-field, in Renfrewshire, is both singular and interesting. The upper stratum of rock is a mass of compact greenstone or trap, above 100 feet in thickness, not at all in a conformable position with the coal strata, but overlying; next there are a few fathoms of soft sandstone and slate-clay, alternating, and uncommonly soft Beneath these beds, there are no fewer than ten seams of coal, lying on each other, with a few divisions of dark indurated clay. These coal-seams have an aggregate thickness of no less than 100 feet; a mass of combustible matter, in the form of coal, unparalleled for its accumulation in so narrow a space. The greater part of this field contains only 5 beds of coal; but at the place where the section shown in *fig.* 807 is taken, these five coals seem to have been overlapped or made to slide over each other by violence. This structure is represented in *fig.* 808, which is a section of the Quarrelton coal in the Johnstone field, showing the overlapped coal and the double coal, with the thick bed of greenstone, overlying the coal-field.

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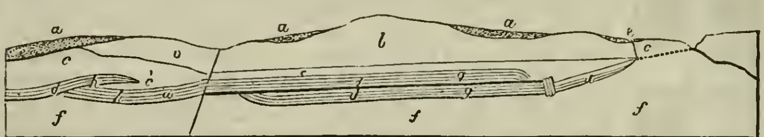

a. Alluvial cover.
b. Bed of trap or greenstone.
c. Alternating coal strata.
d. Coal-seams.
e. Position of greenstone, not ascertained.
f. Strata in which no coals have been found.
g. The overlapped coal.
h. The double coal.

Before proceeding to examine the modes of working coal, I shall introduce here a description of the two principal species of this mineral.

1. *Cubical coal.*—It is black, shining, compact, moderately hard, but easily frangible. When extracted in the mine, it comes out in rectangular masses, of which the smaller fragments are cubical. The lamellæ (*reed* of the coal) are always parallel to the bed or plane on which the coal rests; a fact which holds generally with this substance. There are two varieties of cubical coal; the *open-burning* and the *caking*. The latter, however small its fragments may be, is quite available for fuel, in consequence of its agglutinating into a mass at a moderate heat, by the abundance of its bitumen. This kind is the true smithy or forge-coal, because it readily forms itself into a vault round the blast of the bellows, which serves for a cupola in concentrating the heat on objects thrust into the cavity.

The open-burning cubical coals are known by several local names; the rough coal or

* This paper does honor to its author, the eminent coal-viewer of Scotland.

clod coal, from the large masses in which they may be had and the cherry coal, from the cheerful blaze with which they spontaneously burn; whereas the caking coals, such as most of the Newcastle qualities, require to be frequently poked in the grate. Its specific gravity varies from 1·25 to 1·4.

2. *Slate or splint coal.*—This is dull-black, very compact, much harder, and more difficultly frangible than the preceding. It is readily fissile, like slate, but powerfully resists the cross fracture, which is conchoidal. Specific gravity from 1·26 to 1·40. In working, it separates in large quadrangular sharp-edged masses. It burns without caking, produces much flame and smoke, unless judiciously supplied with air, and leaves frequently a considerable bulk of white ashes. It is the best fuel for distilleries and all large grates, as it makes an open fire, and does not clog up the bars with glassy scoriæ. I found good splint coal of the Glasgow field to have a specific gravity of 1·266, and to consist of—carbon, 70·9; hydrogen, 4·3; oxygen, 24·8.

3. *Cannel coal.*—Color between velvet and grayish-black; lustre resinous; fracture even; fragments trapezoidal; hard as splint coal; spec. grav. 1·23 to 1·28. In working, it is detached in four-sided columnar masses, often breaks conchoidal, like pitch, kindles very readily, and burns with a bright white projective flame, like the wick of a candle, whence its name. It occurs most abundantly in the coal-field of Wigan, in Lancashire, in a bed 4 feet thick; and there is a good deal of it in the Clydesdale coal-field, of which it forms the lowest seam that is worked. It produces very little dust in the mine, and hardly soils the fingers with carbonaceous matter. Cannel coal from Woodhall, near Glasgow, spec. grav. 1·228, consists by my analysis of—carbon, 72·22; hydrogen, 3·93; oxygen, 21·05; with a little azote (about 2·8 in 100 parts.) This coal has been found to afford, in the Scotch gas-works, a very rich-burning gas. The azote is there converted into ammonia, of which a considerable quantity is distilled over into the tar-pit.

4. *Glance coal.*—This species has an iron-black color, with an occasional iridiscence, like that of tempered steel; lustre in general splendent, shining, and imperfect metallic; does not soil; easily frangible; fracture flat conchoidal; fragments sharp-edged. It burns without flame or smell, except when it is sulphureous; and it leaves a white-colored ash. It produces no soot, and seems, indeed, to be merely carbon, or coal deprived of its volatile matter or bitumen, and converted into coke by subterranean calcination, frequently from contact with whin-dikes. Glance coal abounds in Ireland, under the name of Kilkenny coal; in Scotland it is called blind coal, from its burning without flame or smoke; and in Wales, it is the malting or stone coal. It contains from 90 to 97 per cent. of carbon. Specific gravity from 1·3 to 1·5; increasing with the proportion of earthy impurities.

The dislocations and obstructions found in coal-fields, which render the search for coal so difficult, and their mining so laborious and uncertain, are the following:—

1. *Dikes.* 2. *Slips or Faults.* 3. *Hitches.* 4. *Troubles.*

The first three infer dislocation of the strata; the fourth changes in the bed of coal itself.

1. A dike is a wall of extraneous matter, which divides all the beds in a coal-field.

Dikes extend not only in one line of bearing through coal-fields for many miles, but run sometimes in different directions, and have often irregular bendings, but no sharp angular turns. When from a few feet to a few fathoms in thickness, they occur sometimes in numbers within a small area of a coal basin, running in various directions, and even crossing each other. *Fig.* 809 represents a ground plan of a coal-field, intersected with greenstone dikes. A B and C D are two dikes standing parallel to each other; E F and G H are cross or oblique dikes, which divide both the coal strata and the primary dikes A B and C D.

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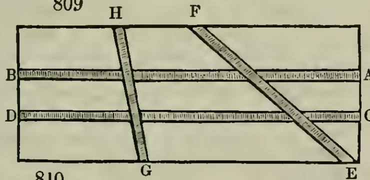

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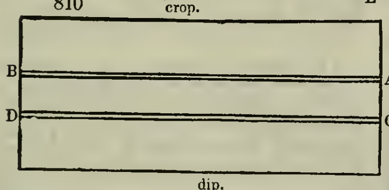

2. *Slips* or *faults* run in straight lines through coal-measures, and at every angle of incidence to each other. *Fig.* 810 represents a ground plan of a coal-field, with two slips A B and C D in the line of bearing of the planes of the strata, which throw them down to the outcrop. This is the simplest form of a slip. *Fig.* 811 exhibits part of a coal-field intersected with slips, like a cracked sheet of ice. Here A B is a dike; while the narrow lines show faults of every kind, producing dislocations varying in amount of slip from a few feet to a great many fathoms. The faults at the points *a*, *a*, *a* vanish; and the lines at c denote four small partial slips called *hitches.*

The effects of slips and dikes on the coal strata appear more prominently when viewed in a vertical section, than in a ground plan, where they seem to be merely walls, veins, and lines of demarcation. *Fig.* 812 is a vertical section of a coal-field, from dip to rise, showing three strata of coal *a*, *b*, *c*. A B represents a dike at right angles to the plane of the coal-beds. This rectangular wall merely separates the coal-measures, affecting their line of rise; but further to the rise, the oblique dike C D interrupts the coals *a*, *b*, *c*, and not only disjoins them, but throws them and their concomitant strata greatly lower down; but still, with this depression, the strata retain their parallelism and general slope. Nearer to the outcrop, another dike E, F, interrupts the coals *a*, *b*, *c*, not merely breaking the continuity of the planes, but throwing them moderately up, so as to produce a steeper inclination, as shown in the figure. It sometimes happens that the coals in the compartment H, betwixt the dikes C and E, may lie nearly horizontal, and the effect of the dike E, F, is then to throw out the coals altogether, leaving no vestige of them in the compartment K. "Such," says Mr. Bald, from whom these illustrations are borrowed, "are the most prominent changes in the strata, as to their line of direction, produced by dikes; but of these changes there are various modifications."

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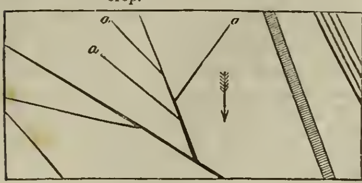

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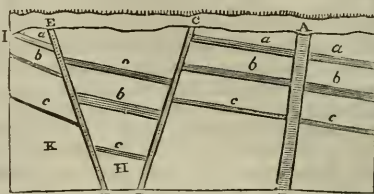

The effect of slips on the strata is also represented in the vertical section, *fig.* 813, where *a*, *b*, *c* are coals with their associated strata. A, B, is an intersecting slip, which throws all the coals of the first compartment much lower, as is observable in the second No. 2; and from the amount of the slip, it brings in other coal-seams, marked 1, 2, 3 not in the compartment No. 1. C, D, is a slip producing a similar result, but not of the same magnitude. E, F represents a slip across the strata, reverse in direction to the former; the effect of which is to throw up the coals, as shown in the area No. 4. Such a slip occasionally brings into play seams seated under those marked *a*, *b*, *c*, as seen at 4, 5, 6; and it may happen that the coal marked 4 lies in the prolongation of a well-known seam, as C, in the compartment No. 3, when the case becomes puzzling to the miner. In addition to the above varieties, a number of slips or hitches are often seen near one another, as in the area marked No. 5, where the individual displacements are inconsiderable, but the aggregate dislocation may be great, in reference to the seams of the 6th compartment.

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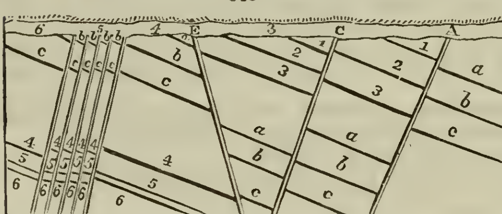

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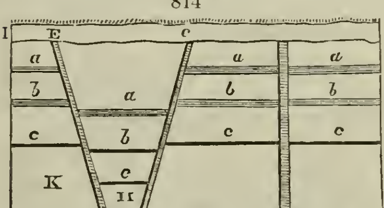

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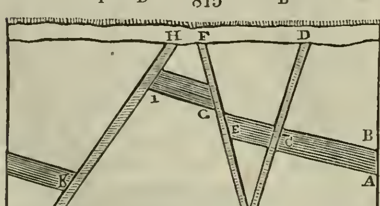

The results of dikes and slips on a horizontal portion of a field are exemplified in *fig.* 814. Where the coal-measures are horizontal, and the faults run at a greater angle than 45° to the line of bearing, they are termed dip and rise faults, as A B, C D, E F.

Coal-viewers or engineers regard the dislocations now described as being subject in one respect to a general law, which may be thus explained:—Let *fig.* 815

be a portion of a coal-measure; A, being the pavement and B the roof of the coal-seam. If, in pursuing the stratum at C, a dike D occurs, standing at right angles with the pavement, they conclude that the dike is merely a partition-wall between the beds by its own thickness, leaving the coal-seam underanged on either side; but if a dike F forms, as at E, an obtuse angle with the pavement, they conclude that the dike is not a simple partition between the strata, but has thrown up the several seams into the predicament shown at G. Finally, should a dike H make at I an acute angle with the pavement, they conclude that the dike has thrown down the coal-measures into the position of K.

The same important law holds with slips, as I formerly stated; only when they form right angles with the pavement, the case is ambiguous; that is, the strata may be dislocated either upwards or downwards.

Dikes and faults are denominated upthrow or downthrow, according to the position they are met with in working the mine. Thus, in *fig.* 812, if the miner in advancing to the rise, the dike A, B obviously does not change the direction; but C, D is a downthrow dike of a certain number of fathoms towards the rise of the basin, and E, F is an upthrow dike likewise towards the rise. On the other hand, when the dikes are met with by the miner in working from the rise to the dip, the names of the above dikes would be reversed; for what is an upthrow in the first case, becomes a downthrow in the second, relative to the mining operations.

3. We have seen that *hitches* are small and partial slips, where the dislocation does not exceed the thickness of the coal-seam; and they are correctly enough called *steps* by the miner. *Fig.* 816 represents the operation of the *hitches* A, B, C, D, E, F, G, H, on the coal-measures. Though observed in one or two seams of a field, they may not appear in the rest, as is the case with dikes and faults.

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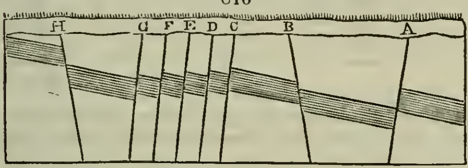

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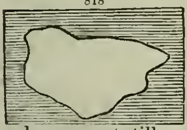

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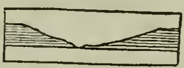

4. *Troubles* in coal-fields are of various kinds.

1. *Irregular layers of sandstone*, appearing in the middle of the coal-seam, and gradually increasing in thickness till they separate the coal into two distinct seams, too thin to continue workable.

2. *Nips*, occasioned by the gradual approximation of the roof and pavement, till not a vestige of coal is left between them; the softer shale disappearing also at the same time. *Figs.* 817 and 818 represent this accident, which is fortunately rare; the first being a vertical, and the second a horizontal view.

3. *Shaken coal.* It resembles the rubbish of an old waste, being a confused heap of coal-dust, mixed with small pieces of cubical coal, so soft that it can frequently be dug with the spade. This shattering is analogous to that observed occasionally in the flint nodules of the chalk formation; and seems like the effect of some electric tremor of the strata.

In searching for coal in any country, its concomitant rocks ought to be looked for, especially the carboniferous or mountain limestone, known by its organic fossils; (see Ure's Geology, p. 175, and corresponding plate of fossils;) likewise the outcrop of the millstone grit, and the newer red sandstone, among some rifts or façades of which, seams of coal may be discerned. But no assurance of coal can be had without boring or pitting.

Skill in boring judiciously for coal, distinguishes the genuine miner from the empirical adventurer, who, ignorant of the general structure of coal-basins, expends labor, time, and money at random, and usually to no purpose; missing the proper coal-field, and leading his employer to sink a shaft where no productive seams can be had. A skilful viewer, therefore, should always direct the boring operations, especially in an unexplored country.

The boring rods should be made of the best and most tenacious Swedish iron; in area, about an inch and a quarter square. Each rod is usually 3 feet long, terminating in a male screw at one end, and a female screw at the other. The boring chisels are commonly 18 inches long, and from 2 inches and a half to 3 inches and a quarter at their cutting edge, which must be tipped with good steel. The chisel is screwed to an intermediate 18-inch rod, called the double box-rod, forming together a rod 3 feet long. There are, moreover, three short rods, a foot, 18 inches, and 2 feet long each, which may be screwed, as occasion requires, to the brace-head, to make the height above the mouth of the bore convenient for the hands of the men in working the rods. Hence the series of rods becomes a scale of measurement for noting the depth of the bore, and keeping a journal of the strata that are perforated. The brace-head rod, also 18 inches long, has two large eyes or rings at its top, set at right angles to each other, through which arms of wood are fixed for the men to lift and turn the rods by, in the boring process.

When the bore is intended to penetrate but a few fathoms, the whole work may be performed directly by the hands; but when the bore is to be of considerable depth, a lofty triangle of wood is set above the bore-hole, with a pulley depending at its summit angle, for conducting the rope to the barrel of a windlass or wheel and axle, secured to the ground with heavy stones. The loose end of the rope is connected to the rods by an oval iron ring, called a runner; and by this mechanism they may be raised and let fall in the boring; or the same effect may be more simply produced by substituting for the wheel and axle, a number of ropes attached to the rod rope, each of which may be pulled by a man, as in raising the ram of the pile engine.

In the Newcastle coal district there are professional master-borers, who undertake to search for coal, and furnish an accurate register of the strata perforated. The average price of boring in England or Scotland, where no uncommon difficulties occur, is six shillings for each of the first five fathoms, twice 6 shillings for each of the second five fathoms, thrice 6 shillings for each of the third five fathoms, and so on; hence the series will be—

1st five fathoms	6s. each	£1	10
2d five fathoms	12s. —	3	0
3d five fathoms	18s. —	4	10
4th five fathoms	24s. —	6	0
20 fathoms of bore		£15	0

Thus the price increases equably with the depth and labor of the bore, and the undertaker usually upholds his rods. There are peculiar cases, however, in which the expense greatly exceeds the above rate.

The boring tools are represented in the following figures:—

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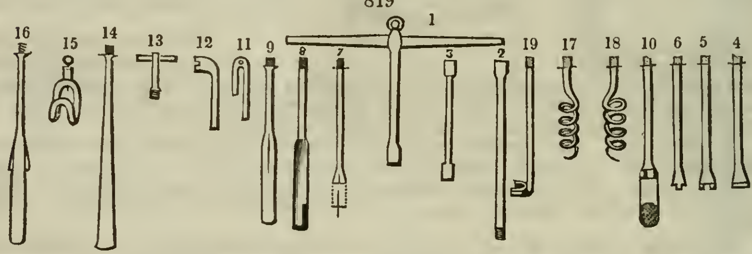

Fig. 819.

1. The *brace-head.*
2. The common rod.
3. The double-box rod; intermediate piece.
4. The common chisel.
5. The indented chisel.
6. Another of the same.
7. The cross-mouthed chisel.
8. The wimble.
9. The sludger, for bringing up the mud.
10. The rounder.
11. The key for supporting the train of rods at the bore-mouth.
12. The key for screwing together and asunder the rods.
13. The topit, or top-piece.
14. The beché, for catching the rod when it breaks in the bore.
15. The runner, for taking hold of the topit.
16. The tongued chisel.
17. The right-handed worm screw.
18. The left-handed do.
19. The finger grip or catch.

We shall now explain the manner of conducting a series of bores in searching ground for coal.

Fig. 820 represents a district of country in which a regular survey has proved the existence and general distribution of coal strata, with a dip to the south, as here shown. In this case, a convenient spot should be pitched upon in the north part of the district, so that the successive bores put down may advance in the line of the

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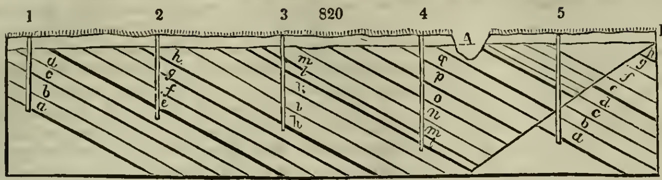


dip. The first bore may therefore be made at No. 1, to the depth of sixty yards. In the progress of this perforation, many diversities and alternations of strata will be probably passed through, as we see in the sections of the strata; each of which, as to quality and thickness, is noted in the journal, and specimens are preserved. This bore is seen to penetrate the strata *d*, *c*, *b*, *a*, without encountering any coal. Now, suppose that the dip of the strata be one yard in ten, the question is, at what distance from bore No. 1, in a south direction, will a second bore of 60 yards strike the first stratum, *d*, of the preceding? The rule obviously is, to multiply the depth of the bore by the dip, that is, 60 by 10, and the product, 600, gives the distance required; for, by the rule of three, if 1 yard of depression corresponds to 10 in horizontal length, 60 yards of depression will correspond to 600 in length. Hence the bores marked 1, 2, 3, 4, and 5, are successively distributed as in the figure, the spot where the first is let down being regarded as the point of level to which the summits of all the succeeding bores are referred. Should the top of No. 2 bore be 10 yards higher or lower than the top of No. 1, allowance must be made for this difference in the operation; and hence a surface level survey is requisite. Sometimes ravines cut down the strata, and advantage should be taken of them, when they are considerable.

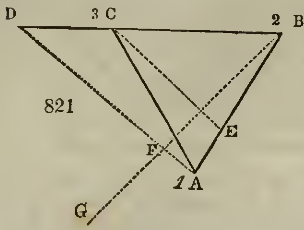
In No. 2, a coal is seen to occur near the surface, and another at the bottom of the bore; the latter seam resting on the first stratum *d*, that occurred in bore No. 1; and No. 2 perforation must be continued a little farther, till it has certainly descended to the stratum *d*. Thus these two bores have, together, proved the beds to the depth of 120 yards.

No. 3 bore being placed according to the preceding rule, will pass through two coal-seams near the surface, and after reaching to nearly its depth of 60 yards, it will touch the stratum *h*, which is the upper stratum of bore No. 2; but since a seam of coal was detected in No. 2, under the stratum *h*, the proof is confirmed by running the borer down through that coal. The field has now been probed to the depth of 180 yards. The fourth bore is next proceeded with, till the two coal-seams met in No. 3 have been penetrated; when a depth of 240 yards has been explored. Hence No. 4 bore could not reach the lower stratum *a*, unless it were sunk 240 yards.

The fifth bore (No. 5) being sunk in like manner, a new coal-seam occurs within a few yards of the surface; but after sinking to the depth at which the coal at the top of the fourth bore was found, an entirely different order of strata will occur. In this dilemma, the bore should be pushed 10 or 20 yards deeper than the 60 yards, to ascertain the alternations of the new range of superposition. It may happen that no coals of any value shall be found, as the figure indicates, in consequence of a slip or dislocation of the strata at B, which has thrown up all the coals registered in the former borings, to such an extent that the strata *b*, *a*, of the first bore present themselves immediately on perforating the slip, instead of lying at the depth of 300 yards (5×60), as they would have done, had no dislocation intervened. Some coal-fields, indeed, are so intersected with slips as to bewilder the most experienced miner, which will particularly happen when a lower coal is thrown upon one side of a slip, directly opposite to an upper coal situated on the other side of it; so that if the two seams be of the same thickness, erroneous conclusions are almost inevitable.

When a line of bores is to be conducted from the dip of the strata towards their outcrop, they should be placed a few yards nearer each other than the rule prescribes, lest the strata last passed through be overstepped, so that they may disappear from the register, and a valuable coal-seam may thereby escape notice. In fact, each successive bore should be so set down, that the first of the strata perforated should be the last passed through in the preceding bore; as is exemplified by viewing the bores in the retrograde direction, Nos. 4, 3, and 2. But if the bore No. 2 had gone no deeper than *f*, and the bore No. 1 had been as represented, then the stratum *e*, with its immediately subjacent coal, would have been overstepped, since none of the bores would have touched it; and they would have remained unnoticed in the journal, and unknown.

When the line of dip, and consequently the line of bearing which is at right angles to it, are unknown, they are sought for by making three bores in the following position. —Let *fig.* 821 be a horizontal diagram, in which the place of a bore, No. 1, is shown, which reaches a coal-seam at the depth of 50 yards; bore No. 2 may be made at B, 300 yards from the former; and bore No. 3 at C, equidistant from Nos. 1 and 2, so that the bores are sunk at the three angles of an equilateral triangle. If the coal occur in No. 2 at the depth of 30 yards, and in No. 3 of 44 yards, it is manifest that none of the lines A B, B C, or C A, is in the line of level, which for short distances may be taken for the line of bearing, with coal-seams of moderate dip. But since No. 1 is the deepest of the three bores, and No. 3 next in depth, the line A C joining them must be nearer the line of level than either of the lines A B or B C. The question is, therefore, at what distance on the prolonged line B C is the point for sinking a bore which would reach the coal at the same depth as No. 1, namely, 50 yards. This problem is solved by the following rule of proportion: as 14 yards (the difference of depth between bores 2 and 3) is to 300 yards (the distance between them), so is 20 (the difference of depth betwixt 1 and 2) to a fourth proportion, or $x = 428$ yards, 1 foot, and 8 inches. Now, this distance, measured from No. 2, reaches to the point D on the prolonged line B C, under which point D the coal will be found at a depth of 50 yards, the same as under A. Hence the line A D is the true level line of the coal-field; and a line B F G, drawn at right angles to it, is the true dip-line of the plane which leads to the outcrop. In the present example the dip is 1 yard in $14\frac{1}{2}$; or 1 in $14\frac{1}{2}$, to adopt the judicious language of the miner; or the sine is 1 to a radius of $14\frac{1}{2}$, measured along the line from B to F. By this theorem for finding the lines of dip and level, the most eligible spot in a coal-field for sinking a shaft may be ascertained.



Suppose the distance from B to G in the line of dip to be 455 yards; then, since every $14\frac{1}{2}$ gives a yard of depression, 455 will give 30 yards, which added to 30 yards, the depth of the bore at B, will make 60 yards for the depth of the same coal-seam at G. Since any line drawn at right angles to the line of level A D is the line of dip, so any line drawn parallel to A D is a level line. Hence, if from C the line C E be drawn parallel to D A, the coal-seam at the points E and C will be found in the same horizontal plane, or 44 yards beneath the surface level, over these two points. The point E level with C may also be found by this proportion: as 20 yards (the difference in depth of the bores under B and A) is to 300 yards (the distance between them), so is 14 yards (the difference of depth under B and C) to 210 yards, or the distance from B to E.

As boring for coal is necessarily carried on in a line perpendicular to the horizon, and as coal-seams lie at every angle of inclination to it, the thickness of the seam as given obliquely by the borer, is always greater than the direct thickness of the coal; and hence the length of that line must be multiplied by the cosine of the angle of dip, in order to find the true power of the seam.

Of fitting or winning a coal-field.—In sinking a shaft for working coal, the great obstacle to be encountered is water, particularly in the first opening of a field, which proceeds from the surface of the adjacent country; for every coal-stratum, however deep it may lie in one part of the basin, always rises till it meets the alluvial cover, or crops out, unless it be met by a slip or dike. When the basset-edge of the strata is covered with gravel or sand, any body or stream of water will readily percolate downwards through it, and fill up the porous interstices between the coal-measures, till arrested by the face of a slip, which acts as a valve or flood-gate, and confines the water to one compartment of the basin, which may, however, be of considerable area, and require a great power of drainage.

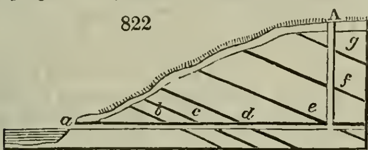
In reference to water, coal-fields are divided into two kinds: 1. level free coal; 2. coal not level free. In the practice of mining, if a coal-field, or portion of it, is so situated above the surface of the ocean that a level can be carried from that plane till it intersects the coal, all the coal above the plane of intersection is said to be level free; but if a coal-field, though placed above the surface of the ocean, cannot, on account of the expense, be drained by a level or gallery, but by mechanical power, such a coal-field is said to be not level free.

Besides these general levels of drainage, there are subsidiary levels, called off-takes or drifts, which discharge the water of a mine, not at the mouth of the pit, but at some depth beneath the surface, where, from the form of the country, it may be run off level free. From 20 to 30 fathoms off-take is an object of considerable economy in pumping; but even less is often had recourse to; and when judiciously contrived, may serve to intercept much of the crop water, and prevent it from getting down to the dip part of the coal, where it would become a heavy load on a hydraulic engine.

Day levels were an object of primary importance with the early miners, who had not the gigantic pumping power of the steam-engine at their command. Levels ought to be no less than 4 feet wide, and from 5 feet and a half to 6 feet high; which is large enough for carrying off water, and admitting workmen to make repairs and clear out depositions. When a day-level, however, is to serve the double purpose of drainage and an outlet for coals, it should be nearly 5 feet wide, and have its bottom gutter covered over. In other instances a level not only carries off the water from the colliery, but is converted into a canal for bearing boats loaded with coals for the market. Some subterranean canals are nine feet wide, and twelve feet high, with 5 feet depth of water.

If in the progress of driving a level, workable coals are intersected before reaching the seam which is the main object of the mining adventure, an air-pit may be sunk, of such dimension as to serve for raising the coals. These air-pits do not in general exceed 7 feet in diameter; and they ought to be always cylindrical. *Fig.* 822 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

822



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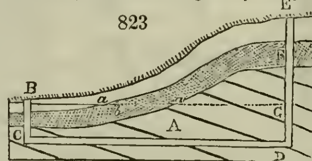


forward, the coal-seams *f*, g, and any others which lie in that direction, will also be drained, and then worked by the pit A. The chief obstacle to the execution of day-levels, is presented by quicksands in the alluvial cover, near the entrance of the gallery. The best expedient to be adopted amid this difficulty is the following:—*Fig.* 823 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 syphon, is called a drowned or a blind level.

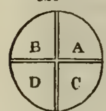
When a coal-basin is so situated that it cannot be rendered level free, the winning must be made by the aid of machinery. The engines at present employed in the drainage of coal-mines are:—

1. The water-wheel, and water-pressure engine.
2. The atmospheric steam-engine of Newcomen.
3. The steam-engine, both atmospheric and double stroke, of Watt.
4. The expansion steam-engine of Woolf.
5. The high-pressure steam-engine without a condenser.

The depth at which the coal is to be won, or to be drained of moisture, regulates the power of the engine to be applied, taking into account the probable quantity of water which may be found, a circumstance which governs the diameter of the working barrels of the pumps. Experience has proved, that in opening collieries, even in new fields, the water may generally be drawn off by pumps of from 10 to 15 inches diameter; excepting where the strata are connected with rivers, sand-beds filled with water, or marsh-lands. As feeders of water from rivers or sand-beds may be hindered from descending coal-pits, the growth proceeding from these sources need not be taken into account; and it is observed, in sinking shafts, that though the influx which cannot be cut off from the mine, may be at first very great, even beyond the power of the engine for a little while, yet as this excessive flow of water is frequently derived from the drainage of fissures, it eventually becomes manageable. An engine working the pumps for 8 or 10 hours out of the 24, is reckoned adequate to the winning of a new colliery, which reaps no advantage from neighboring hydraulic powers. In the course of years, however, many water-logged fissures come to be cut by the workings, and the coal-seams get excavated towards the outcrop, so that a constant increase of water ensues, and thus a colliery which has been long in operation, frequently becomes heavily loaded with water, and requires the action of its hydraulic machinery both night and day.

Of Engine Pits.—In every winning of coal, the shape of the engine-pit deserves much consideration. For shafts of moderate depth, many forms are in use; as circular, oval, square, octagonal, oblong rectangular, and oblong elliptical. In pits of inconsiderable depth, and where the earthy cover is firm and dry, any shape deemed most convenient may be preferred; but in all deep shafts, no shape but the circular should be admitted. Indeed, when a water-run requires to be stopped by tubbing or cribbing, the circular is the only shape which presents a uniform resistance in every point to the equable circumambient pressure. The elliptical form is the next best, when it deviates little from the circle; but even it has almost always given way to a considerable pressure of water. The circular shape has the advantage, moreover, of strengthening the shaft walls, and is less likely to suffer injury than other figures, should any failure of the pillars left in working out the coal cause the shaft to be shaken by subsidence of the strata. The smallest engine-pit should be ten feet in diameter, to admit of the pumps being placed in the lesser segment, and the coals to be raised in the larger one, as shown in *fig.* 824, which is called a double pit. If much work is contemplated in drawing coals, particularly if their masses be large, it would be advantageous to make the pit more than 10 feet wide. When the area of a shaft is to be divided into three compartments, one for the engine pumps, and two for raising coals, as in *fig.* 825, 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.* 826, with one space for the pumps, and three for ventilation and coal drawing, the total circle should be 15 feet in diameter. These dimensions are, however, governed by local circumstances, and by the proposed daily discharge of coals.

826



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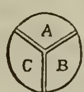

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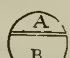
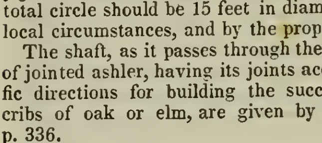


The shaft, as it passes through the earthy cover, should be securely faced with masonry of jointed ashler, having its joints accurately bevelled to the centre of the circle. Specific directions for building the successive masses of masonry, on a series of rings or cribs of oak or elm, are given by Mr. Bald, article MINE, *Brewster's Encyclopædia*, p. 336.

When the alluvial cover is a soft mud, recourse must be had to the operation of tubbing. A circular tub, of the requisite diameter, is made of planks from 2 to 3 inches thick, with the joints bevelled by the radius of the shaft, inside of which are cribs of hard wood, placed from 2 to 4 feet asunder, as circumstances may require. These cribs are constructed of the best heart of oak, sawn out of the natural curvature of the wood, adapted to the radius, in segments from 4 to 6 feet long, from 8 to 10 inches in the bed, and 5 or 6 inches thick. The length of the tub is from 9 to 12 feet, if the layer of mud have that thickness; but a succession of such tubs must be set on each other, provided the body of mud be thicker. The first tub must have its lower edge thinned all round, and shod with sharp iron. If the pit be previously secured to a certain depth, the tub is made to pass within the cradling, and is lowered down with tackles till it rests fair among the soft alluvium. It is then loaded with iron weights at top, to cause it to sink down progressively as the mud is removed from its interior. Should a single tub not reach the solid rock (sandstone or basalt), then another of like construction is set on, and the gravitating force is transferred to the top. *Fig.* 827 represents a bed of quicksand resting on a bed of impervious clay, that immediately covers the rock. A is the finished shaft; *a a*, the quicksand; *b b*, the excavation necessarily sloping much outwards; *c 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

827



keep the lower part always further down than the top of the quicksand, where the men are at work with their shovels, and where the bottom of the pumps hangs for withdrawing the surface water. This is an improvement adopted of late years in the Newcastle district with remarkable success.

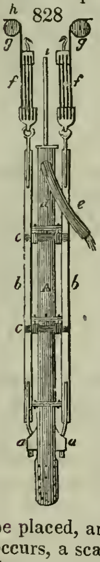
The engine pit being secured, the process of sinking through the rock is ready to be commenced, as soon as the divisions of the pit formed of carpentry, called brattices, are made. In common practice, and where great tightness of jointing is not required, for ventilating inflammable air, bars of wood, called 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 calked 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.* 824 is a double shaft: A, the pump pit; B, the pit for raising coal. *Fig.* 825 is a triple shaft; in which A is the pump compartment; B and C are coal-pits. *Fig.* 826 is a quadrant shaft: A, the pump pit; B, pit of ventilation or upcast for the smoke; C and D, pits for raising coals.

A depth of 75 fathoms is fully the average of engine pits in Great Britain. In practice, it embraces three sets of pumps. Whenever the shaft is sunk so low that the engine is needed to remove the water, the first set of pumps may be let down by the method represented in *fig.* 828; where A is the pump; *a*, *a*, strong ears through which

828



pass the iron rods connected with the spears *b b*; *c c* are the lashings; *d*, the hoggar pump; *e*, the hoggar; *f f*, the tackles; *g g*, the single pulleys; *h h*, the tackle fold leading to the capstans; and *i*, the pump-spears. By this mechanical arrangement the pumps are sunk in the most gradual manner, and of their own accord, so to speak, as the pit descends. To the arms of the capstans, sledges are fastened with ropes or chains; these sledges are loaded with weights, as counterpoises to the weight of the column of pumps, and when additional pumps are joined in, more weight is laid on the sledges. As the sinking set of pumps is constantly descending, and the point for the delivery of the water above always varying, a pipe of equal diameter with the pumps, and about 11 feet long, but much lighter in the metal, is attached to *e*, and is terminated by a hose of leather, of sufficient length to reach the cistern where the water is delivered. This is called the hoggar-pipe. In sinking, a vast quantity of air enters with the water, at every stroke of the engine; and therefore the lifting stroke should be very slow, and a momentary stop should take place before the returning stroke, to suffer all the air to escape. As the working barrels are generally 9 or 10 feet long, and the full stroke of the engine from 7 to 8 feet, when at regular work, it is customary to diminish the length of stroke, in sinking, to about 6 feet; because, while the pumps are constantly getting lower, the bucket in the working barrel has its working range progressively higher.

The usual length for a set of pumps, is from 25 to 30 fathoms. Whenever this depth is arrived at by the first set, preparations are made for fixing firmly the *upper* pit-cistern, into which the upper set of pumps is to be placed, and the water of the second set is to be thrown. If a strong bed of sandstone occurs, a scarcement of it is left projecting about 3 feet into the shaft, which is formed in the course of sinking into a strong chin or bracket, to sustain that part of the cistern in which the superior set of pumps stands. A few feet beneath this scarcement the shaft resumes its usual shape.

But although from 20 to 30 fathoms be the common length of a pump-lift, it sometimes becomes necessary to make it much longer, when no place can be found in the shaft for lodging a cistern, on account of the tubbing. Hence a pump-lift has been occasionally extended to 70 fathoms; which requires extraordinary strength of materials. The best plan for collaring the pumps in the pit, and keeping them steady in a perpendicular line, is to fix a strong bunton of timber under the joints of each pipe; and to attach the pipes firmly to these buntons by an iron collar, with screws and nuts, as represented in *fig.* 829.

829

The water obtained in sinking through the successive strata is, in ordinary cases, conducted down the walls of the shaft; and if the strata are compact, a spiral groove is cut down the sides of the shaft, and when it can hold no more, the water is drawn off in a spout to the nearest pump-cistern; or a perpendicular groove is cut in the side of the shaft, and a square box-pipe either sunk in it, flush with the sides of the pit, or it is covered with deal boards well fitted over the cavity. Similar spiral rings are formed in succession downwards, which collect the trickling streams, and conduct them into the nearest cistern; or rings, made of wood or cast iron, are inserted flush with the sides of the pipe; and the water is led from one ring to another, through perpendicular pipes, until the undermost ring is full, when it delivers its water into the nearest pump-cistern. Keeping the shaft dry is very important to the comfort of the miners, and the durability of the work.

When an engine shaft happens to pass through a great many beds of coal, a gallery a few yards long is driven into each coal-seam, and a bore then put down from one coal to another, so that the water of each may pass down through these bores to the pump-cisterns.

While a deep pit is sinking, a register is kept of every part of the excavations, and each feeder of water is measured daily, to ascertain its rate of discharge, and whether it increases or abates. The mode of measurement, is by noting the time, with a seconds watch, in which a cistern of 40 or 50 gallons gets filled. There are three modes of keeping back or stopping up these feeders, by plank tubbing; iron tubbing; and by oak cribs. Let *fig.* 830 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 that 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 floodgate would need to have a strength to resist 100 fathoms of water-pressure. For though the water at first oozes merely in discontinuous particles through the open pores of the sands and sandstones, yet it soon fills them up, like a myriad of tubes, which transfer to the bottom the total weight of the hydrostatic column of 100 fathoms; and experience shows, as we have already stated, that whatever water occurs in coal-pits or in mines, generally speaking, proceeds from the surface of the ground. Hence, if the cover be an impervious bed of clay, very little water will be met with among the strata, in comparison of what would be found under sand.

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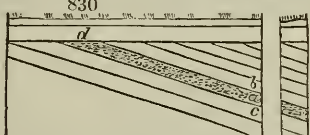

When several fathoms of the strata must be tubbed, in order to stop up the water-flow, the shaft must be widened regularly to admit the kind of tubbing that is to be inserted; the greatest width being needed for plank-tubbing, and the least for iron-tubbing. *Fig.* 831 represents a shaft excavated for 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

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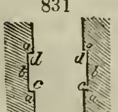

tightness of the tub at its jointing with the rock, several plans have been contrived to effect this object; the most approved being represented in *fig.* 832. To make room

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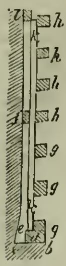

for the lower wedging crib, the recess is excavated a few inches wider, as at *c*; and from *b* to *c*, sheeting deals are laid all around the circle, or a thin stratum of oakum is introduced. On this the wedging crib *d* is applied, and neatly jointed in the radius-line of the pit, each segment being drawn exactly to the circle; and at each of its segments sheeting deal is inserted. This wedging crib must be 10 inches in the bed, and 6 inches deep. The vacuity *e*, at the back of the crib, about 2 and a half inches wide, is filled with pieces of dry clean reeded deal, inserted endwise; which is regularly wedged with one set of wedges all round, and then with a second and a third set of wedges, in the same regular style, to keep the crib in a truly circular posture. By this process, well executed, no water can pass downwards by the back of the crib. The next operation is to fix spiking cribs *f*, to the rock, about 10 or 12 feet from the lower crib, according to the length of the planks to be used for the tubs. They must be set fair to the sweep of the shaft, as on them its true circular figure depends. The tubbing deals *k*, must now be fixed. They are 3 inches thick, 6 broad, and planed on all sides, with the joints accurately worked to the proper bevel for the circle of the pit. The main cribs g, *g*, are then to be placed as counterforts, for the support and strength of the tubbing. The upper ends of the first set of tub-planks being cut square and level all round, the second spiking crib *l*, is fixed, and another set of tubbing deals put round like the former, having sheeting deal inserted betwixt the ends of the two sets at *f*. When this is wedged, the cribs *h*, *h*, are placed.

Oak cribbing is made with pieces of the best oak, from 3 to 4 feet long, 10 inches in the bed, and 7 or 8 inches deep.

The third mode of tubbing, by means of iron cylinders cast in segments, is likely henceforth to supersede the wooden tubbing, from the great reduction in the price of iron, and its superior strength and durability. Each segment is adjusted piece to piece in the circular recess of the pit cut out for their reception. The flange for the wedging joint is best turned inwards. In late improvements of this plan, executed by Mr. Buddle, where the pressure amounted to several hundred feet, the segments were 6 feet long, 2 feet broad, and an inch thick, counterforted with ribs or raised work on the back; the lip of the flange was strong, and supported by brackets. These segments of the iron cylinder are set true to the radius of the pit; and every horizontal and perpendicular joint is made tight with a layer of sheeting deal. A wedging crib is fixed at the bottom, and the segments are built up regularly with joints like ashlerwork. This kind of tubbing can be carried to any height, till the water finds an outlet at the surface, or till strata containing water can be tubbed off, as by the modes of tubbing already described. A shaft finished in this manner presents a smooth lining-wall of iron, the flanges being turned towards the outside of the cylinders. In this iron tubbing, no screw bolts are needed for joining the segments together; as they are packed hard within the pit, like the staves of a cask. There is a shaft in the Newcastle district, where 70 fathoms have been executed in this way, under the direction of Mr. Buddle.

When a porous thin bed or parting betwixt two impervious strata gives out much water, or when the fissures of the strata, called cutters, are very leaky, the water can be

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completely stopped up by the improved process of wedging. The fissure is cut open with chisels, to a width of two, and a depth of seven inches, as represented in *fig.* 833. The lips being rounded off about an inch and a half, pieces of clean deal are then driven in, whose face projects no further than the contour of the lips; when the whole is firmly wedged, till the water is entirely stopped. By sloping back the edges of the fissures, and wedging back from the face of the stone, it is not liable to burst or crack off in the operation, as took place in the old way, of driving in the wedge directly.

Ventilation of Engine pits.—In ordinary cases, while the sinking of the shaft is going on, the brattice walls produce a circulation, in consequence of the air being slightly

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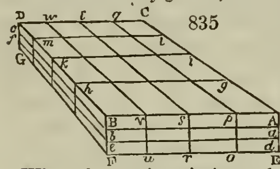
lighter in one compartment than in another. If this does not occur, the circulation of air must be produced by artificial means. The most approved contrivance is, to cover the engine compartment of the shaft with deals, leaving apertures for the pump-spears and tackling to pass through, with hatch-doors for the men, and to carry a brick flue at leat 3 feet square, in a horizontal direction, from the mouth of that compartment to an adjoining high chimney connected with a furnace, as represented in *fig.* 834. *a*, *a*, are double doors, for the fireman to supply fuel by; *b*, the mouth of the horizontal flue; *c*, the furnace; *d*, the ash-pit; *e*, the furnace; *f*, the upright chimney for draught, from 50 to 100 feet high, from 8 to 10 feet square at bottom, and tapering upwards to 3 or 4 feet square inside. Such a furnace and chimney are also needed for ventilating the coal-mine through all its underground workings. When a great quantity of gas issues from one place in a pit, it is proper to carry it up in a square wooden pipe, which terminating at some distance above the surface in a helmet-shaped funnel, fitted to turn like a vane, may cause considerable ventilation of itself; or the top of such a pipe may be connected with a small fireplace, which will cause a rapid current up through it, from the pit. The stones and rubbish produced in sinking are drawn up with horse-gins, when the pit is not deep; but in all shafts of considerable depth, a steam engine is used, and the workmen have now more confidence in them, as to personal safety, than in machines impelled by horses.

The great collieries of Newcastle are frequently worked by means of one shaft divided into compartments, which serves as an engine-pit, and coal-pits, and by these the whole ventilation is carried on to an extent and through ramifications altogether astonishing. This system has been adopted on account of the vast expense of a large shaft, often amounting to 60,000*l.* or 80,000*l.*, including the machinery. The British collieries, however, are in general worked by means of an engine-pit, and a series of other pits, sunk at proper distances for the wants of the colliery.

WORKING OF COAL.

A stratum, bed, or seam of coal, is not a solid mass, of uniform texture, nor always of homogeneous quality in burning. It is often divided and intersected, with its concomitant strata, by what are named partings, backs, cutters, reeds, or ends. Besides the chief partings at the roof and pavement of the coal seam, there are subordinate lines of parting in the coal mass, parallel to these, of variable dimensions. These divisions are delineated in *fig.* 835, where A, B, C, D, E F G D, represent a portion of a bed of coal,



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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 backs; *o p*, *p q*, *r s*, *s t*, *u v*, and *v w*, the cutters. It is thus manifest that a bed of coal, according to the number of these natural divisions, is subdivided into solid figures of various dimensions, and of a cubical or rhomboidal shape.

When the engine-pit is sunk, and the lodgment formed, a mine is then run in the coal to the rise of the field, or a cropping from the engine-pit to the second pit. This mine may be 6 or 8 feet wide, and carried either in a line directly to the pit bottom, or at right angles to the backs or web of the coal, until it is on a line with the pit, where a mine is set off, upon one side, to the pit bottom. This mine or gallery is carried as nearly parallel to the backs as possible, till the pit is gained. *Fig.* 836 represents this

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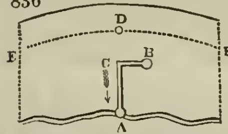

mining operation. A is the engine-pit. B, the second or by-pit. A C, the gallery driven at right angles to the backs. C B, the gallery set off to the left hand, parallel to the backs. The next step is to drive the drip-head or main-levels from the engine-pit bottom, or from the dip-hand of the backset immediately contiguous to the engine-pit bottom. In this business, the best colliers are always employed, as the object is to drive the gallery in a truly level direction, independently of all sinkings or risings of the pavement. For coal seams of ordinary thickness, this gallery is usually not more than 6 feet wide; observing to have on the dip side of the gallery a small quantity of water, like that of a gutter, so that it will always be about 4 or 6 inches deep at the forehead upon the dip-wall. When the level is driven correctly, with the proper depth of water, it is said to have dead water at the forehead. In this operation, therefore, the miner pays no regard to the backs or cutters of the coal; but is guided in his line of direction entirely by the water-level, which he must attend to solely, without regard to slips or dislocations of the strata throwing the coal up or down. In the last figure, the coal-field is a portion of a basin; so that if the shape be uniform and unbroken, and if any point be assumed a dipping from the crop, as D, the level lines from that point will be parallel to the line of crop, as D E, D F, and the levels from any point whatever a-dipping, will be also parallel to these; and hence, were the coal-field an entire elliptical basin, the dip-head levels carried from any point would be elliptical, and parallel to the crop. If, as is more commonly the case, the coal-field be merely a portion of a basin,

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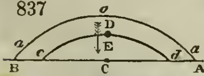

formed by a slip of the strata, as represented in *fig.* 837, where *a*, *a*, *a*, is the crop, and A B, a slip of great magnitude, forming another coal-field on the side C, then the crop not only meets the alluvial cover, but is cut off by the slip at A and at B. Should any point, therefore, be assigned 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.

In British practice, there are four different systems of working coal-mines:—

1. Working with pillars and rooms, styled post and stall, where the pillars left bear such proportion to the coal excavated, as is just adequate to the support of the incumbent strata.

2. Working with post and stall, where the pillars are left of an extra size, and stronger than may be requisite for bearing the superior strata, with the intention of removing a considerable portion of each massive pillar, whenever the regular working of post and stall has been finished in the colliery.

3. Working with post and stall, or with comparatively narrow rooms or boards, whereby an uncommonly large proportion of coal is left, with the view of working back towards the pits, whenever the colliery is worked in this manner to the extent of the coal-field, and then taking away every pillar completely, if possible, and allowing the whole superincumbent strata to crush down, and follow the miners in their retreat.

4. Working the long way, being the Shropshire method; which leaves no pillars, but takes out all the coal progressively as the workings advance. On this plan, the incumbent strata crush down, creeping very close to the heads of the miners.

The post and stall system is practised with coals of every thickness. The Shropshire method is adopted generally with thin coals; for when the thickness exceeds 6 or 7 feet, this mode has been found impracticable.

The following considerations must be had in view in establishing a coal-mine:—

1. The lowest coal of the winning should be worked in such a manner as not to injure the working or the value of the upper coals of the field; but if this cannot be done, the upper coals should be worked in the first place.

2. The coals must be examined as to texture, hardness, softness, the number and openness of the backs and cutters.

3. The nature of the pavement of the coal seam, particularly as to hardness and softness; and if soft, to what depth it may be so.

4. The nature of the roof of the coal-seam, whether compact, firm, and strong; or weak and liable to fall; as also the nature of the superincumbent strata.

5. The nature of the alluvial cover of the ground, as to water, quicksands, &c.

6. The situation of rivers, lakes, or marshes, particularly if any be near the outcrop of the coal strata.

7. The situation of towns, villages, and mansion-houses, upon a coal-field, as to the chance of their being injured by any particular mode of mining the coal.

Mr. Bald gives the following general rules for determining the best mode of working coal:—

"1. If the coal, pavement, and roof are of ordinary hardness, the pillars and rooms may be proportioned to each other, corresponding to the depth of the superincumbent strata, providing all the coal proposed to be wrought is taken away by the first working, as in the first system; but if the pillars are to be winged afterwards, they must be left of an extra strength, as in the second system.

"2. If the pavement is soft, and the coal and roof strong, pillars of an extra size must be left, to prevent the pillars sinking into the pavement, and producing a creep.

"3. If the coal is very soft, or has numerous open backs and cutters, the pillars must be left of an extra size, otherwise the pressure of the superincumbent strata will make the pillars fly or break off at the backs and cutters, the result of which would be a total destruction of the pillars, termed a crush or sit, in which the roof sinks to the pavement, and closes up the work.

"4. If the roof is very bad, and of a soft texture, pillars of an extra size are required, and the rooms or boards comparatively very narrow.

"In short, keeping in view all the circumstances, it may be stated generally, that when the coal, pavement, and roof are good, any of the systems before mentioned may be pursued in the working; but if they are soft, the plan is to work with rooms of a moderate width, and with pillars of great extra strength, by which the greater part of the coal may be got out at the last of the work, when the miners retreat to the pit bottom, and there finish the workings of a pit."

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Fig. 838 represents the effects of pillars sinking into the pavement, and producing a creep; and *fig.* 839 exhibits large pillars and a room, with the roof stratum bending down before it falls at *a*. Thus the roads will be shut up, the air-courses destroyed, and the whole economy of the mining operations deranged.

The proportion of coal worked out, to that left in the pillars, when all the coal intended to be removed is taken out at the first working, varies from four fifths to two thirds; but as the loss of even one third of the whole area of coal is far too much, the better mode of working suggested in the third system ought to be adopted.

The proportion of a winning to be worked may be thus calculated. Let *fig.* 840 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.

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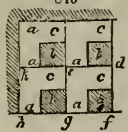

In forming the pillars and carrying forwards the boards with regularity, especially where the backs and cutters are very distinct and numerous, it is of importance to work the rooms at right angles to the backs, and the thirlings in the direction of the cutters, however oblique these may be to the backs, 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.* 841. By neglect of this rule, much confusion and irregular work are 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.

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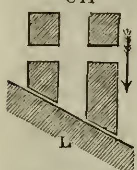

We shall now explain the different systems of working: one of the simplest of which is shown in *fig.* 842; where A represents the engine-pit, B the by-pit, C D the dip-head levels, always carried in advance of the rooms, and E the rise or crop gallery, also carried in advance. These galleries not only 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 a cropping in the one case, till the coal is cropped out, or is no longer workable; and in the other, they are extended as far as the extremity of the dip-head level, which is finally cut off, either by a dike or slip, or by the boundary of the coal-field.

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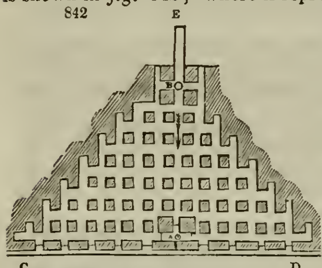
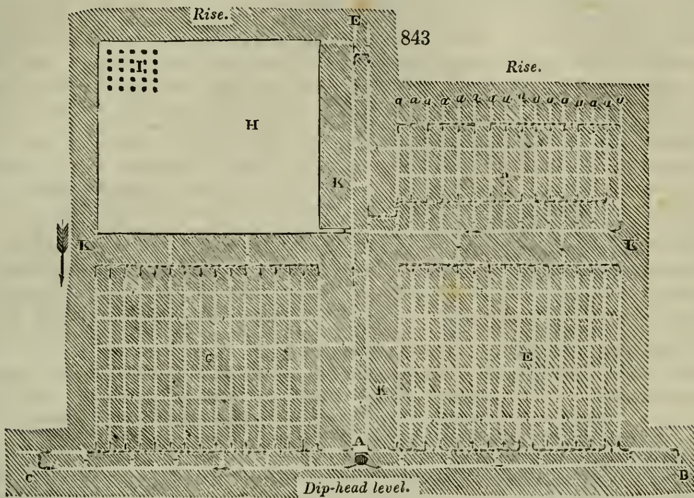


When the winnings are so very deep as from 100 to 200 fathoms, the first workings are carried forward with rooms, pillars, and thirlings, but under a different arrangement, on account of the great depth of the superincumbent strata, the enormous expense incident to sinking a pit, and the order and severity of discipline indispensable to the due ventilation of the mines, the preservation of the workmen, and the prosperity of the whole establishment. To the celebrated Mr. Buddle the British nation is under the greatest obligations for devising a new system of working coal-mines, whereby nearly one third of the coals has been rescued from waste and permanent destruction. This system is named panel work; because, instead of carrying on the coal-field winning in one extended area of rooms and pillars, it is divided into quadrangular panels, each panel containing an area of from 8 to 12 acres; and round each panel is left at first a solid wall of coal from 40 to 50 yards thick. Through the panel walls roads and air-courses are driven, in order to work the coal contained within these walls. Thus all the panels are connected together with the shaft, as to roads and ventilation. Each district or panel has a particular name; so that any circumstance relative to the details of the colliery, casualties as to falls and crushes, ventilation, and the safety of the workmen, can be referred to a specific place.

Fig. 843 represents a part of a colliery laid out in four panels, according to the improved method. To render it as distinct as possible, the line of the boards is at right



angles with the dip-head level, or level course of the coal. A is the engine-shaft, divided into three compartments, an engine-pit and two coal-pits, like *fig.* 825. 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 panel fully worked out, whence nearly all the coal has been extracted; the loss amounting in general to no more than a tenth, instead of a third, or even a half, by the old method. By this plan of Mr. Buddle's, also, the pillars of a panel may be worked out at any time most suitable for the economy of the mining operation; whereas formerly, though the size of the pillars and general arrangement of the mine were made with the view of taking out ultimately a great proportion of the pillars, yet it frequently happened that, before the workings were pushed to the proposed extent, some part of the mine gave way, and produced a crush; but the most common misfortune was the pillars sinking into the pavement, and deranging the whole economy of the field. Indeed, the crush or creep often overran the whole of the pillars, and was resisted only by the entire body of coal at the wall faces; so that the ventilation was entirely destroyed, the roads leading from the wall faces to the pit-bottom shut up and rendered useless, and the recovery of the colliery by means of new air-courses, new roads, and by opening up the wall faces or rooms, was attended with prodigious expense and danger. Even when the pillars stood well, the old method was attended with other very great inconveniences. If water broke out in any particular spot of the colliery, it was quite impossible to arrest its progress to the engine-pit; and if the ventilation was thereby obstructed, no idea could be formed where the cause might be found, there being instances of no less than 30 miles of air-courses in one colliery. And if from obstructed ventilation an explosion of the fire-damp occurred while many workmen were occupied along the extended wall faces, it was not possible to determine where the disaster had taken place; nor could the viewers and managers know where to bring relief to the forlorn and mutilated survivers.

In Mr. Buddle's system all these evils are guarded against, as far as human science and foresight can go. He makes the pillars very large, and the rooms or boards narrow; the pillars being in general 12 yards broad, and 24 yards long; the boards 4 yards wide, and the walls or thirlings cut through the pillars from one board to another, only 5 feet wide, for the purpose of ventilation. In the figure, the rooms are represented as proceeding from the dip to the crop, and the panel walls act as barriers thrown round the area of the panel, to prevent the weight of the superincumbent strata from overrunning the adjoining panels. Again, when the *pillars* of a panel are to be worked, one range of pillars, as at I (in H), is first attacked; and as the workmen cut away the furthest pillars, columns of prop-wood are erected betwixt the pavement and the roof, within a few feet of each other (as shown by the dots), till an area of above 100 square yards is cleared of pillars, presenting a body of strata perhaps 130 fathoms thick, suspended clear and without support, except at the line of the surrounding pillars. This operation is termed working the *goaff*. The only use of the prop-wood is to prevent the seam, which forms the ceiling over the workmen's heads, from falling down and killing them by its splintery fragments. Experience has proved, that before proceeding to take away another set of pillars, it is necessary to allow the last-made goaff to fall. The workmen then begin to draw out the props, which is a most hazardous employment. They begin at the more remote props, and knock them down one after another, retreating quickly under the protection of the remaining props. Meanwhile the roof-stratum begins to break by the sides of the pillars, and falls down in immense pieces; while the workmen still persevere, boldly drawing and retreating till every prop is removed. Nay, should any props be so firmly fixed by the top pressure, that they will not give way to the blows of heavy mauls, they are cut through with axes; the workmen making a point of honor to leave not a single prop in the goaff. The miners next proceed to cut away the pillars nearest to the sides of the goaff, setting prop-wood, then drawing it, and retiring as before, until every panel is removed, excepting small portions of pillars which require to be left under dangerous stones to protect the retreat of the workmen. While this operation is going forward, and the goaff extending, the superincumbent strata being exposed without support over a large area, break progressively higher up; and when strong beds of sandstone are thus giving way, the noise of the rending rocks is very peculiar and terrific; at one time loud and sharp, at another hollow and deep.

As the pillars of the panels are taken away, the panel walls are also worked progressively backwards to the pit bottom; so that only a very small proportion of coal is eventually lost. This method is undoubtedly the best for working such coals as those of Newcastle, considering their great depth beneath the surface, their comparative softness, and the profusion of inflammable air. It is evident that the larger the pillars and panel walls are, in the first working, the greater will be the security of the miners, and the greater the certainty of taking out, in the second stage, the largest proportion of coal. This system may be applied to many of the British collieries; and it will produce a vast quantity of coals beyond the post and stall methods, so generally persisted in.

In thus tearing to pieces the massive rocks over his head, the miner displays a determined and cool intrepidity; but his ingenuity is no less to be admired in contriving modes of carrying currents of pure atmospheric air through every turning of his gloomy labyrinth, so as to sweep away the explosive spirit of the mine.

The fourth system of working coal, is called the *long way*, the long-wall, and the Shropshire method. The plan must at first have been extremely hazardous; though now it is so improved as to be reckoned as safe, if not safer, to the workmen, than the other methods, with rooms and pillars.

The object of the Shropshire system, is to begin at the pit-bottom pillars, and to cut away at once every inch of coal progressively forward, and to allow the whole superincumbent strata to crush down behind and over the heads of the workmen. This plan is pursued chiefly with coals that are thin, and is very seldom adopted when the seam is 7 feet thick; from 4 to 5 feet being reckoned the most favorable 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.

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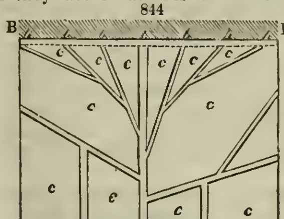

When the operation is commenced by working on the Shropshire plan, the dip-head levels are driven in the usual manner, and very large bottom pillars are formed, as represented in *fig.* 844. Along the rise side of the dip-head level, chains of wall, or long pillars, are also made, from 8 to 10 yards in breadth, and only mined through occasionally, for the sake of ventilation, or of forming new roads. In other cases no pillars are left upon the rise side of the level; but, instead of them, buildings of stone are reared, 4 feet broad at the base, and 9 or 10 feet from the dip side of the level. Though the roads are made 9 feet wide at first, they are reduced to half that width after the full pressure of the strata is upon them. 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* 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 crushed strata, the miners in the first place cut away about 15 feet of coal round the pit-bottom pillars, and along the upper sides of the dip-head chain walls; and then, at the distance of 9 or 10 feet, carry regular buildings of stone 3 feet broad, with props set flush with the faces of these, if necessary. As the miners advance, they erect small pillars of roof or pavement stone in regular lines with the wall face, and sometimes with props intermediate.

There are two principal modifications of the Shropshire plan. The first, or the original system, was to open out the wall round the pit-bottom; and, as the wall face extended, to set off main roads and branches, very like the branches of a tree. These roads were so distributed, that between the ends of any two branches there should be a distance of 30 or 40 yards, as might be most convenient. (See *fig.* 844.) 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.* 844 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 Shropshire system is represented in *fig.* 845, 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

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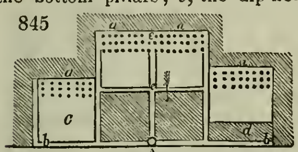

stones not be forthcoming, coals must be substituted, which are built about 20 inches in the base. In this method, the roads are likewise from 20 to 40 yards apart; but instead of ramifying, they are arranged parallel to each other. The miners secure the waste by gobbing; and three rows of props are carried forwards next the wall faces *a*, with pillars of stone or of coal reared betwixt them. This mode has a more regular appearance than the other; though it is not so generally practised.

In the post and stall system, each man has his own room, and performs all the labor of it; but in that of Shropshire, there is a division of labor among the workmen, who are generally divided into three companies. The first set curves or pools the coal along the whole line of walls, laying in or pooling at least 3 feet, and frequently 45 inches, or 5 quarters, as it is called. These men are named *holers*. As the crush is constantly following them, and impending over their heads, causing frequent falls of coal, they plant props of wood for their protection at regular distances in an oblique direction between the pavement and wall face. Indeed, as a further precaution, staples of coal, about 10 inches square, are left at every 6 or 8 yards, till the line of holing or curving is completed. The walls are then marked off into spaces of from 6 to 8 yards in length; and at each space a shearing or vertical cut is made, as deep as the holing; and when this is done, the holer's work is finished. The set who succeed the holers, are called getters. These commence their operations at the centre of the wall divisions, and drive out the *gibbs* and staples. They next set wedges along the roof, and bring down progressively each division of coal; or, if the roof be hard-bound, the coal is blown down with gunpowder. When the roof has a good parting, the coals frequently fall down the moment the gibbs are struck; which makes the work very easy. The getters are relieved in their turn by the third set, named butty-men, who break down the coals into pieces of a proper size for sending up the shaft, and take charge of turning out the coal from the wall face to the ends of the roads. This being done, they build up the stone pillars, fill up the gobb, set the trees, clear the wall faces of all obstructions, set the gibbs, and make every thing clear and open for the holers to resume their work. If the roads are to be heightened by taking down the roof, or removing the pavement, these butty-men do this work also, building forwards the sides of the roads, and securing them with the requisite props. When a coal has a following or roof stone, which regularly separates with the coal, this facilitates the labor, 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.* 846, 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 gobb, or the gobb 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.

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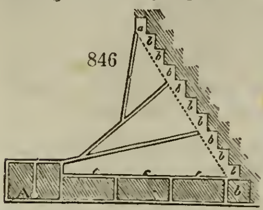


It is estimated that from one eighth to one twelfth part only of the coals remains under ground by the Shropshire plan; nay, in favorable circumstances, almost every inch of coal may be taken out, as its principle is to leave no solid pillars nor any coal below, except what may be indispensable for securing the gobb. 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.

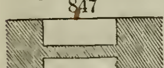
In Great Britain, seams of coal are mined when they are only 18 inches thick; but if thinner, the working of fire-clay or ironstone immediately adjoining must be included. A few instances may be adduced, indeed, where caking coals of a fine quality for blacksmiths have been worked, though only in 12-inch seams.

Eighteen-inch seams are best worked by young lads and boys. The coal itself may be mined without lifting the pavement, or taking down the roof in the rooms; but roads must be cut either in the pavement or the roof, for removing the coals to the pit-bottom. All coals less than 2 feet 3 inches thick, are worked with the view of taking out all the coal, either on the Shropshire system, or with pillar-walls and rooms; with this peculiarity, that, on account of the thinness of the seam, the rooms are worked as wide as the roof will bear up; or if a following of the roof-stone, or fall of it, can be brought on, it proves advantageous, by not only giving head-room, but by filling up the waste, and rendering the roads easily kept for the working of the pillars. Where no following takes place, small temporary pillars, about 8 feet square, are left along the chain-wall side. The walls may vary in thickness from 4 to 16 yards, according to circumstances, and they are holed through only for ventilation.

Coals from 5 to 8 feet thick are the best suited in every point of view for the effective work of the miner, and for the general economy of underground operations. When they exceed that thickness, they require very excellent roofs and pavements, to render the working either safe or comfortable; or to enable those who superintend the field to get out a fair proportion of coal from a given area. In such powerful beds the Shropshire method is impracticable, from want of gobbin; and long props, unless of prodigious girth, would present an inadequate resistance to the pressure of the massive ceiling.

When coals do not exceed 20 feet in thickness, and have good roofs, they are sometimes worked as one bed of coal; but if the coal be tender or free, it is worked as two beds. One half of such thick coal, however, is in general lost in pillars; and it is very seldom that less than one third can be left. When the coal is free and ready to crumble by the incumbent pressure, as well as by the action of the air, the upper portion of the coal is first worked, then a scaffolding of coal is left, 2 or 3 feet thick, according to the compactness of the coal; and the lower part of the coal is now worked, as shown in *fig.* 847. As soon as the workings are completed to the proposed extent, the coal scaffoldings are worked away, and as much of the pillars as can be removed with safety. As propwood is of no use in coal-seams of such a height, and as falls from the roof would prove frequently fatal to the miners, it is customary with tender roofs to leave a ceiling of coal from 2 to 3 feet thick. This makes an excellent roof; and should it break, gives warning beforehand, by a peculiar crackling noise, very different from that of roof-stones crushing down.

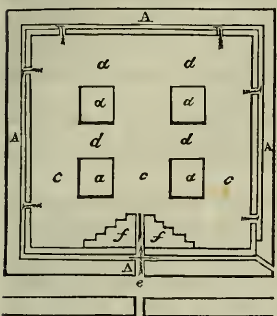
847



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.* 848 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.

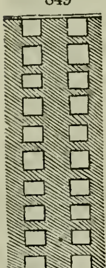
848



In working the ten-yard coal, a very large proportion of it is left under ground, not merely in pillars and rib-walls, but in the state of small coal produced in breaking out the coal. Hence, from four tenths to a half of the total amount is lost for ever.

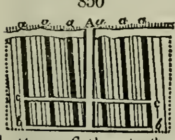
Another method of working coal of uncommon thickness is by scaffoldings or stages of coals, as practised in the great coal bed at Johnstone, near Paisley, of which a section has already been given. In one part of the field the coal is from 50 to 60 feet thick, and in another it amounts to 90 feet. The seams of stone interspersed through the coal are generally inconsiderable, and amount in only two cases to 27 inches in thickness. The roof of the coal is so unsound, and the height so prodigious, that it could not possibly be worked in one seam, like that of Staffordshire. About 3 feet of the upper coal is therefore left as a roof, under which a band of coal, from 6 to 7 feet thick, is worked on the post and stall plan, with square pillars of extra strength, which are thereafter penetrated. A platform about 3 feet high is left at the sole; under which the rooms and pillars are set off and worked in another portion of the coal, from 5 to 7 feet thick, great care being had to place pillar under pillar, and partition under partition, to prevent a crush. Where the coal is thickest, no less than 10 bands of it are worked in this way, as is shown in *fig.* 849. When any band of the coal is foul from sulphur or other causes, it is left for the next platform, so that a large proportion of it is lost, as in the Staffordshire mines. Much attention must here be paid to the vertical distribution of the pillars and apartments; the miner's compass must be continually consulted, and bore-holes must be put down through the coal scaffoldings, to regulate correctly the position of the pillars under one another.

849



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.

850



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.* 850, 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 neighborhood of Edinburgh, and the coals are carried on the backs of women from the wall-face to the bottom of the engine-pit.

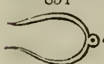
The modes of carrying coals from the point where they are excavated to the pit bottom are nearly as diversified as the systems of working.

One method employs hutches, or baskets, having slips or cradle feet shod with iron, containing from 2 to 3 hundred weight of coals. These baskets are dragged along the floor by ropes or leather harness attached to the shoulders of the workmen, who are either the colliers or persons hired on purpose. This method is used in several small collieries; but it is extremely injudicious, exercising the muscular action of a man in the most unprofitable manner. Instead of men, horses are sometimes yoked to these basket-hurdles, which are then made to contain from 4 to 6 hundred weight of coals; but from the magnitude of the friction, this plan cannot be commended.

An improvement on this system, where men draw the coals, is to place the basket or corve on a small four-wheeled carriage, called a tram, or to attach wheels to the corve itself. Thus much more work is performed, provided the floor be hard; but not on a soft pavement, unless some kind of wooden railway be laid.

The transport of coals from the wall-face to the bottom of the shaft was greatly facilitated by the introduction of cast-iron railways, in place of wooden roads, first brought into practice by Mr. John Curr of Sheffield. The rails are called tram-rails, or plate-rails, consisting of a plate from 3 to 4 inches broad, with an edge at right angles to it about two inches and a half high. Each rail is from 3 to 4 feet long, and is fixed either to cross bearers of iron, called sleepers, or more usually to wooden bearers. In some collieries, the miners, after working out the coals, drag them along these railways to the pit bottom; but in others, two persons called trammers are employed to transport the coals; the one of whom, in front of the corve, draws with harness; and the other, called the patter, pushes behind. The instant each corve arrives, from the wall-face, at a central spot in the system of the railways, it is lifted from the tram by a crane placed there, and placed on a carriage called a rolley, which generally holds two corves. Whenever three or four rolleys are loaded, they are hooked together, and the rolley driver, with his horse, takes them to the bottom of the engine-shaft. The rolley horses have a peculiar kind of shafts, commonly made of iron, named limbers, the purpose of which is to prevent the carriage from overrunning them. One of these shafts is represented in *fig.* 851. 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.

851



The power of the engine for drawing the coals up the shaft is made proportional to the depth of the pit and the quantity to be raised, the corves ascending at an average velocity of about 12 feet per second. So admirable is the modern arrangement of this operation, that the corves are transported from the wall-faces to the pit bottom, and moved up the shaft, as fast as the onsetters at the bottom, and the banksmen at the top, can hook the loaded and empty corves on and off the engine ropes. Thus 100 corves of coals have been raised every hour up a shaft 100 fathoms deep, constituting a lift of 27 tons per hour, or 324 tons in a day, or shift of 12 hours. Coals mined in large cubical masses cannot, however, be so rapidly raised as the smaller coal of the Newcastle district.

When coals have so great a rise from the pit bottom to the crop that horses cannot be used on the rolley ways, the corves descend along the tram-roads, by means of inclined-plane machines, which are moved either by vertical rope-barrels, or horizontal rope-sheaves. These inclined planes are frequently divided into successive stages, 200 or 300 yards long, at the end of each of which is an inclined-plane machine, whereby the coals are lowered from one level to another.

The wheels of the trams and rolleys vary in diameter from 8 to 16 inches, according to the thickness of the coal. In some, the axles not only revolve on their journals, but the wheels also revolve on their axles.

Various forms of machines have been employed for raising the coals out of the pits. The steam engine with fly-wheel and rope-barrels is, however, now preferred in all considerable establishments. When of small power, they are usually constructed with a fly wheel, and short fly-wheel shaft, on which there is a small pinion working into the teeth of a large wheel, fixed upon the rope-barrel. Thus the engine may move with great rapidity, while it imparts an equable slow motion to the corves ascending in the shaft. When the engines are of great power, however, they are directly connected with the rope-barrel; some of these being of such dimensions, that each revolution of the rope-barrel produces an elevation of 12 yards in the corve. A powerful brake is usually connected with the circumference of the fly-wheel or rope-barrel, whereby the brakeman, by applying his foot to the governing lever of the brake, and by shutting at the same time the steam valves with his hands, can arrest the corve, or pitch its arrival within a few inches of the required height of every delivery. An endless chain, suspended from the bottom to the top of the shaft, has, in a few pits of moderate depth, been worked by a steam engine, for raising corves in constant succession; but the practice has not been found hitherto applicable on the greater scale.

There is a kind of water engines for raising coals, strictly admissible only in level free pits, where the ascent of the loaded corve is produced by the descent of a cassoon filled with water. When the ascent and descent are through equal spaces, the rope barrels for the cassoon and the corves are of equal diameter; but when the point from which the coals have to be lifted is deeper than the point of discharge for the water into the dry level, the cassoon must be larger, and the rope barrel smaller; so that by the time the cassoon reaches to the half-depth, for example, the corve may have mounted through double the space. The cassoon is filled with water at the pit mouth, and is emptied by a self-acting valve whenever it gets to the bottom. The loaded corve is replaced by an empty one at the pit mouth, and its weight, with that of the descending rope, pull up the empty cassoon; the motions of the whole mechanism being regulated by a powerful brake.

Various plans have been devised to prevent collision between the ascending and descending corves, which sometimes pass each other with a joint velocity of 20 or 30 feet per second. One method is by dividing the pit from top to bottom, so that each corve moves in a separate compartment. Another mode was invented by Mr. Curr of Sheffield, in which wooden guides were attached from top to bottom of the pit; being spars of deal about 4 inches square, attached perpendicularly to the sides of the shaft, and to buntons in the middle of the pit. Betwixt these guides, friction-roller sliders are placed, attached to the gin-ropes, to which sliders the corves are suspended. In this way, the corves can be raised with great rapidity; but there is a considerable loss of time in banking the corve at the pit mouth, where shutters or sliding boards must be used. This plan is highly beneficial where the coals are in large lumps.

Both ropes and chains are used for lifting coals. The round ropes are shroud-laid; but the preferable rope is the flat band, made of four ropes placed horizontally together, the ropes being laid alternately right and left. In this way, the ropes counteract one another in the twist, hanging like a riband down the shaft; and are stitched strongly together by a small cord. Such rope bands are not only very pliable for their strength, which protects the heart of the rope from breaking, but as they lap upon themselves, a simple sheave serves as a rope-barrel. They possess the additional advantge, that by so lapping, they enlarge the diameter of the axle in which they coil, and thus make a compensation mechanically against the increasing length of rope descending with its corve. Thus the counterpoise chains, used in deep pits to regulate the descent, have been superseded. See Rope-spinning.

When chains are preferred to ropes, as in very deep pits, the short pudding-link chains are mostly used. See Cable.

The corves, after being landed or banked at the pit mouth, are drawn to the bin or coal-hill, either upon slips by horses, or by trammers on a tram-road. But with small coals, like the Newcastle, the pit head is raised 8 or 9 feet above the common level of the ground, and the coal-heap slopes downwards from that height. As the bins increase, tram-roads are laid outwards upon them.

I shall now describe the *ventilation* of coal mines. Into their furthest recesses, an adequate supply of fresh air must be carried forwards, for the purposes of respiration, and the combustion of candles; as also for clearing off the carbonic acid and carbureted hydrogen gases, so destructive to the miners, who call these noxious airs, from their most obvious qualities, choke-damp and fire-damp.

Before the steam engine was applied to the drainage of the mines, and the extraction of the coal, the excavations were of such limited extent, that when inflammable air accumulated in the foreheads, it was usual in many collieries to fire it every morning. This was done by fixing a lighted candle to the end of a long pole, which being extended towards the roof by a person lying flat on the floor, the gas was fired, and the blast passed safely over him. If the gas was abundant, the explosive miner put on a wet jacket, to prevent the fire from scorching him. In other situations, where the fire-damp was still more copious, the candle was drawn forwards into it, by a cord passing over a catch at the end of the gallery, while the operator stood at a distance. This very rude and dangerous mode of exploding the inflammable gas is still practised, in a few mines, under the name of the firing line.

The carbonic acid or choke-damp, having a greater specific gravity than atmospheric air, in the proportion of about 3 to 2, occupies the lower part of the workings, and gives comparatively little annoyance. Its presence may moreover be always safely ascertained by the lighted candle. This cannot, however, be said of the fire-damp, which being lighter and more moveable, diffuses readily through the atmospheric air, so as to form a most dangerous explosive mixture, even at a considerable distance from the blowers or sources of its extrication from the coal strata. Pure subcarbureted hydrogen has a specific gravity = 0·555, air being 1; and consists of a volume of vapor of carbon, and two volumes of hydrogen, condensed by mutual affinity into one volume. The choke-damp is a mixture of the above, with a little carbonic acid gas, and variable proportions of atmospheric air. As the pure subcarbureted hydrogen requires twice its bulk of oxygen to consume it completely, it will take for the same effect about 10 times its bulk of atmospheric air, since this volume of air contains about two volumes of oxygen. Ten volumes of air, therefore, mixed with one volume of subcarbureted hydrogen, form the most powerfully explosive mixture. If either less or more air be intermixed, the explosive force will be impaired; till 3 volumes of air below or above that ratio, constitute non-explosive mixtures; that is, 1 of the pure fire-damp mixed with either 7 or 13 of air, or any quantity below the first, or above the second number, will afford an unexplosive mixture. With the first proportion, a candle will not burn; with the second, it burns with a very elongated blue flame. The fire-damp should therefore be still further diluted with common air, considerably beyond the above proportion of 1 to 13, to render the working of the mine perfectly safe.

These noxious gases are disengaged from the cutters, fissures, and minute pores of the coal; and if the quantity be considerable, relative to the orifice, a hissing noise is heard.

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Though the choke-damp, or carbonic acid gas, be invisible, yet its line of division from the common air is distinctly observable on approaching a lighted candle to the lower level, where it accumulates, which becomes extinguished the instant it comes within its sphere, as if it were plunged in water. The stratum of carbonic acid sometimes lies 1 or 2 feet thick on the floor, while the superincumbent air is perfectly good. When the coal has a considerable dip and rise, the choke-damp will be found occupying the lower parts of the mine, in a wedge form, as represented in *fig.* 852, where *a* shows the place of the carbonic acid gas, and *b* that of the common air.

When a gallery is driven in advance of the other workings, and a discharge of this gas takes place, it soon fills the whole mine, if its direction be in the line of level, and the mine is rendered unworkable until a supply of fresh air is introduced to dislodge it. As the flame of a candle indicates correctly the existence of the choke-damp, the miners may have sufficient warning of its presence, so as to avoid the place which it occupies, till adequate means be taken to drive it away.

The fire-damp is not an inmate of every mine, and is seldom found, indeed, where the carbonic acid prevails. It occurs in the greatest quantities in the coal mines of the counties of Northumberland, Durham, Cumberland, Staffordshire, and Shropshire. It is more abundant in coals of the caking kind, with a bright steel-grained fracture, than in cubic coals of an open-burning quality. Splint coals are still less liable to disengage this gas. In some extensive coal-fields it exists copiously on one range of the line of bearing, while on the other range none of it is observed, but abundance of carbonic acid gas.

In the numerous collieries in the Lothians, south from the city of Edinburgh, the fire-damp is unknown; while in the coal-fields round the city of Glasgow, and along the coast of Ayrshire, it frequently appears.

The violent discharge of the gas from a crevice or cutter of the coal, is called a blower; and if this be ignited, it burns like an immense blowpipe, inflaming the coal at the opposite side of the gallery. The gas evidently exists in a highly compressed and elastic state; whence it seems to loosen the texture of the coals replete with it, and renders them more easily worked. The gas is often peculiarly abundant near a great dislocation or slip of the strata; so that the fissure of the dislocation will sometimes emit a copious stream of gas for many years. It has also happened, that from certain coals, newly worked, and let fall from a height into the hold of a vessel, so much inflammable gas has been extricated that, after the hatches were secured, and the ship ready to proceed to sea, the gas has ignited with the flame of a candle, so as to scorch the seamen, to blow up the decks, and otherwise damage the vessel. In like manner, when the pillars in a mine are crushed by sudden pressure, a great discharge of gas ensues. This gas, being lighter than common air, always ascends to the roof or to the rise of the galleries; and, where the dip is considerable, occupies the forehead of the mine, in a wedge form, as shown in *fig.* 853, where *a* represents the fire-damp, and *b* the common air. In this case, a candle will burn without danger near the point c, close to the floor; but if it be advanced a few feet further towards the roof, an explosion will immediately ensue; since at the line where the two elastic fluids are in contact, they mix, and form an explosive body.

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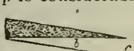

When this gas is largely diluted with air, the workmen do not seem to feel any inconvenience from breathing the mixture for a period of many years; but on inhaling pure carbureted hydrogen, the miner instantly drops down insensible, and, if not speedily removed into fresh air, he dies

The production of these noxious gases renders ventilation a primary object in the system of mining. The most easily managed is the carbonic acid. If an air-pipe has been carried down the engine pit for the purpose of ventilation in the sinking, other pipes are connected with it, and laid along the pavement, or are attached to an angle of the mine next the roof. These pipes are prolonged with the galleries, by which means the air at the forehead is drawn up the pipes and replaced by atmospheric air, which descends by the shaft in an equable current, regulated by the draught of the furnace at the pit mouth. This circulation is continued till the miners cut through upon the second shaft, when the air-pipes become superfluous; for it is well known that the instant such communication is made, as is represented in *fig.* 854, the air spontaneously descends in the engine pit A, and, passing along the gallery *a*, ascends in a steady current in the second pit B. The air, in sinking through A, has at first the atmospheric temperature, which in winter may be at or under the freezing point of water; but its temperature increases in passing down through the relatively warmer earth, and ascends in the shaft B, warmer than the atmosphere. When shafts are of unequal depths, as represented in the figure, the current of air flows pretty uniformly in one direction. If the second shaft has the same depth with the first, and the bottom and mouth of both be in the same horizontal plane, the air would sometimes remain at rest, as water would do in an inverted syphon, and at other times would circulate down one pit and up another, not always in the same direction, but sometimes up the one, and sometimes up the other, according to the variations of temperature at the surface, and the barometrical pressures, as modified by winds. There is in mines a proper heat, proportional to their depth, increasing about one degree of Fahrenheit's scale for every 60 feet of descent.

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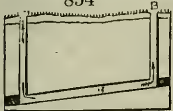

There is a simple mode of conducting air from the pit bottom to the forehead of the mine, by cutting a ragglin, or trumpeting, as it is termed, in the side of the gallery as represented in *fig.* 855, where A exhibits the gallery in the coal, and B the ragglin, which is from 15 to 18 inches square. The 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.

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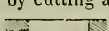

When the ragglin or air-pipes are not made spontaneously active, the air is sometimes impelled through them by means of ventilating fanners, having their tube placed at the pit bottom, while the vanes are driven with great velocity by a wheel and pinion worked with the hand. In other cases, large bellows like those of the blacksmith, furnished with a wide nozzle, are made to act in a similar way with the fanners. But these are merely temporary expedients for small mines. A very slight circulation of air can be effected by propulsion, in comparison of what may be done by exhaustion; and hence it is better to attach the air-pipe to the valve of the bellows, than to their nozzle.

Ventilation of collieries has been likewise effected on a small scale, by attaching a horizontal funnel to the top of air-pipes elevated a considerable height above the pit mouth. The funnel revolves on a pivot, and by its tail-piece places its mouth so as to receive the wind. At other times, a circulation of air is produced by placing coal-fires in iron grates, either at the bottom of an upcast pit, or suspended by a chain a few fathoms down.

Such are some of the more common methods practised in collieries of moderate depth, where carbonic acid abounds, or where there is a total stagnation of air. But in all great coal mines the aerial circulation is regulated and directed by double doors, called main or bearing doors. These are true air-valves, which intercept a current of air moving in one direction from mixing with another moving in a different direction. Such valves are placed on the main roads and passages of the galleries, and are essential to a just ventilation. Their functions are represented in the annexed *fig.* 856, where A shows the downcast shaft, in which the aerial current is made to descend; B is the upcast shaft, sunk towards the rise of the coal; and C, the dip-head level. Were the mine here figured to be worked without any attention to the circulation, the air would flow down the pit A, and proceed in a direct line up the rise mine to the shaft B, in which it would ascend. The consequence would therefore be, that all the galleries and boards to the dip of the pit A, and those lying on each side of the pits, would have no circulation of air; or, in the language of the collier, would be laid dead. To obviate this result, double doors are placed in three of the galleries adjoining the pit; viz., at *a* and *b*, *c* and *d*, *e* and *f*; all of which open inwards to the shaft A. By this plan, as the air is not suffered to pass directly from the shaft A to the shaft B, through

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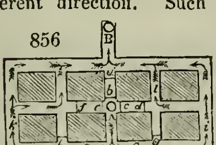

the doors *a* and *b*, it would have taken the next shortest direction by *c d* and *e f*; but the doors in these galleries prevent this course, and compel it to proceed downwards to the dip-head level c, where it will spread or divide, one portion pursuing a route to the right, another to the left. On arriving at the boards *g* and *h*, it would have naturally ascended by them; but this it cannot do, by reason of the building or stopping placed at *g* and *h*. By means of such stoppings placed in the boards next the dip-head level, the air can be transported to the right hand or to the left for many miles, if necessary, providing there be a train or circle of aerial communication from the pit A to the pit B. If the boards *i* and *k* are open, the air will ascend in them, as traced out by the arrows; and after being diffused through the workings, will again meet in a body at *a*, and mount the gallery to the pit B, sweeping away with it the deleterious air which it meets in its path. Without double doors on each main passage, the regular circulation of the air would be constantly liable to interruptions and derangements; thus, suppose the door *c* to be removed, and only *d* to remain in the left hand gallery, all the other doors being as represented, it is obvious, that whenever the door *d* is opened, the air, finding a more direct passage in that direction, would mount by the nearest channel *l*, to the shaft B, and lay dead all the other parts of the work, stopping all circulation. As the passages on which the doors are placed constitute the main roads by which the miners go to and from their work, and as the corves are also constantly wheeling along all the time, were a single door, such as *d*, so often opened, the ventilation would be rendered precarious or languid. But the double doors obviate this inconvenience; for both men and horses, with the corves, in going to or from the pit bottom A, no sooner enter the door *d*, than it shuts behind them, and encloses them in the still air contained between the doors *d* and *c*; *c* having prevented the air from changing its proper course while *d* was open. When *d* is again shut, the door *c* may be opened without inconvenience, to allow the men and horses to pass on to the pit bottom at A; the door *d* preventing any change in the aerial circulation while the door *c* is open. In returning from the pit, the same rule is observed, of shutting one of the double doors, before the other is opened.

If this mode of disjoining and insulating air-courses from each other be once fairly conceived, the continuance of the separation through a working of any extent, may be easily understood.

When carbonic acid gas abounds, or when the fire-damp is in very small quantity, the air may be conducted from the shaft to the dip-head level, and by placing stoppings of each room next the level, it may be carried to any distance along the dip-head levels; and the furthest room on each side being left open, the air is suffered to diffuse itself through the wastes, along the wall faces, and mount in the upcast pit, as is represented in *fig.* 842. 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.* 834 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.

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.* 857, where *a* represents the lower part of the upcast shaft; *b*, the furnace, built of brick, arched at top, with its sides insulated from the solid mass of coal which surrounds it. Between the furnace wall and the coal beds, a current of air constantly passes towards the shaft, in order to prevent the coal catching fire. From the end of the furnace a gallery is cut in a rising direction at *c*, which communicates with the shaft at *d*, about 7 or 8 fathoms from the bottom of the pit. Thus the furnace and furnace-keeper are completely disjoined from the shaft; and the pit bottom is not only free from all encumbrances, but remains comfortably cool. To obviate the inconveniences from the smoke to the banksmen in landing the coals at the pit mouth, the following plan has been contrived for the Newcastle collieries. *Fig.* 858 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.

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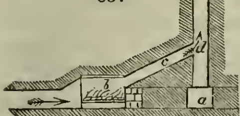

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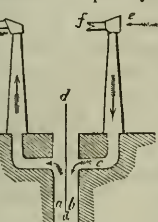

The principle of ventilation being thus established, the next object in opening up a colliery, and in driving all galleries whatever, is the *double mine* or double *headways course;* on the simple but very ingenious distribution of which, the circulation of air depends at the commencement of the excavations.

The double headways course is represented in *fig.* 859, where *a* is the one heading or gallery, and *b* the other; the former being immediately connected with the upcast side of the pit *c*, and the latter with the downcast side of the pit *d*. The pit itself is made completely air-tight by its division of deals from top to bottom, called the brattice wall; so that no air can pass through the brattice from *d* to *c*, and the intercourse betwixt the two currents of air is completely intercepted by a stopping betwixt the pit bottom and the end of the first pillar of coal; the pillars or walls of coal, marked *e*, are called stenting walls; and the openings betwixt them, walls or thirlings. The arrows show the direction of the air. The headings *a* and *b* are generally made about 9 feet wide, the stenting walls 6 or 8 yards thick, and are holed or thirled at such a distance as may be most suitable for the state of the air. The thirlings are 5 feet wide.

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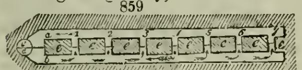

When the headings are set off from the pit bottom, an aperture is left in the brattice at the end of the pillar next the pit, through which the circulation betwixt the upcast and downcast pits is carried on; but whenever the workmen cut through the first thirling No. 1, the aperture in the brattice at 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.* 860, where

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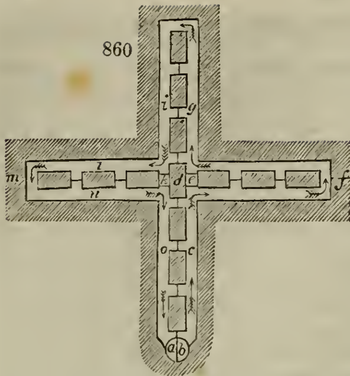

a is the upcast, and *b* the downcast shaft. The air advances along the heading *c*, but cannot proceed further in that direction than the pillar *d*, being obstructed by the double doors at *e*. It therefore advances in the direction of the arrows to the foreheads at *f*, and passing through the last thirling made there, returns to the opposite side of the double doors, ascends now the heading *g*, to the foreheads at *h*, passes through the last-made thirling at that point, and descends, in the heading *i*, till it is interrupted by the double doors at *k*. The aerial current now moves along the heading *l*, to the foreheads at *m*, returns by the last-made thirling there, along the heading *n*, and finally goes down the heading *o*, and mounts by the upcast shaft *a*, carrying with it all the noxious gases which it encountered during its circuitous journey. This wood-cut is a faithful representation of the system by which collieries of the greatest extent are worked and ventilated. In some of these, the air courses are from 30 to 40 miles long. Thus the air conducted by the medium of a shaft divided by a brattice wall only a few inches thick, after descending in the downcast in one compartment of the pit at 6 o'clock in the morning, must thence travel through a circuit of nearly 30 miles, and cannot arrive at its reascending compartment on the other side of the brattice, or pit partition, till 6 o'clock in the evening, supposing it to move all the time at the rate of 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.* 860, 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 aerial circulation, without hazard of being burned by the combustion of the gas at their candles. To guard against this accident, temporary shifting brattices are employed. These are formed of deal, about 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 (*fig.* 861), 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 two feet clear of the sides of the next pillar, leaving room for the miner to pass along between the pillar side and the brattice. The brattices are then fastened with nails to the props, the lower edge of the under brattice resting on the pavement, while the upper edge of the upper is in contact with the roof. By this means any variation of the height in the bed of coal is compensated by the overlap of the brattice boards; and as these are advanced, shifting brattices are laid close to, and alongside of, the first set. The miner next sets up additional props in the same parallel line with the former, and slides the brattices forwards, to make the air circulate close to the forehead where he is working; and he regulates the distance betwixt the brattice and the forehead by the disengagement of fire-damp and the velocity of the aerial circulation. The props are shown at *d*, *d*, and the brattices at *f*, *f*. By this arrangement the air is prevented from passing directly through the thirling *a*, and is forced along the right-hand side of the brattice, and, sweeping over the wall face or forehead, returns by the back of the brattice, and passes through the thirling *a*. It is prevented, however, from returning in its former direction by the brattice planted in the forehead *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 forwards for a similar operation.

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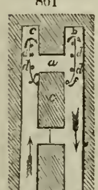

When blowers occur in the roof, and force the strata down, so as to produce a large vaulted excavation, the accumulated gas must be swept away; because, after filling that space, it would descend in an unmixed state under the common roof of the coal. The manner of removing it is represented in *fig.* 862, 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 aerial current is carried close to the roof, and constantly sweeps off or dilutes the inflammable gas of the blower, as fast as it issues. The arrows show the direction of the current; but for which, the accumulating gas would be mixed in explosive proportions with the atmospheric air, and destroy the miners.

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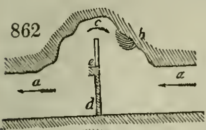

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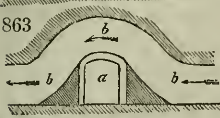

There is another modification of the ventilating system, where the air-courses are traversed across; that is, when one air-course is advanced at right angles to another, and must pass it in order to ventilate the workings on the further side. This is accomplished on the plan shown in *fig.* 863, where *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.

Mr. Taylor's hydraulic air-pump, formerly described, p. 845, 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.

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The general plan of distributing the air, in all cases, is to send the first of the current that descends in the downcast shaft among the horses in the stables, next among the workmen in the foreheads, after which the air, loaded with whatever mixtures it may have received, is made to traverse the old wastes. It then passes through the furnace with all the inflammable gas it has collected, ascends the upcast shaft, and is dispersed into the atmosphere. This system, styled *coursing the air*, was invented by Mr. Spedding of Cumberland. According to the quantity of the fire-damp, the coursing is conducted either up one room, and returned by the next alternately, through the whole extent of the works, or it passes along 2 or 3 connected rooms, and returns by the same number.

This admirable system has received the greatest improvements from the mining engineers of the Newcastle district, and especially from Mr. Buddle of Wallsend. His plan being a most complete scale of ventilation, where the aerial current is made to sweep away every corner of the workings, is shown in *fig.* 865; in which *a* represents the downcast, and *b* the upcast shaft. By pursuing the track of the arrows, we may observe that the air passes first along the two rooms *c*, *d*, having free access to each through the walls, but is hindered from entering into the adjoining rooms by the stoppings which form the air-courses. It sweeps along the wall faces of the rooms *c*, *d*, and makes a return down the rooms *e*, *f*, but is not allowed to proceed further in that direction by the stoppings *g*, *h*. It then proceeds to the foreheads *i*, *k*, and single courses all the rooms to the foreheads *l*, *m*; from this point it would go directly to the upcast pit *b*, were it not prevented by the stopping *n*, which throws it again into double coursing the rooms, till it arrives at *o*, whence it goes directly to the furnace, and ascends the shaft *b*. The lines across each other represent the passing doors; and these may be substituted in any place for a passage where there is a stopping. The stopping *p*, near the bottom of the downcast shaft, is termed a main stopping; because if it were removed, the whole circulation would instantly cease, and the air, instead of

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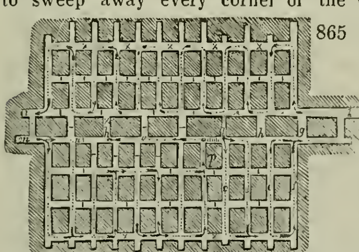

traversing in the direction of the arrows, would go directly from the downcast pit *a*, to the upcast pit *b*, along the gallery *q*. Hence every gallery and room of the workings would be laid *dead*, as it is termed, and be immediately filled with fire-damp, which might take fire either at the workmen's candles, or at the furnace next the upcast shaft *b*. Thus also a partial stagnation in one district of the colliery, would be produced by any of the common stoppings being accidentally removed or destroyed, since the air would thereby always pursue the nearest route to the upcast pit. Main stoppings are made particularly secure, by strong additional stone buildings, and they are set up at different places, to maintain the main air courses entire in the event of an explosion; by which precautions great security is given to human life. This system of ventilation may be extended to almost any distance from the pit-bottom, provided the volume of fresh air introduced be adequate to dilute sufficiently the fire-damp, so that the mixture shall not reach the explosive point. The air, by this management, ventilates first one panel of work, and then other panels in succession, passing onwards through the barriers or panel walls, by means of galleries, as in *fig*. 843, by the principle either of single, double, or triple coursing, according to the quantity of gas in the mine.

In ventilating the very thick coal of Staffordshire, though there is much inflammable air, less care is needed than in the north of England collieries, as the workings are very roomy, and the air courses of comparatively small extent. The air is conducted down one shaft, carried along the main roads, and distributed into the sides of work, as shown in *fig*. 848. A narrow gallery, termed the air-head, is carried in the upper part of the coal, in the rib walls, along one or more of the sides. In the example here figured, it is carried all round, and the air enters at the bolt-hole *e*. Lateral openings, named spouts, are led from the air-head gallery into the side of work; and the circulating stream mixed with the gas in the workings, enters by these spouts, as represented by the arrows, and returns by the air-head at g, to the upcast pit.

When the fire-damp comes off suddenly in any case, rendering the air foul and explosive at the foreheads, if no other remedy be found effectual, the working of the coal must be suspended, and a current of air sent directly from the fresh in-going stream, in order to dilute the explosive mixture, before it reaches the furnace. This is termed *skailing the air;* for otherwise the gas would kindle at the furnace, and flame backwards, like a train of gunpowder, through all the windings of the work, carrying devastation and death in its track. By *skailing* the air, however, time is given for running forward with water, and drowning the furnace. A cascade of water from the steam engine pumps is then allowed to fall down the pit, the power of which, through a fall of 500 or 600 feet, is so great in carrying down a body of air, that it impels a sufficient current through every part of the workings. The ventilation is afterwards put into its usual train at leisure.

In collieries which have been worked for a considerable time, and particularly in such as have goaves, creeps, or crushed wastes, the disengagement of the fire-damp from these recesses is much influenced by the state of atmospheric pressure. Should this be suddenly diminished, as shown by the fall of the barometer, the fire-damp suddenly expands and comes forth from its retirement, polluting the galleries of the mine with its noxious presence. But an increase of barometric pressure condenses the gases of the mine, and restrains them within their sequestered limits. It is therefore requisite that the coal-viewer should consult the barometer before inspecting the subterraneous workings of an old mine, on the Monday mornings, in order to know what precautions must be observed in his personal survey.

The catastrophe of an explosion in an extensive coal-mine is horrible in the extreme. Let us imagine a mine upwards of 100 fathoms deep, with the workings extended to a great distance under the surrounding country, with machinery complete in all its parts, the mining operations under regular discipline, and railways conducted through all its ramifications; the stoppings, passing doors, brattices, and the entire economy of the mine, so arranged that every thing moves like a well-regulated machine. A mine of this magnitude at full work is a scene of cheering animation, and happy industry; the sound of the hammer resounds in every quarter, and the numerous carriages, loaded or empty, passing swiftly to and fro from the wall faces to the pit bottom, enliven the gloomiest recesses. At each door a little boy, called a trapper, is stationed, to open and shut it. Every person is at his post, displaying an alacrity and happiness pleasingly contrasted with the surrounding gloom. While things are in this merry train, it has but too frequently happened that from some unforeseen cause, the ventilation has partially stagnated, allowing a quantity of the fire-damp to accumulate in one space to the explosive pitch; or a blower has suddenly sprung forth, and the unsuspecting miner, entering this fatal region with his candle, sets the whole in a blaze of burning air, which immediately suffocates and scorches to death every living creature within its sphere, while multitudes beyond the reach of the flame are dashed to pieces by the force of the explosion, rolling like thunder along the winding galleries. Sometimes the explosive flame seems to linger in one district for a few moments; then gathering strength for a giant effort, it rushes forth from its cell with the violence of a hurricane, and the speed of lightning, destroying every obstacle in its way to the upcast shaft. Its power seems to be irresistible. The stoppings are burst through, the doors are shivered into a thousand pieces; while the unfortunate miners, men, women, and boys, are swept along with an inconceivable velocity, in one body, with the horses, carriages, corves, and coals. Should a massive pillar obstruct the direct course of the aerial torrent, all these objects are dashed against it, and there prostrated or heaped up in a mass of common ruin, mutilation, and death. Others are carried directly to the shaft, and are either buried there amid the wreck, or are blown up and ejected from the pit mouth. Even at this distance from the explosive den, the blast is often so powerful, that it frequently tears the brattice walls of the shaft to pieces, and blows the corves suspended in the shaft as high up into the open air as the ropes will permit. Not unfrequently, indeed, the ponderous pulley-wheels are blown from the pit-head frame, and carried to a considerable distance in the bosom of a thick cloud of coals and coal dust brought up from the mine by the fire-damp, whose explosion shakes absolutely the superincumbent solid earth itself, with a mimic earthquake. The dust of the ruins is sometimes thrown to such a height above the pit as to obscure the light of the sun. The silence which succeeds to this awful turmoil is no less formidable; for the atmospheric back-draught, rushing down the shaft, denotes the consumption of vital air in the mine, and the production of the deleterious choke-damp and azote.

Though many of the miners may have escaped by their distance in the workings from the destructive blast and the fire, yet their fate may perhaps be more deplorable. They hear the explosion, and are well aware of its certain consequences. Every one, anxious to secure his personal safety, strains every faculty to reach the pit-bottom. As the lights are usually extinguished by the explosion, they have to grope their way in utter darkness. Some have made most marvellous escapes, after clambering over the rubbish of fallen roofs, under which their companions are entombed; but others, wandering into uncertain alleys, tremble lest they should encounter the pestilential airs. At last they feel their power, and aware that their fate is sealed, they cease to struggle with their inevitable doom; they deliberately assume the posture of repose, and fall asleep in death. Such has been too often the fate of the hardy and intelligent miners who immure themselves deep beneath the ground, and venture their lives for the comfort of their fellow-men; and such frequently is the ruinous issue of the best ordered and most prosperous mining concerns.

In such circumstances the mining engineers or coal viewers have a dangerous and difficult duty to perform. The pit into which they must descend as soon as possible, is rendered unsafe by many causes; by the wrecks of loose timber torn away by the eruption, or by the unrespirable gases; by the ignition perhaps of a portion of the coal itself, or by the flame of a blower of fire-damp; either of which would produce violent and repeated explosions whenever the gas may again accumulate to the proper degree. Such a predicament is not uncommon, and it is one against which no human skill can guard. Yet even here, the sense of duty, and the hope of saving some workmen from a lingering death by wounds or suffocation, lead this intrepid class of men to descend amid the very demons of the mine.

As soon as the ventilation is restored by temporary brattices, the stoppings and doors are rebuilt in a substantial manner, and the workings are resumed with the wonted activity. From an inspection of *fig.* 864, p. 1035, it is obvious that the stability of the main stopping *p*, is an important point; for which reason it is counterforted by strong walls of stone, to resist the explosive force of fire-damp.

When it is known that fire exists in the wastes, either by the burning of the small coal-dust along the roads, or from the ignition of the solid coal by a blower of gas, the inspection of the mine is incomparably more hazardous, as safety cannot be ensured for an instant; for if the extrication of gas be great, it rapidly accumulates, and whenever it reaches the place where the fire exists, a new explosion takes place. There have been examples of the most furious detonations occurring regularly after the interval of about an hour, and being thus repeated 36 times in less than two days, each eruption appearing at the pit mouth like the blast of a volcano. It would be madness for any one to attempt a descent in such circumstances. The only resource is to moat up the pit, and check the combustion by exclusion of atmospheric air, or to drown the workings by letting the water accumulate below ground.

When fire exists in the wastes, with less apparent risk of life, water is driven upon it by portable fire-extinguishing engines, or small cannon are discharged near the burning coal, and the concussion thus produced in the air sometimes helps to extinguish the flame.

Since the primary cause of these tremendous catastrophes is the accension of the explosive gases by the candle of the miner, it has been long a desideratum to procure light of such a nature as may not possess the power of kindling the fire-damp. The train of light producible from the friction of flint and steel, by a mechanism called *a steel mill*, has been long known, and afforded a tolerable gleam, with which the miners were obliged to content themselves in hazardous atmospheres.

It consists of a small frame of iron, mounted with a wheel and pinion, which give rapid rotation to a disk of hard steel placed upright, to whose edge a piece of flint is applied. The use of this machine entailed on the miner the expense of an attendant, called the miller, who gave him light. Nor was the light altogether safe, for occasionally the ignited shower of steel particles attained to a sufficient heat to set fire to the fire-damp.

At length the attention of the scientific world was powerfully attracted to the means of lighting the miner with safety, by an awful catastrophe which happened at Felling Colliery, near Newcastle, on the 25th May, 1812. This mine was working with great vigor, 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 neighboring villages. The subterraneous fire broke forth with two heavy discharges from the dip-pit, and these were instantly followed by one from the rise-pit. A slight trembling, as from an earthquake, was felt for about half a mile round the colliery, and the noise of the explosion, though dull, was heard at from 3 to 4 miles' distance. Immense quantities of dust and small coal accompanied these blasts, and rose high into the air, in the form of an inverted cone. The heaviest part of the ejected matter, such as corves, wood, and small coal, fell near the pits; but the dust, borne away by a strong west wind, fell in a continuous shower a mile and a half from the pit. In the adjoining village of Heworth it caused a darkness like that of early twilight, covering the roads where it fell so thickly that the footsteps of passengers were imprinted in it. The heads of both shaft-frames were blown off, their sides set on fire, and their pulleys shattered to pieces. The coal-dust ejected from the rise-pit into the horizontal part of the ventilating tube, was about 3 inches thick, and speedily burnt to a cinder; pieces of burning coal, driven off the solid stratum of the mine, were also blown out of this shaft. Of the 121 persons in the mine at the time of the explosion, only 32 were drawn up the pit alive, 3 of whom died a few hours after the accident. Thus no less than 92 valuable lives were instantaneously destroyed by this pestilential fire damp. The scene of distress among the relatives at the pit mouth was indescribably sorrowful.

Dr. W. Reid Clanny, of Sunderland, was the first to contrive a lamp which might burn among explosive air without communicating flame to the gas in which it was plunged. This he effected, in 1813, by means of an air-tight lamp, with a glass front, the flame of which was supported by blowing fresh air from a small pair of bellows through a stratum of water in the bottom of the lamp, while the heated air passed out through water by a recurved tube at top. By this means the air within the lamp was completely insulated from the surrounding atmosphere. This lamp was the first ever taken into a body of inflammable air in a coal-mine, at the exploding point, without setting fire to the gas around it. Dr. Clanny made another lamp upon an improved plan, by introducing into it the steam of water generated in a small vessel at the top of the lamp, heated by the flame. The chief objection to these lamps is their inconvenience in use.

Various other schemes of safe-lamps were offered to the miner by ingenious mechanicians, but they have been all superseded by the admirable invention of Sir H. Davy, founded on his fine researches upon flame. The lamp of Davy was instantly tried and approved of by Mr. Buddle and the principal mining engineers of the Newcastle district. A perfect security of accident is therefore afforded to the miner in the use of a lamp which transmits its light, and is fed with air, through a cylinder of wire gauze; and this invention has the advantage of requiring no machinery, no philosophical knowledge to direct its use, and is made at a very cheap rate.

In the course of a long and laborious investigation on the properties of the fire-damp, and the nature and communication of flame, Sir H. Davy ascertained that the explosions of inflammable gases were incapable of being passed through long narrow metallic tubes; and that this principle of security was still obtained by diminishing their length and diameter at the same time, and likewise diminishing their length, and increasing their number, so that a great number of small apertures would not pass an explosion, when their depth was equal to their diameter. This fact led him to trials upon sieves made of wire-gauze, or metallic plates perforated with numerous small holes; and he found it was impossible to pass explosions through them.

The apertures in the gauze should never be more than 1-20th of an inch square. In the working models sent by Sir H. to the mines, there were 748 apertures in the square inch, and the wire was about the 40th of an inch diameter. The cage or cylinder of wire-gauze should be made by double joinings, the gauze being folded over in such a manner as to leave no apertures. It should not be more than two inches in diameter; for in large cylinders the combustion of the fire-damp renders the top inconveniently hot; and a double top is always a proper precaution, fixed at a distance of about half an inch above the first top. The gauze cylinder should be fastened to the lamp by a screw of 4 or 5 turns. All joinings in the lamp should be made with hard solder; and the security depends upon the condition, that no aperture exists in the apparatus larger than in the wire gauze.

The forms of the lamp and cage, and the mode of burning the wick, may be greatly diversified; but the principle which ensures their safety must be strictly attended to. See Lamp of Davy, Safety Lamp, and Ventilation.

The state of the air in coal mines, from very early periods till the discovery of the safe-lamp, was judged of by the appearances exhibited by the flame of a candle; and this test must in many circumstances be still had recourse to. When there is merely a defect of atmospheric oxygen, the air being also partially vitiated by a little carbonic acid, either from choke-damp or the lungs and candles of the miners, the lights burn with a very dull flame, the tallow ceases to melt in the cup formed round the wick, till the flame flickers and expires. In this case the candle may be kept burning by slanting it more or less towards a horizontal position, which causes the tallow to melt with the edge of the flame. The candle is thus rapidly wasted, however; and therefore an oil lamp is preferable, as it continues to burn where a candle would be extinguished. The candles of the collier are generally small, with a very small wick; such being found to produce a more distinct flame than candles of a large size with a thick wick.

In trying the quality of the air by the flame of a candle, the wick must be trimmed by taking off the snuff, so as to produce a clear, distinct, and steady burning flame. When a candle thus trimmed is looked at in common air, a distinct and well-defined cone of flame is seen, of a fine sky-blue at the bottom next the wick, and thence of a bright yellow to the apex of the cone. Besides this appearance, there is another, surrounding the cone, which the brightness of the flame prevents the eye from discerning. This may be seen by placing one of the hands expanded as a screen betwixt the eyes and the candle, and at the distance of about an inch, so that the least point of the apex of the yellow flame may be seen, and no more. By this method, a top, as the miners term it, will be distinctly observed close to the apex of the yellow flame, from an eighth to a quarter of an inch in length. This top is of a yellowish-brown color, and like a misty haze. This haze is seen not only on the top, but it extends downwards and surrounds the flame fully half way, about a twentieth of an inch in thickness; here it assumes a violet color, which passes into a beautiful blue at the bottom next the wick. The test of the state of the air in mines, or "trying the candle," as practised by miners, depends entirely on the appearance which this haze assumes in shape and color at the top of the flame. In fact, this top has distinct appearances when burning in atmospheric air, carbonated air, azotized air, or fire-damp air; displaying many modifications, according to the proportions of the various admixtures.

When azote or carbonic acid abounds, the top is frequently an inch or two in length, of a decided brown color, and the flame is short and dim. When they are still more copious, the flame goes out, and the miners immediately retire.

When inflammable air is imagined to exist in considerable quantity, the miner trims his candle, and advances with cautious step, holding the candle with the left hand, and screening the flame with the right; and as the fire-damp floats in the upper part of the gallery next the roof, he holds the candle as low as he can, and keeping his eye fixed on the tip, he moves forwards. If the gas be small in quantity, he may reach the forehead without observing any material change in his light. But if in his advance he perceives the tip to elongate, and take a bluish-gray color, he is put on his guard, and steps on with much caution; and if the tip begins to spire, he drops down on one knee, and holding the candle near the pavement, gradually raises it up, and watches the change it undergoes as it approaches the roof. If the gas be copious, the flame elongates into a sharp spire, as well as the top. It is in general reckoned dangerous when the tip changes from the bluish-gray to a fine blue color, accompanied with minute luminous points, which pass rapidly upwards through the flame and top. When the symptoms are manifestly dangerous, a sudden movement of the hands or body is liable to produce ignition by agitation of the fire-damp. The experienced miner therefore slowly and cautiously lowers his candle to the pavement, and then turning round, effects his retreat slowly, or slips up his right hand and extinguishes the flame with his finger and thumb. Should he venture too far, and approach the body of gas in an explosive condition, the tip of the candle rapidly elongates, and the whole rises in a sharp spire several inches in length; and then the whole surrounding atmosphere is in a blaze, an explosion ensues, and destructive ravage is the consequence, to an extent proportioned to the quantity of fire-damp. See Safety Lamp, and Ventilation.

This *trying the candle* is a delicate operation, requiring much practical sagacity, where the lives of so many men, and the welfare of the whole establishment, are at stake. Almost every colliery, after having been worked for some time, gives a peculiar top to the candle; so that while in one mine liable to fire-damp an explosion will take place with a top less than an inch long, in another mine the top may be two inches high, and yet the air be considerably under the point of accension. These differences depend on several particulars. If the gas has not passed through a long course of ventilation, and is little mixed with air, it will ignite with a very short top; while, on the other hand, a gas which has run through a ventilation of 20 or 30 miles may cause the production of a long top without hazard. It is hence obvious, that skilful experience, and thorough practical knowledge, are the only sure guides in these cases.

We shall now describe briefly the modern modes of working coals a-dipping of, and deeper than, the engine-pit bottom. One of these consists in laying a working pump barrel with a long wind-bore at the bottom of the downset mine, furnished with a smooth rod working through a collar at the top of the working barrel. At one side of this, near the top, a kneed pipe is attached, and from it pipes are carried to the point of delivery, either at the engine pit bottom or day level, as represented in *fig.* 866. The spears are worked sometimes by rods connected with the machinery at the surface; in which case the spears, if very long, are either suspended from swing or pendulum rods, or move on friction rollers. But since the action of the spears, running with great velocity the total length of the engine stroke, very soon tears every thing to pieces, the motion of the spears under ground has been reduced from 6 or 8 feet, the length of the engine stroke, to about 15 inches; and the due speed in the pump is effected by the centring of a beam, and the attachment of the spears to it, as represented in *fig.* 867, where *a* is the working barrel, *b* the beam centred at *c*, having an arc-head and martingale sinking-chain. The spears *d* are fastened by a strong bolt, which passes through the beam; and there are several holes, by means of which the stroke in the pumps can be lengthened or shortened at convenience. The movement of the spears is regulated by a strong iron quadrant or wheel at the bottom.

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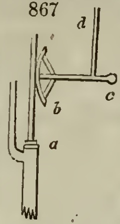
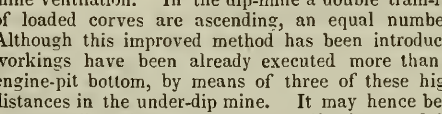


In level-free coals, these pumps may be worked by a water-wheel, stationed near the bottom of the pit, impelled by water falling down the shaft, to be discharged by the level to the day (day-level).

But the preferable plan of working under-dip coal, is that recently adopted by the Newcastle engineers; and consists in running a mine a-dipping of the engine-pit, in such direction of the dip as is most convenient; and both coals and water are brought up the rise of the coal by means of high-pressure engines, working with a power of from 30 to 50 pounds on the square inch. These machines are quite under command, and, producing much power in little space, they are the most applicable for underground work. An excavation is made for them in the strata above the coal, and the air used for the furnace under the boiler, is the returned air of the mine ventilation. In the dip-mine a double tram-road is laid; so that while a number of loaded corves are ascending, an equal number of empty ones are going down. Although this improved method has been introduced only a few years back, under-dip workings have been already executed more than an English mile under-dip of the engine-pit bottom, by means of three of these high-pressure engines, placed at equal distances in the under-dip mine. It may hence be inferred, that this mode of working is susceptible of most extensive application; and in place of sinking pits of excessive depth upon the dip of the coal, at an almost ruinous expense, much of the under-dip coal will in future be worked by means of the actual engine-pits. In the Newcastle district, coals are now working in an engine pit 115 fathoms deep under-dip of the engine-pit bottom, above 1600 yards, and fully 80 fathoms of perpendicular depth more than the bottom of the pit.

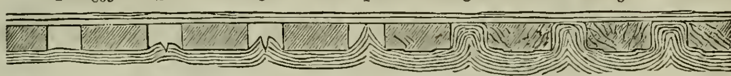
If an engine-pit be sunk to a given coal at a certain depth, all the other coals of the coal-field, both above and below the coal sunk to, can be drained and worked to the same depth, by driving a level cross-cut mine, both to the dip and rise, till all the coals are intersected, as represented in *fig.* 868, 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.

868



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.* 869 exhibits the creep in all its progressive stages, from its commencement until it has completely closed all the workings, and crushed the pillars of coal. The section of the figures supposes us standing on the level of the different galleries which are opened in the seam. The black is the coal pillars between each gallery; when these are weakened too much, or, in other words, when their bases become too narrow for the pavement below, by the pressure of the incumbent stratification, they sink down into the pavement, and the first appearance is a little curvature in the bottom of each gallery: that is the first symptom obvious to sight; but it may generally be heard before it is seen. The next stage is when the pavement begins to open with a crack longitudinally. The next stage is when that crack is completed, and it assumes the shape of a metal ridge. The next is when the metal ridge reaches the roof. The next stage is when the peak of the metal ridge becomes flattened by pressure, and forced into a horizontal direction, and becomes quite close; just at this moment the coal pillars begin to sustain part of the pressure. The next is when the coal pillars take part of the pressure. The last stage is when it is dead and settled; that is, when the metal or factitious ridge, formed by the sinking of the pillar into the pavement, bears, in common with the pillars of coal on each side, the full pressure, and the coal becomes crushed or cracked, and can be no longer worked, except by a very expensive and dangerous process. *Fig.* 869.

869



1. First stage of active creep.
2. Second do.
3. Third do.
4. Fourth do.
5. The metal ridge closed, and the creep beginning to settle.
6. The creep settled, the metal ridges being closely compressed, and supporting the roof.

The quantity of coals, cinders, and culm shipped coastwise, and exported from the several ports of the United Kingdom in the year 1837, was 8,204,301 tons; in 1836, the quantity was 7,389,272 tons, being an increase of 815,029 tons, or 11·03 per cent. in favor of 1837.

The following Table shows the separate proportions of this quantity supplied by England and Wales, Scotland and Ireland :—

	1836.	1837.	Increase.
	Tons.	Tons.	Tons.
England and Wales -	6,757,937	7,570,254	812,317 or 12·02 per cent.
Scotland - - -	624,308	626,532	2,204 - 0·36
Ireland - - - -	7,027	7,515	488 - 6·94
Total - -	7,389,272	8,204,301	815,029 or 11·03 per cent.

PITCOAL, COKING OF. See also Charcoal.

Fig. 870 represents a *shachtofen*, or pit-kiln, for coking coals in Germany. *a* is the lining (*chemise*), made of fire-bricks; the enclosing walls are built of the same material; *b*, *b*, is a cast-iron ring covered with a cast-iron plate *c*. The floor of the kiln is massive. The coals are introduced, and the coke taken out, through a hole in the side *d*; during the process it is bricked up, and closed with an iron door. In the surrounding walls are 4 horizontal rows of flues *e*, *e*, *e*, *e*, which are usually iron pipes; the lowest row is upon a level with the floor of the kiln; and the others are each respectively one foot and a half higher than the preceding. Near the top of the shaft there is an iron pipe *f*, of from 8 to 10 inches in diameter, which allows the incoercible vapors generated in the coking to escape into the condenser, which consists either of wood or brick chambers. For kindling the coal, a layer of wood is first placed on the bottom of the kiln.

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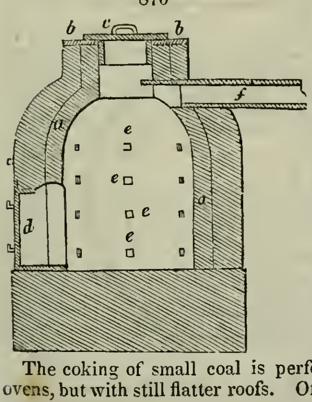

The coking of small coal is performed upon vaulted hearths, somewhat like bakers' ovens, but with still flatter roofs. Of such kilns, several are placed alongside one another,

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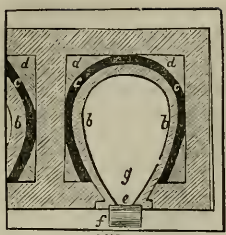

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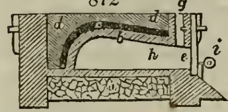

each being an ellipse deviating little from a circle, so that the mouth may project but a small space. The dimensions are such, that from 10 to 12 cubic feet of coal-culm may be spread in a layer 6 inches deep upon the sole of the furnace. The top of the flat arch of fire brick should be covered with a stratum of loam and sand.

Figs. 871 and 872 represent such a kiln as is mounted at Zabrze, in Upper Silesia, for coking small coal. *Fig.* 871 is the ground plan; *fig.* 872 the vertical section in the line of the long axis of *fig.* 871. *a*, is the sand-bed of the hearth, under the brick sole; *b*, is the roof of large fire-bricks; *c*, the covering of loam; *d*, the top surface of sand; *e*, the orifice in the front wall, for admission of the culm, and removal of the coke, over the sloping stone *f*. The flame and vapors pass off above this orifice, through the chimney marked g, or through the aperture *h*, into a lateral chimney. *i*, is a bar of iron laid across the front of the door, as a fulcrum to work the iron rake upon. A layer of coals is first kindled upon the hearth, and when this is in brisk ignition, it is covered with the culm in successive sprinklings. When the coal is sufficiently coked, it is raked out, and quenched with water.

Fig. 873 represents a simple coking *meiler* or *mound*, constructed in a circular form

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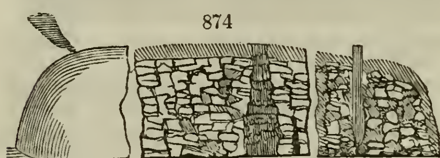

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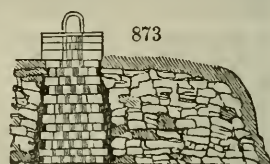

round a central chimney of loose bricks, towards which small horizontal flues are laid among the lumps of coals. The sides and top are covered with culm or slack, and the heap is kindled from certain openings towards the circumference. *Fig.* 874 represents an oblong *meiler*, sometimes made 100 or 150 feet in length, and from 10 to 12 in breadth. The section in the middle of the figure shows how the lumps are piled up; the wooden stakes are lifted out when the heap is finished, in order to introduce kindlings at various points; and the rest of the meiler is then covered with slack and clay, to protect it from the rains. A jet of smoke and flame is seen issuing from its left end.

An excellent range of furnaces for making a superior article of coke, for the service of the locomotive engines of the London and Birmingham Railway Company, has been recently erected at the Camden Town station; consisting of 18 ovens in two lines, the whole discharging their products of combustion into a horizontal flue, which terminates

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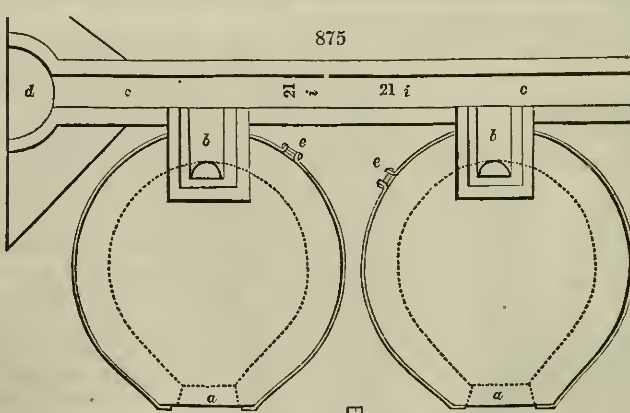

in a chimney-stalk, 115 feet high. *Fig.* 875 is a ground plan of the elliptical ovens, each being 12 feet by 11 internally, and having 3 feet thickness of walls. *a*, *a*, is the mouth, 3½ feet wide outside, and about $2\frac{3}{4}$ feet within. *b*, *b*, are the entrances into the flue; they may be shut more or less completely by horizontal slabs of fire-brick, resting on iron frames, pushed in from behind, to modify the draught of air. The grooves of these damper-slabs admit a small stream of air to complete the combustion of the volatilized particles of soot. By this means the smoke is well consumed. The flue *c*, *c*, is $2\frac{1}{2}$ feet high, by 21 inches wide. The chimney *d*, at the level of the flue, is 11 feet in diameter inside, and 17 outside; being built from an elegant design of Robert Stephenson, Esq. (See CHIMNEY.) *d*, *d*, are the keys of the iron hoops, which bind the brickwork of the oven. *Fig.* 876 is a vertical section in the line A, B, of *fig.* 875, showing, at *b*, *b*, and *e*, *e*, the entrances of the different ovens into the horizontal flue; the direction of the draught being indicated by the arrows. *f*, *f*, is a bed of concrete, upon which the whole furnace-range is built, the level of the ground being in the middle of that bed. *g* is a stanchion on which the crane is mounted; (see *fig.* 877.) *h* is a section of the chimney wall, with part of the interior to the left of the strong line. *Fig.* 877 is a front elevation of two of these elegant coke-ovens; in which the

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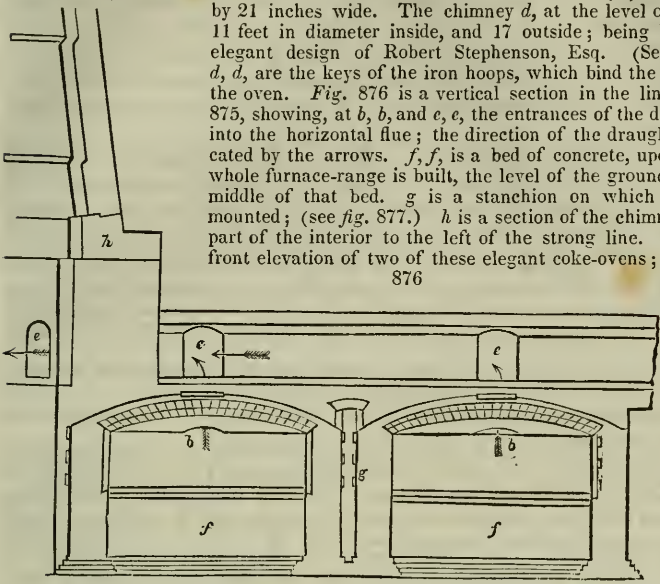

bracing hoops *i*, *i*, *i*, are shown; *k*, *k*, are the cast iron doors, strengthened outside with diagonal ridges; each door being $5\frac{1}{2}$ feet high, by 4 feet wide, and lined internally with fire-bricks. They are raised and lowered by means of chains and counterweights, moved by the crane *l*.

Each alternate oven is charged, between 8 and 10 o'clock every morning, with $3\frac{1}{2}$ tons of good coals. A wisp of straw is thrown in on the top of the heap, which takes fire by the radiation from the dome (which is in a state of dull ignition from the preceding operation), and inflames the smoke then rising from the surface, by the re-action of the hot sides and bottom upon the body of the fuel. In this way the smoke is consumed at the very commencement of the process, when it would otherwise be most abundant. A neighbor of the above coking ovens, having lately indicted

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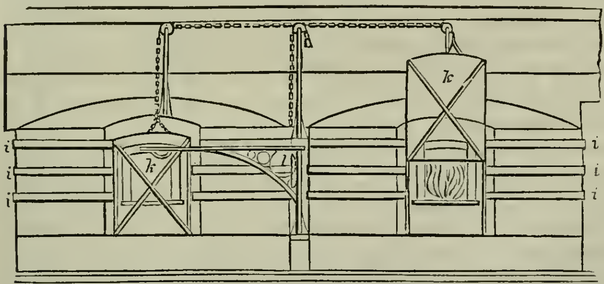

them as a nuisance, procured, *secundum artem*, a parcel of affidavits from sundry chemical and medical men. Two of the former, who had not entered the premises, but had espied the outside of the furnaces' range at some distance, declared that "the coking process, as performed at the ovens, is a species of distillation of coal!" How rashly do unpractical theorists affirm what is utterly unfounded, and mislead an unscientific judge! That the said coking process is in no respect a species of distillation, but a complete combustion of the volatile principles of the coal, will be manifest from the following description of its actual progress. The mass of coals is first kindled at the surface, as above stated, where it is supplied with abundance of atmospheric oxygen; because the doors of the ovens in front, and the throat-vents behind, are then left open.

The consequence is, that no more smoke is discharged from the top of the chimney, at this the most sooty period of the process, than is produced by an ordinary kitchen fire. In these circumstances, the coal gas, or other gas, supposed to be generated in the slightly heated mass beneath, cannot escape destruction in passing up through the bright open flame of the oven. As the coking of the coal advances most slowly and regularly from the top of the heap to the bottom, only one layer is affected at a time, and in succession downwards, while the surface is always covered with a stratum of redhot cinders, ready to consume every particle of carbureted or sulphureted hydrogen gases which may escape from below. The greatest mass, when calcined in this downward order, cannot emit into the atmosphere any more of the above-mentioned gases than the smallest heap; and therefore the argument raised on account of the magnitude of the operations, is altogether fallacious.

The coke being perfectly freed from all fuliginous and volatile matters by a calcination of upwards of 40 hours, is cooled down to moderate ignition by sliding in the dampers, and sliding up the doors, which had been partially closed during the latter part of the process. It is now observed to form prismatic concretions, somewhat like a columnar mass of basalt. These are loosened by iron bars, lifted out upon shovels furnished with long iron shanks, which are poised upon swing chains with hooked ends, and the lumps are thrown upon the pavement, to be extinguished by sprinkling water upon them from the rose of a watering-can; or, they might be transferred into a large chest of sheet-iron set on wheels, and then covered up. Good coals thus treated, yield 80 per cent. of an excellent compact glistening coke; weighing about 14 cwt. per chaldron.

The loss of weight in coking in the ordinary ovens is usually reckoned at 25 per cent.; and coal, which thus loses one fourth in weight, gains one fourth in bulk.

Laborers who have been long employed at rightly-constructed coke ovens, seem to enjoy remarkably good health.

PITTACALL is one of the 6 curious principles detected in wood-tar by Reichenbach. It is a dark-blue solid substance, somewhat like indigo, assumes a metallic fiery lustre on friction, and varies in tint from copper to golden. It is void of taste and smell, not volatile; carbonizes at a high heat without emitting an ammoniacal smell; is soluble or rather very diffusible in water; gives a green solution with a cast of crimson, in sulphuric acid, with a cast of red blue, in muriatic acid, and with a cast of aurora red, in acetic acid. It is insoluble in alkalis. It dyes a fast blue upon linen and cotton goods, with tin and aluminous mordants.

PLASTER; See Mortar.

PLASTER OF PARIS; see Gypsum.

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, 1½ 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 color, 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 form 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 oxydize 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 cokes, 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 *riveting* 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.

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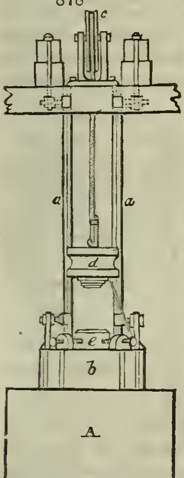

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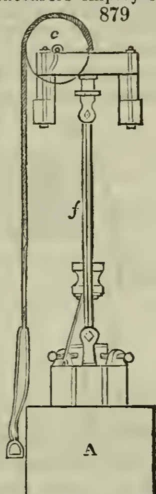

Figs. 878 and 879 are two views of the stamp. A is a large stone, the more massy the better; *b*, the anvil on which the die *e* is secured by four screws, as shown in the ground plan, *fig.* 880. In *fig.* 878, *a a* are two upright square prisms, set diagonally with the angles opposed to each other; 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 *c*, 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 with 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 afterward 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.* 881. 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.

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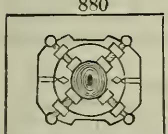

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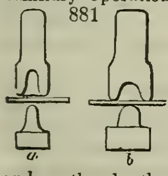
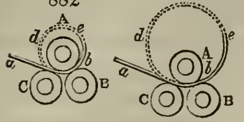
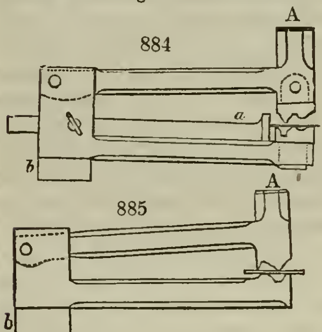


Cylindrical and conical vessels are mostly formed by bending and soldering. The bending is performed on blocks of wood, with wooden mallets; but the machine so much used by the tin-smiths, to form their tubes and cylindric vessels (see the end section, *figs.* 882 and 883), might be employed with advantage. 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 color 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.

882 883



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.* 884 and 885. The part A lifts up by a joint, and the metal to be *swaged* is placed between the dies, as shown in the figures; the tail *b* being held in the jaws of a vice, while the shear-shaped hammer rests upon it. By striking on the head A, while the metal plate is shifted successively forwards, the beading is formed. In *fig.* 884 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 expe-



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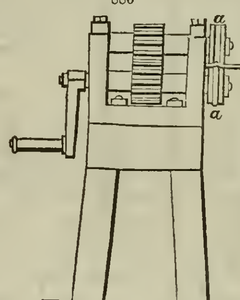

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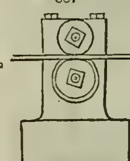

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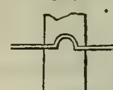


ditious manner by the rollers, *figs.* 885, 886. *Fig.* 888 is a section to show the form of the bead. The two wheels *a*, *a*, *fig.* 886, are placed upon axes, two of which are furnished with toothed pinions in their middle; the lower one, being turned by the handle, gives motion to the upper. The 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 edgings is laminated exceedingly thin; a square inch sometimes weighing no more than 10 or 12 grains. This is too fragile to bear the action of the opposite steel dies of the swage above described. It is necessary, therefore, that the sunk part of the die should be steel, and the opposite side lead, as was observed in the stamping; and this is the method now generally employed to form these silver ornaments. The inside shell of this silver moulding is filled with soft solder, and then bent into the requisite form.

The base of candlesticks is generally made in a die by the stamp, as well as the neck, the dish part of the nozzle or socket, and the tubular stem or pillar. The different parts are united, some with soft and others with hard solder. The branches of candlesticks are formed in two semi-cylindrical halves, like the feet of tea-urns. When an article is to be engraved on, an extra plate of silver is applied at the proper part, while the plate is still flat, and fixed by burnishing with great pressure over a hot anvil. This is a species of welding.

The last finish of plated goods is given by burnishing-tools of bloodstone, fixed in sheet-iron cases, or hardened steel, finely polished.

The ingots for lamination might probably be plated with advantage by the delicate pressure process employed for silvering copper wire.

The total value of the plate, plated ware, jewellery, and watches, exported in the year 1836, was 338,889*l.*; but the value of the plated goods is not given in the tables of revenue. M. Parquin, the greatest manufacturer of plated goods in Paris (or France, for this business is monopolized by the capital), who makes to the value of 700,000 francs per annum, out of the 1,500,000 which, he says, is the whole internal consumption of the kingdom, states that the internal consumption of the United Kingdom amounts to 30,000,000, or 20 times that of France! He adds, that our common laminated copper costs 26 sous the pound, while theirs costs 34. Their plated goods are fashioned, not in general with stamps, but by the pressure of tools upon wood moulds in the turning lathe, which is a great economy of capital to the manufacturer. There are factories at Birmingham which possess a heavy stock of 300,000 different die-moulds. See STAMPING OF METALS.

PLATINA-MOHR. The following easy method of preparing igniferous black platinum, proposed thirty years ago by Descotil, has been recently recommended by M. Dobereiner:—

Melt platina ore with double its weight of zinc, reduce the alloy to powder, and treat it first with dilute sulphuric acid, and next with dilute nitric acid, to oxydize and dissolve out all the zinc, which, contrary to one's expectations, is somewhat difficult to do, even at a boiling heat. The insoluble black-gray powder contains some osmiuret of iridium, united with the crude platinum. This compound acts like simple platina-black, after it has been purified by digestion in potash ley, and washing with water. Its oxydizing power is so great, as to transform not only the formic acid into the carbonic, and alcohol into vinegar, but even some osmic acid, from the metallic osmium. The above powder explodes by heat like gunpowder.

When the platina-*mohr* prepared by means of zinc is moistened with alcohol, it becomes incandescent, and emits osmic acid; but if it be mixed with alcohol into a paste, and spread upon a watch-glass, nothing but acetic acid will be disengaged; affording an elegant means of diffusing the odor of vinegar in an apartment.

PLATINUM is a metal of a grayish-white color, resembling in a good measure polished steel. It is harder than silver, and of about double its density, being of specific gravity 21. It is so infusible, that no considerable portion of it can be melted by the strongest heats of our furnaces. It is unchangeable in the air and water; nor does a white heat impair its polish. The only acid which dissolves it, is the nitro-muriatic; the muriate or chloride thus formed, affords, with pure ammonia or sal ammoniac, a triple salt in a yellow powder, convertible into the pure metal by a red heat. This character distinguishes platinum from every other metal.

Native Platinum.—In the natural state it is never pure, being alloyed with several other metals. It occurs only under the form of grains, which are usually flattened, and resemble in shape the gold *pepitas*. Their size is in general less than linseed, although in some cases they equal hempseed, and, occasionally, peas. One piece brought from Choco, in Peru, and presented to the Cabinet of Berlin, by M. Humboldt, weighs 55 grammes = 850 grains, or nearly 2 oz. avoirdupois. The greatest lump of native platinum known, till of late years, was one in the Royal Museum of Madrid, which was found in 1814 in the gold mine of Condoto, province of Novita, at Choco. Its size is greater than a turkey's egg, (about 2 inches one diameter, and 4 inches the other,) and its weight 760 grammes, = 24 oz., or fully 2 lbs. troy. See *infrà*.

The color of the grains of native platinum is generally a grayish-white, like tarnished steel. The cavities of the rough grains are often filled with earthy and ferruginous matters, or sometimes with small grains of black oxyde of iron, adhering to the surface of the platinum grains. Their specific gravity is also much lower than that of forged pure platinum; varying from 15 in the small particles, to 18·94 in M. Humboldt's large specimen. This relative lightness is owing to the presence of iron, copper, lead, and chrome; besides its other more lately discovered metallic constituents, palladium, osmium, rhodium, and iridium.

Its main localities in the New Continent, are in the three following districts:—

1. At Choco, in the neighborhood of Barbacoas, and generally on the coasts of the South Sea, or on the western slopes of the Cordillera of the Andes, between the 2d 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 deposite 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.

Platinum has been discovered lately in the Russian territories, in the auriferous sands of Kuschwa, 250 wersts from Ekaterinebourg, and consequently in a geological position which seems to be analogous with that of South America.

These auriferous sands are, indeed, almost all superficial; they cover an argillaceous soil; and include, along with gold and platinum, débris of dolerite (a kind of green-stone), protoxyde of iron, grains of corundum, &c. The platinum grains are not so flat as those from Choco, but they are thicker; they have less brilliancy, and more of a leaden hue. This platinum, by M. Laugier's analysis, is similar in purity to that of Choco; but the leaden-gray grains, which were taken for a mixture of osmium and iridium, are merely an alloy of platinum, containing 25 per cent. of these metals.

The mines of Brazil, Columbia, and Saint Domingo furnish altogether only about 400 kilos. of platinum ore per annum; but those of Russia produce above 1800 kilos. The latter were discovered in 1822, and were first worked in 1824. They are all situated in the Ural mountains. The ore is disseminated in an argillaceous sand, of a greenish-gray color, resulting from the disintegration of the surrounding rocks, and constitutes from 1 to 3 parts in 4000 of the sand. Occasionally it has been found in lumps weighing 8 kilogrammes (16 lbs.!), but it generally occurs in blackish angular grains, which contain 70 per cent. of platinum, and 3 to 5 of iridium. The ore of Goro-Blagodatz is in small flattened grains, which contain 88 per cent. of this precious metal. The osmiure of iridium is found upon a great many points of the Urals, throughout a space of 140 leagues, being a product accessory to the gold washings. 32 kilogrammes of osmiure are collected there annually, which contain upon an average 2 per cent. of platinum.

M. Vauquelin found nearly ten per cent. of platinum in an ore of argentiferous copper, which was transmitted to him as coming from Guadalcanal in Spain. This would be the only example of platinum existing in a rock, and in a vein. As the same thing has not again been met with, even in other specimens from Guadalcanal, we must delay drawing geological inferences, till a new example has confirmed the authenticity of the first.

Platinum has been known in Europe only since 1748, though it was noticed by Ulloa in 1741. It was compared at first to gold; and was, in fact, brought into the market under the name of white gold. The term platinum, however, is derived from the Spanish word *plata*, silver, on account of its resemblance in color to that metal.

The whole of the platinum ore from the Urals is sent to St. Petersburg, where it is treated by the following simple process:—

One part of the ore is put in open platina vessels, capable of containing from 6 to 8 lbs., along with 3 parts of muriatic acid at 25° B. and 1 part of nitric acid at 40°. Thirty of these vessels are placed upon a sand-bath covered with a glazed dome with moveable panes, which is surmounted by a ventilating chimney to carry the vapors out of the laboratory. Heat is applied for 8 or 10 hours, till no more red vapors 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 deposite 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 crystallized in regular octahedrons. The washings are evaporated to dryness in porcelain vessels; the residuum is calcined and treated like fresh ore; but the platinum it affords needs a second purification.

For agglomerating the platinum, the spongy mass is pounded in bronze mortars; the powder is passed through a fine sieve, and put into a cylinder of the intended size of the ingot. The cylinder is fitted with a rammer, which is forced in by a coining press, till the powder be much condensed. It is then turned out of the mould, and baked 36 hours in a porcelain kiln, after which it may be readily forged, if it be pure, and may receive any desired form from the hammer. It contracts in volume from 1-6th to 1-5th during the calcination. The cost of the manufacture of platinum is fixed by the administration at 32 francs the Russian pound; but so great a sum is never expended upon it.

For Dr. Wollaston's process, see Phil. Trans. 1829, Part I.

Platinum furnishes most valuable vessels to both analytical and manufacturing chemists. It may be beat out into leaves of such thinness as to be blown about with the breath.

This metal is applied to porcelain by two different processes; sometimes in a rather coarse powder, applied by the brush, like gold, to form ornamental figures; sometimes in a state of extreme division, obtained by decomposing its muriatic solution, by means of an essential oil such as rosemary or lavender. In this case, it must be evenly spread over the whole ground. Both modes of application give rise to a steely lustre.

The properties possessed in common by gold and platinum, have several times given occasion to fraudulent admixtures, which have deceived the assayers. M. Vauquelin having executed a series of experiments to elucidate this subject, drew the following conclusions:—

If the platinum do not exced 30 or 40 parts in the thousand of the alloy, the gold does not retain any of it when the parting is made with nitric acid in the usual way; and when the proportion of platinum is greater, the fraud becomes manifest; 1st by the higher temperature required to pass it through the cupel, and to form a round button; 2. by the absence of the lightning, fulguration, or coruscation; 3. by the dull white color of the button and its crystallized surface; 4. by the straw-yellow color which platinum communicates to the aquafortis in the parting; 5. by the straw-yellow color, bordering on white, of the cornet, after it is annealed. If the platinum amounts to one fourth of the gold, we must add to the alloy at least 3 times its weight of fine silver, laminate it very thin, anneal somewhat strongly, boil it half an hour in the first aquafortis, and at least a quarter of an hour in the second, in order that the acid may dissolve the whole of the platinum.

Were it required to determine exactly the proportions of platinum contained in an alloy of copper, silver, gold, and platinum, the amount of the copper may be found in the first place by *cupellation*, then the respective quantities of the three other metals may be learned by a process founded, 1. upon the property possessed by sulphuric acid of dissolving silver without affecting gold or platinum; and, 2. upon the property of platinum being soluble in the nitric acid, when it is alloyed with a certain quantity of gold and silver.

According to Boussingault, the annual product of platinum in America does not exceed 8½ cwts. At Nischne-Tagilsk, in 1824, a lump of native platinum weighing fully 10 lbs. was found; and in 1830, another lump, of nearly double size, which weighed 35¾ Prussian marcs; fully 18 lbs. avoirdupois.

PRODUCTION OF PLATINUM IN THE URAL.

From 1822 to 1827 inclusively,	52 puds* and	22½ pounds.
1828	94	
1829	78	31½
1830	105	1
1831 to 1833	348	15

* One pud = 40 Russian pounds, = 69,956 Prussian marcs (See SILVER); 1 pound = 96 zolotniks.

Analyses of the Platinum Ores of the Urals, and of that from Barbacoas on the Pacific, between the 2d and 6th degrees of northern latitude.

	From Nischne-Tagilsk. Berzelius.		Goroblagodat. Osann.		Barbacoas. Berzelius.
	Magnetic.	Not Magnetic.			
Platinum -	73·58	78·94	83·07	86·50	84·30
Iridium - -	2·35	4·97	1·91	—	1·46
Rhodium -	1·15	0·86	0·59	1·15	3·46
Palladium -	0·30	0·28	0·26	1·10	1·06
Iron - -	12·98	11·04	10·79	8·32	5·31
Copper - -	5·20	0·70	1·30	0·45	0·74
Undissolved Osmium and Iridium	2·30	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

PLUMBAGO. See Graphite, for its mineralogical and chemical characters. The mountain at Borrowdale, in which the black-lead is mined, is 2000 feet high, and the entrance to the mine is 1000 feet below its summit. This valuable mineral became so common a subject of robbery about a century ago, as to have enriched, it was said, a great many persons living in the neighborhood. Even the guard stationed over it by the proprietors was of little avail against men infuriated with the love of plunder; since in those days a body of miners broke into the mine by main force, and held possession of it for a considerable time.

The treasure is now protected by a strong building, consisting of four rooms upon the ground floor; and immediately under one of them is the opening, secured by a trap-door, through which alone workmen can enter the interior of the mountain. In this apartment, called the dressing-room, the miners change their ordinary clothes for their working dress, as they come in, and after their six hours' post or journey, they again change their dress, under the superintendence of the steward, before they are suffered to go out. In the innermost of the four rooms, two men are seated at a large table, sorting and dressing the plumbago, who are locked in while at work, and watched by the steward from an adjoining room, who is armed with two loaded blunderbusses. Such formidable apparatus of security is deemed requisite to check the pilfering spirit of the Cumberland mountaineers.

The cleansed black-lead is packed up into strong casks, which hold 1 cwt. each. These are all despatched to the warehouse of the proprietors in London, where the black-lead is sold monthly by auction, at a price of from 35*s*. to 45*s*. a pound.

In some years, the net produce of the *six weeks'* annual working of the mine has, it is said, amounted to 30,000*l*. or 40,000*l*.

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 broach 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.

POINT NET is a style of lace formerly much in vogue, but now superseded by the bobbin-net manufacture.

PORCELAIN is the finest kind of pottery-ware. It is considered under that title.

PORPHYRY is a compound mineral or rock, composed essentially of a base of hornstone, interspersed with crystals of feldspar. It frequently contains also quartz, mica, and hornblende. That most esteemed is the ancient porphyry of Egypt, with a ground of a fine red color passing into purple, having snow-white crystals of feldspar imbedded in it. Most beautiful specimens of it are to be seen in the antique colossal statues in the British Museum.

Porphyry occurs in Arran, and in Perthshire between Dalnacardoch and Tummel bridge. It is much used for making slabs, mullers, and mortars.

PORTER is a malt liquor, so called from being the favorite beverage of the porters and workpeople of the metropolis and other large towns of the British empire; it is characterized by its dark-brown color, its transparency, its moderately bitter taste, and peculiar aromatic flavor, which, along with its tonic and intoxicating qualities, make it be keenly relished by thirsty palates accustomed to its use. At first the essential distinction of porter arose from its wort being made with highly-kilned brown malt, while other kinds of beer and ale were brewed from a paler article; but of late years, the taste of the public having run in favor 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 color 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 *coloring* stuff, whereby they can lay claim to the merit of using nothing in their manufacture but malt and hops. The singular flavor of good London porter seems to proceed, in a great degree, from that of the old casks and fermenting tuns in which it is prepared. Though not much addicted to vinous potations of any kind, I feel warranted by long experience to opine, that the porter brewed by the eminent London houses, when drunk in moderation, is a far wholesomer beverage for the people than the thin acidulous wines of France and Germany. See Beer.

PORTLAND STONE is a fine compact oolite, so named from the island where it is quarried. It is a convenient but not a durable building-stone.

POTATO (*Pomme de terre*, Fr.; *Kartoffel*, Germ.) is the well known root of the *Solanum tuberosum*.

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.

POTASH, or POTASSA. (*Potasse*, Fr.; *Kali*, Germ.) This substance was so named from being prepared for commercial purposes by evaporating in iron pots the lixivium of the ashes of wood fuel. In the crude state called potashes, it consists, therefore, of such constituents of burned vegetables as are very soluble in water, and fixed in the fire. The potash salts of plants which originally contained vegetable acids, will be converted into carbonates, the sulphates will become sulphites, sulphurets, or even carbonates, according to the manner of incineration; the nitrates will be changed into pure carbonates, while the muriates or chlorides will remain unaltered. Should quicklime be added to the solution of the ashes, a corresponding portion of caustic potassa will be introduced into the product, with more or less lime, according to the care taken in decanting off the clear ley for evaporation.

In America, where timber is in many places an incumbrance upon the soil, it is felled, piled up in pyramids, and burned, solely with a view to the manufacture of potashes. The ashes are put into wooden cisterns, having a plug at the bottom of one of the sides under a false bottom; a moderate quantity of water is then poured on the mass, and some quicklime is stirred in. After standing for a few hours, so as to take up the soluble matter, the clear liquor is drawn off, evaporated to dryness in iron pots, and finally fused at a red heat into compact masses, which are gray on the outside, and pink-colored 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 ley to dryness in flat iron pans, and stirring it towards the end into white lumpy granulations.

I find the best pink Canadian potashes, as imported in casks containing about 5 cwts., to contain pretty uniformly 60 per cent. of absolute potassa; and the best pearl-ashes to contain 50 per cent.; the alkali in the former being nearly in a caustic state; in the latter, carbonated.

All kinds of vegetables do not yield the same proportion of potassa. The more succulent the plant, the more does it afford; for it is only in the juices that the vegetable salts reside, which are converted by incineration into alkaline matter. Herbaceous weeds are more productive of potash than the graminiferous species, or shrubs, and these than trees; and for a like reason, twigs and leaves are more productive than timber. But plants in all cases are richest in alkaline salts when they have arrived at maturity. The soil in which they grow also influences the quantity of saline matter.

The following TABLE exhibits the average product in potassa of several plants, according to the researches of Vauquelin, Pertuis, Kirwan, and De Saussure :—

In 1000 parts.	Potassa.	In 1000 parts.	Potassa.
Pine or fir	0·45	Dry beech bark	6·00
Poplar	0·75	Fern	6·26
Trefoil	0·75	Large rush	7·22
Beechwood	1·45	Stalk of maize	17·50
Oak	1·53	Bastard chamomile (*Anthemis cotula*, L.)	19·60
Boxwood	2·26	Bean stalks	20·00
Willow	2·85	Sunflower stalks	20·00
Elm and maple	3·90	Common nettle	25·03
Wheat straw	3·90	Vetch plant	27·50
Barb of oak twigs	4·20	Thistles in full growth	35·37
Thistles	5·00	Dry straw of wheat before earing	47·00
Flax stems	5·00	Wormwood	73·00
Small rushes	5·08	Fumitory	79·00
Vine shoots	5·50		
Barley straw	5·80		

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 incrusted with the salts, while a solution of nearly pure carbonate of potash will be found floating above, which may be drawn off clear by a syphon. The salts may be afterwards thrown upon a filter of gravel. If this ley 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 syphoned off, and concentrated by boiling in a covered iron pan, till it assumes the appearance of oil, it will constitute the common caustic of the surgeon, the *potassa fusa* of the shops. But to obtain potassa chemically pure, recourse must be had to the bicarbonate, nitrate, or tartrate of potassa, salts which, when carefully crystallized, are exempt from any thing to render the potassa derived from them impure. The bicarbonate having been gently ignited in a silver basin, is to be dissolved in 6 times its weight of water, and the solution is to be boiled for an hour, along with one pound of slaked lime for every pound of the bicarbonate used. The whole must be left to settle without contact of air. The supernatant ley is to be drawn off by a syphon, and evaporated in an iron or silver vessel provided with a small orifice in its close cover for the escape of the steam, till it assumes, as above, the appearance of oil, or till it be nearly redhot. Let the fused potassa be now poured out upon a bright plate of iron, cut into pieces as soon as it concretes, and put up immediately in a bottle furnished with a well-ground stopper. It is hydrate of potassa, being composed of 1 atom of potassa 48, + 1 atom of water 9, = 57.

A pure carbonate of potassa may be also prepared by fusing pure nitre in an earthen crucible, and projecting charcoal into it by small bits at a time, till it ceases to cause deflagration. Or a mixture of 10 parts of nitre and 1 of charcoal may be deflagrated in small successive portions in a redhot deep crucible. When a mixture of 2 parts of tartrate of potassa, or crystals of tartar, and 1 of nitre, is deflagrated, pure carbonate of potassa remains mixed with charcoal, which by lixiviation, and the agency of quick-lime, will afford a pure hydrate. Crystals of tartar calcined alone yield also a pure carbonate.

Caustic potassa, as I have said, after being fused in a silver crucible at a red heat, retains 1 prime equivalent of water. Hence its composition in 100 parts is, potassium 70, oxygen 14, water 16. Anhydrous potassa, or the oxyde free from water, can be obtained only by the combustion of potassium in the open air. It is composed of $83\frac{1}{3}$ of metal, and $16\frac{2}{3}$ of oxygen. Berzelius's numbers are, 83·05 and 16·95.

Caustic potassa may be crystallized; but in general it occurs as a white brittle substance of spec. grav. 1·708, which melts at a red heat, evaporates at a white heat, deliquesces into a liquid in the air, and attracts carbonic acid; is soluble in water and alcohol, forms soft soaps with fat oils, and soapy-looking compounds with resins and wax; dissolves sulphur, some metallic sulphurets, as those of antimony, arsenic, &c., as also silica, alumina, and certain other bases; and decomposes animal textures, as hair, wool, silk, horn, skin, &c. It should never be touched with the tongue or the fingers.

The following TABLE exhibits the quantity of *Fused Potassa* in 100 parts of *caustic ley*, 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.in100.
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	1·38	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 potassa in any solid or liquid, is from the quantity of a dilute acid of known strength which it can saturate.

The hydrate of potassa, or its ley, 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 ley is poured into a weighed portion of dilute sulphuric acid poised in the scale of a balance.

There are two other oxydes of potassium; the suboxyde, which consists, according to Berzelius, of 90·74 of metal, and 9·26 oxygen; and the hyperoxyde, an orange-yellow substance, which gives off oxygen in the act of dissolving in water, and becomes potassa. It consists of 62 of metal, and 38 of oxygen.

Carbonate of potassa is composed of 48 parts of base, and 22 of acid, according to most British authorities; or, in 100 parts, of 68·57 and 31·43; but according to Berzelius, of 68·09 and 31·91.

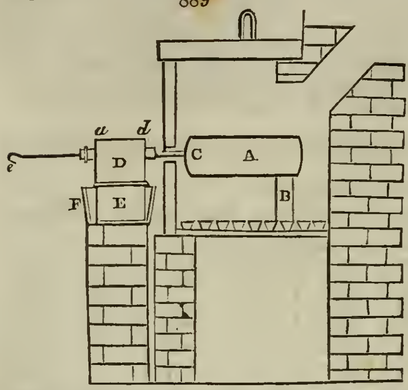
Carbonate of potassa, as it exists associated with carbon in calcined tartar, passes very readily into the *Bicarbonate*, on being moistened with water, and having a current of carbonic acid gas passed through it. The absorption takes place so rapidly, that the mass becomes hot, and therefore ought to be surrounded with cold water. The salt should then be dissolved in the smallest quantity of water at 120° F., filtered, and crystallized.

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.

The easiest and best mode of obtaining this elementary substance, is that contrived by Brunner, which I have often practised upon a considerable scale. Into the orifice of one of the iron bottles, as A, *fig.* 889, in which mercury is imported, adapt, by screwing, a piece of gun-barrel tube, 9 inches long; having brazed into its side, about 3 inches from its outer end, a similar piece of iron tube. Fill this retort two thirds with a mixture of 10 parts of cream of tartar, previously calcined in a covered crucible, and 1 of charcoal, both in powder; and lay it horizontally in an air-furnace, so that while the screw orifice is at the inside wall, the extremity of the straight or nozzle tube may project a few inches beyond the brickwork, and the tube brazed into it at right angles may descend pretty close to the outside wall, so as to dip its lower end a quarter of an inch beneath the surface of some rectified naptha 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 vapor 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 potassureted 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.

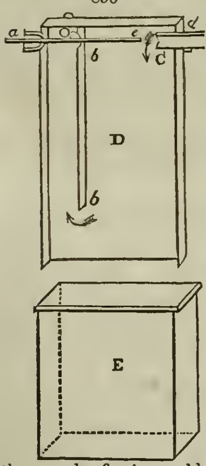
889



A, *fig.* 889, 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 the bottle and the back wal. 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 vapors, the receiver must be adapted, *d*, *a*, D, E, shown in a large scale in *fig.* 890.

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 vapors 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 naptha. E, the bottom copper box, with naptha, which receives pretty closely the upper case D, is to be immersed in a cistern of cold water containing some lumps of ice.

890



The chemical action by which potassa is reduced in this process seems to be somewhat complicated, and has not been thoroughly explained. A very small proportion of pure potassium is obtained; a great deal of it is converted into a black infusible mass, which passes over with the metal, and is very apt to block up the tube. Should this resist clearing out with the probe, the fire must be immediately withdrawn from the furnace, otherwise the apparatus will probably burst or blow up. Care must be taken to prevent any moisture getting into the nozzle, for it would probably produce a violent detonation.

When the operation has proceeded regularly, accompanied to the end with a constant evolution of gas, the retort becomes nearly empty, or contains merely a little charcoal, or carbonate of potassa, and the potassium collects in the naptha at the bottom of the receiver E, in the form of globules or rounded lumps, of greater or less size, and of a leaden hue. But the greater part of the metal escapes with the gas, in a state of combination not well understood. This gaseous compound burns with a white or reddish-white flame, and deposites potassa. Several ounces of potassium may be produced in this way at one operation; but, as thus obtained, it always contains some combined charcoal, which must be separated by distilling it in an iron retort, having its beak plunged in naptha.

Pure potassium, as procured in Sir H. Davy's original method, by acting upon fused potassa under a film of naptha, with the negative wire of a powerful voltaic battery, is very like quicksilver. It is semi-fluid at 60° Fahr., nearly liquid at 92°, and entirely so at 120°. At 50° it is malleable, and has the lustre of polished silver; at 32° it is brittle, with a crystalline fracture; and at a heat approaching to redness, it begins to boil, is volatilized, and converted into a green colored gas, which condenses into globules upon the surface of a cold body. Its specific gravity in the purest state is 0·865 at 60°. When heated in the air, it takes fire, and burns very vividly. It has a stronger affinity for oxygen than any other known substance; and is hence very difficult to preserve in the metallic state. At a high temperature it reduces almost every oxygenated body. When thrown upon water, it kindles, and moves about violently upon the surface, burning with a red flame till it be consumed; that is to say, converted into potassa. When thrown upon a cake of ice, it likewise kindles, and burns a hole in it. If a globule of it be laid upon wet turmeric paper, it takes fire, and runs about, marking its desultory path with red lines. The flame observed in these cases is owing chiefly to hydrogen, for it is at the expense of the water that the potassium burns.

Potassa, even in a pretty dilute solution, produces a precipitate with muriate of platinum, a phenomenon which distinguishes it from soda. It forms, moreover, with sulphuric and acetic acids, salts which crystallize very differently from the sulphates and acetates of soda.

POTTERY, PORCELAIN. (Eng. and Fr.; *Steingut*, *Porzellan*, Germ.) The French, who are fond of giving far-fetched names to the most ordinary things, have dignified the art of pottery with the title of *ceramique*, from the Greek noun *κεραμος*, an earthen pot, compounded of two words which signify, in that language, *burned clay*. In reference to chemical constitution, there are only two genera of baked stoneware. The first consists of a fusible earthy mixture, along with an infusible, which when combined are susceptible of becoming semi-vitrified and translucent in the kiln. This constitutes porcelain or china-ware; which is either hard and genuine, or tender and spurious, according to the quality and quantity of the fusible ingredient. The second kind consists of an infusible mixture of earths, which is refractory in the kiln, and continues opaque. This is pottery, properly so called; but it comprehends several sub-species, which graduate into each other by imperceptible shades of difference. To this head belong earthenware, stoneware, flintware, *fayence*, delftware, iron-stone china, &c.

The earliest attempts to make a compact stoneware, with a painted glaze, seem to have originated with the Arabians in Spain, about the 9th century, and to have passed thence into Majorca, in which island they were carried on with no little success. In the 14th century, these articles, and the art of imitating them, were highly prized by the Italians, under the name of Majolica, and *porcelana*, from the Portuguese word for a cup. The first fabric of stoneware possessed by them was erected at Fayenza, in the ecclesiastical state, whence the French term *fayence* is derived. The body of the ware was usually a red clay, and the glaze was opaque, being formed of the oxydes of lead and tin, along with potash and sand. Bernhard de Pallissy, about the middle of the 16th century, manufactured the first white *fayence*, at Saintes, in France; and not long afterwards the Dutch produced a similar article, of substantial make, under the name of delftware, and delft *porcelain*, but destitute of those graceful forms and paintings for which the ware of Fayenza was distinguished. Common fayence may be, therefore, regarded as a strong, well-burned, but rather coarse-grained kind of stoneware.

It was in the 17th century that a small work for making earthenware of a coarse description, coated with a common lead glaze, was formed at Burslem, in Staffordshire, which may be considered as the germ of the vast potteries now established in that county. The manufacture was improved about the year 1690, by two Dutchmen, the brothers Elers, who introduced the mode of glazing ware by the vapor of salt, which they threw by handfuls at a certain period among the ignited goods in the kiln. But these were rude, unscientific, and desultory efforts. It is to the late Josiah Wedgewood, Esq. that this country and the world at large are mainly indebted for the great modern advancement of the *ceramic* art. It was he who first erected magnificent factories, where every resource of mechanical and chemical science was made to co-operate with the arts of painting, sculpture, and statuary, in perfecting this valuable department of the industry of nations. So sound were his principles, so judicious his plans of procedure, and so ably have they been prosecuted by his successors in Staffordshire, that a population of 60,000 operatives now derives a comfortable subsistence within a district formerly bleak and barren, of 8 miles long by 6 broad, which contains 150 kilns, and is significantly called the Potteries.

OF THE MATERIALS OF POTTERY OR PORCELAIN, AND THEIR PREPARATION.

1. *Clay.*—The best clay from which the Staffordshire ware is made, comes from Dorsetshire; and a second quality from Devonshire; but both are well adapted for working, being refractory in the fire, and becoming very white when burnt. The clay is cleaned as much as possible by hand, and freed from loosely adhering stones at the

pits where it is dug. In the factory mounted by Mr. Wedgewood, which may be regarded as a type of excellence, the clay is cut to pieces, and then kneaded into a pulp with water, by engines; instead of being broken down with pickaxes, and worked with water by hand-paddles, in a square pit or water-tank, an old process, called *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 moveable arms the appearance of two or four opposite square paddle-boards revolving with the shaft. This wooden framework, or large blunger, as it is called, turns round amidst the water and clay lumps, so as to beat them into a fine pap, from which the stony and coarse sandy particles separate, and subside to the bottom. Whenever the pap has acquired a cream-consistenced uniformity, it is run off through a series of wire, lawn, and silk sieves, of different degrees of fineness, which are kept in continual agitation backwards and forward by a crank mechanism; and thus all the grosser parts are completely separated, and hindered from entering into the composition of the ware. This clay liquor is set aside in proper cisterns, and diluted with water to a standard density.

2. But clay alone cannot form a proper material for stoneware, on account of its great contractility by heat, and the consequent cracking and splitting in the kiln of the vessels made of it; for which reason, a silicious 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 exceeding brittle. They are then reduced to a coarse powder in a stamping-mill, similar to that for stamping ores; see Metallurgy. The pieces of flint are laid on a strong grating, and pass through its meshes whenever they are reduced by the stamps to a certain state of comminution. This granular matter is now transferred to the proper flint-mill, which consists of a strong cylindrical wooden tub, bottomed with flat pieces of massive *chert*, or hornstone, over which are laid large flat blocks of similar chert, that are moved round over the others by strong iron or wooden arms projecting from an upright shaft made to revolve in the axis of the mill-tub. Sometimes the active blocks are fixed to these cross arms, and thus carried round over the passive blocks at the bottom. See *infrà*, under Porcelain, figures of the flint and feldspar mill. Into this cylindrical vessel a small stream of water constantly trickles, which facilitates the grinding motion and action of the stones, and works the flint powder and water into a species of pap. Near the surface of the water there is a plug-hole in the side of the tub, by which the creamy-looking flint liquor is run off from time to time, to be passed through lawn or silk sieves, similar to those used for the clay liquor; while the particles that remain on the sieves are returned into the mill. This pap is also reduced to a standard density by dilution with water; whence the weight of dry silicious 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, a 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 odor. The argillaceous and silicious 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 *sloping or wedging*. It consists in seizing a mass of clay in the hands, and, with a twist of both at once, tearing it into two pieces, or cutting it with a wire. These are again slapped together with force, but in a different direction from that in which they adhered before, and then dashed down on a board. The mass is once more torn or cut asunder at right angles, again slapped together, and so worked repeatedly for 20 or 30 times, which ensures so complete an incorporation of the different parts, that if the mass had been at first half black and half white clay, it would now be of a uniform gray color. 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 morcels, which are forced pell-mell by the screw-like pressure into an opening of the bottom of the cylinder or cone, from which a horizontal pipe about 6 inches square proceeds. The dough is made to issue through this outlet, and is then cut into lengths of about 12 inches. These clay pillars or prisms are thrown back into the cylinder, and subjected to the same operation again and again, till the lumps have their particles perfectly blended together. This process may advantageously precede their being set aside to ripen in a damp cellar. In France the stoneware dough is not worked in such a machine; but after being beat with wooden mallets, a practice common also in England, it is laid down on a clean floor, and a workman is set to tread upon it with naked feet for a considerable time, walking in a spiral direction from the centre to the circumference, and from the circumference to the centre. In Sweden, and also in China (to judge from the Chinese paintings which represent their manner of making porcelain), the clay is trodden to a uniform mass by oxen. It is afterwards, in all cases, kneaded like baker's dough, by folding back the cake upon itself, and kneading it out, alternately.

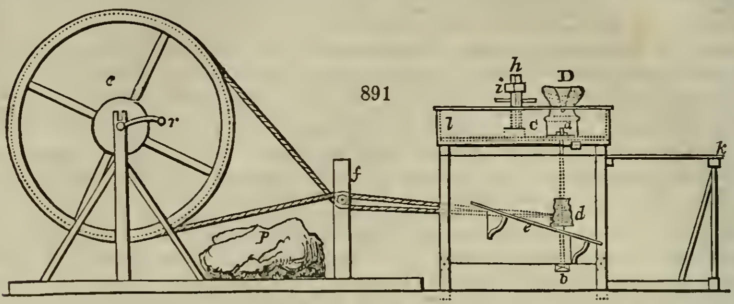
The process of *slapping* consists in cutting through a large mass with a wire, lifting up either half in both hands, and casting it down with great violence on the other; and this violent treatment of the clay is repeated till every appearance of air-bubbles is removed, for the smallest remaining vesicle expanding in the kiln, would be apt to cause blisters or warts upon the ware.

Having thus detailed the preparation of the stoneware paste, we have next to describe the methods of forming it into articles of various forms.

Throwing is performed upon a tool called the potter's lathe. (See fig., *infrà.*) 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 laborer. Sometimes, indeed, the wooden plate is replaced by a large thick disc of Paris plaster, which is whirled round by the hand of the potter, without the intervention of a pulley and fly-wheel, and affords sufficient centrifugal power for fashioning small vessels. The mass of dough to be thrown, is weighed out or gauged by an experienced hand. The thrower dashes down the lump on the centre of the revolving board, and dipping his hands frequently in an adjoining tub of water, he works up the clay into a tall irregular cylinder, and then down into a cake, alternately, till he has secured the final extrication of air-bubbles, and then gives the proper form to the vessel under a less speed of rotation, regulating its dimensions by wooden pegs and gauges. He now cuts it off at the base with a piece of fine brass wire, fastened to a handle at either end. The vessel thus rudely fashioned is placed in a situation where it may dry gradually to a proper point. At a certain stage of the drying, called the *green state*, it possesses a greater tenacity than at any other, till it is baked. It is then taken to another lathe, called the turning lathe, where it is attached by a little moisture to the vertical face of a wooden chuck, and turned nicely into its proper shape with a very sharp tool, which also smooths it. After this it is slightly burnished with a smooth steel surface.

DESCRIPTION OF THE POTTER'S LATHE.

A, *fig.* 891, is the profile of the English potter's lathe, for blocking out round ware; C is the table or tray; *a* is the head of the lathe, with its horizontal disc; *a, b*, is the upright shaft of the head; *d*, pulleys with several grooves of different diameters, fixed upon the shaft, for receiving the driving-cord or band; *k* is a bench upon which the workman sits astride; *e*, the treadle foot-board; *l* is a ledge-board,



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 (see the conical drum apparatus of the *Stearine-press*), while it is made to traverse horizontally, in order to vary the speed of the lathe at pleasure. When the belt is at the base of the driving-cone, it works near the vertex 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 finishing the article thrown. The strap is then transferred to a pair of loose pulleys, and the lathe stops. The vessel is now cut off at the base with small wire; is dried, turned on a power lathe, and polished as above described.

The same degree of dryness which admits of the clay being turned on the lathe, also suits for fixing on the handles and other appendages to the vessels. The parts to be attached, being previously prepared, are joined to the circular work by means of a thin paste which the workmen call *slip*, and the seams are then smoothed off with a wet sponge. They are now taken to a stove-room heated to 80° or 90° F., and fitted up with a great many shelves. When they are fully dried, they are smoothed over with a small bundle of hemp, if the articles be fine, and are then ready for the kiln, which is to convert the tender clay into the hard *biscuit*.

A great variety of pottery wares, however, cannot be fashioned on the lathe, as they are not of a circular form. These are made by two different methods, the one called *press-work*, and the other *casting*. The press-work is done in moulds made of Paris plaster, the one half of the pattern being formed in the one side of the mould, and the other half in the other side: these moulding-pieces fit accurately together. All vessels of an oval form, and such as have flat sides, are made in this way. Handles of 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 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.

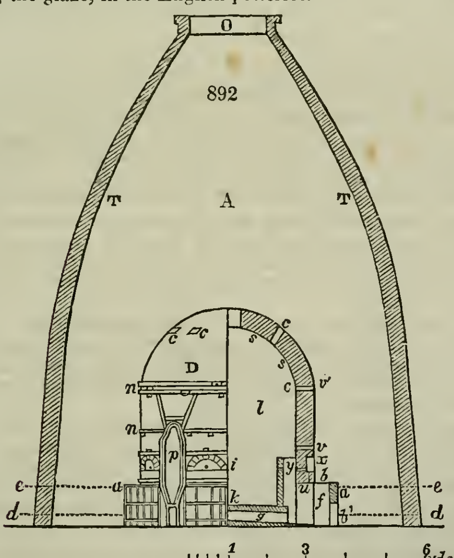
The saggers for the unglazed colored stoneware should be covered inside with a glaze composed of 12 parts of common salt and 30 of potash, or 6 parts of potash and 14 of salt; which may be mixed with a little of the common enamel for the glazed pottery saggers. The bottom of each sagger has some bits 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.

The English kilns differ from those of France and Germany, in their construction, in the nature of their fuel, and in the high temperature required to produce a surface sufficiently hard for a perfectly fine glaze.

When the ware is sufficiently dry, and in sufficient quantity to fill a kiln, the next process is placing the various articles in the baked fire-clay vessels, which may be either of a cylindrical or oval shape; called *gazettes*, Fr.; *kapseln*, Germ. These are from 6 to 8 inches deep, and from 12 to 18 inches in diameter. When packed full of the dry ware, they are piled over each other in the kiln. The bottom of the upper sagger forms the lid of its fellow below; and the junction of the two is luted with a ring of soft clay applied between them. These dishes protect the ware from being suddenly and unequally heated, and from being soiled by the smoke and vapors of the fuel. Each pile of saggers is called a *bung*.

POTTERY KILN OF STAFFORDSHIRE.

Figs. 892, 893, 894, 895, 896, represent the kiln for baking the biscuit, and also for running the glaze, in the English potteries.



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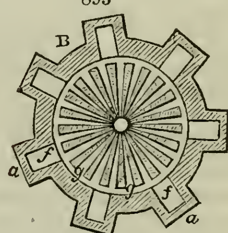

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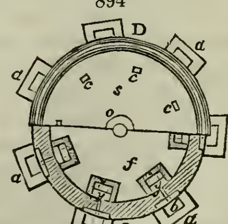


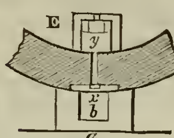
a, a, figs. 892, 893, and 894, are the furnaces which heat the kiln; of which *b*, in *fig* 892, are the upper mouths, and *b′* the lower; the former being closed more or less by the fire-tile *z*, shown in *fig*. 896.

f is one fireplace; for the manner of distributing the fuel in it, see *fig*. 896.

g, y, figs. 892 and 896, 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 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.* 893, 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.

895



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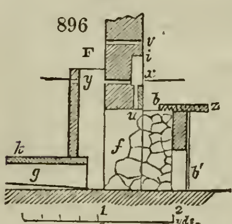


A, is the complete kiln and *howell*, with all its appurtenances.

B, *fig*. 893, 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*. 894, 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*. 894, 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*. 895, is a detailed plan at the level *c, c*, of one furnace and its dependencies.

F, *fig*. 896, is a transverse section, in detail, of one furnace and its dependencies.

The same letters in all the figures indicate the same objects.

Charging of the kiln.—The 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 furnace 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 neighborhood of the *howell*, while a laborer 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.* 896, 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.

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 silicious 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-colored 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 colors; 26 parts of white feldspar are fritted with 6 parts of soda, 2 of nitre, and 1 of borax; to 20 pounds of this frit, 26 parts of feldspar, 20 of white lead, 6 of ground flints, 4 of chalk, 1 of oxyde of tin, and a small quantity of oxyde 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 feld spar, 8 of flints, and 6 of flint glass; then grind the whole together into a 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-color 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.

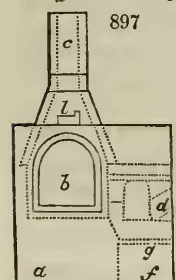
In order that the saggers in which the articles are baked, after receiving the glaze, may not absorb some of the vitrifying matter, they are themselves coated, as above mentioned, with a glaze composed of 13 parts of common salt, and 30 parts of potash, simply dissolved in water, and brushed over them.

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-colored 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 color 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 color, 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 *glazier* 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 color 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.* 897 is a lateral elevation of one of these muffles; *fig.* 898 is a front view. The same letters denote the same parts in the two figures.



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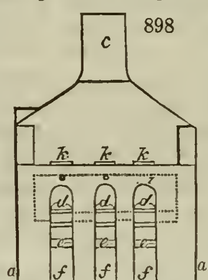

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a is the furnace; *b*, the oblong muffle, made of fire-clay, surmounted with a dome pierced with three apertures *k*, *k*, *k*, for the escape of the vaporous matters of the colors and volatile oils with which they are ground up; *c* is the chimney; *d*, *d*, feed-holes, by which the fuel is introduced; *e*, the fire-grate; *f*, the ash-pit; channels are left in the bottom of the furnace to facilitate the passage of the flame beneath the muffle; *g* is a lateral hole, which makes a communication across the furnace in the muffle, enabling the kiln man to ascertain what is passing within; *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 moveable 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.

Printing of stoneware.—The printing under the stoneware glaze is generally performed by means of cobalt, and has different shades of blue according to the quantity of coloring matter employed. After having subjected this oxyde 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 color upon the biscuit, so that the immersion in the glaze liquor may not displace the lines printed on, as also to aid in fluxing the cobalt.

The following are the processes usually practised in Staffordshire for printing under the glaze.

The cobalt, or whatever color is employed, should be ground upon a porphyry slab, with a varnish prepared as follows:—A pint of linseed oil is to be boiled to the consistence of thick honey, along with 4 ounces of rosin, half a pound of tar, and half a pint of oil of amber. This is very tenacious, and can be used only when liquefied by heat; which the printer effects by spreading it upon a hot cast-iron plate.

The printing plates are made of copper, engraved with pretty deep lines in the common way. The printer, with a leather muller, spreads upon the engraved plate, previously heated, his color, 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 color, and unsized, like tissue blotting-paper.

The stoneware biscuit never receives any preparation before being imprinted, the oil of the color 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 color 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 ley to saponify the oil, after which it is immersed in the glaze liquor, with which the printed figures readily adhere. This process, which is easy to execute, and very economical, is much preferable to the old plan of passing the biscuit into the muffle after it had been printed, for the purpose of fixing and volatilizing the oils. When the paper impression is applied to pieces of porcelain, they are heated before being dipped in the water, because, being already semi-vitrified, the paper sticks more closely to them than to the biscuit, and can be removed only by a hard brush.

The impression above the glaze is done by quite a different process, which dispenses with the use of the press. A quantity of fine clean glue is melted and poured hot upon a large flat dish, so as to form a layer about a quarter of an inch thick, and of the consistence of jelly. When cold it is divided into cakes of the size of the copper-plates it is intended to cover.

The operative (a woman) rubs the engraved copper-plate gently over with linseed oil boiled thick, immediately after which she applies the cake of glue, which she presses down with a silk dossil filled with bran. The cake licks up all the oil out of the engraved lines; it is then cautiously lifted off, and transferred to the surface of the glazed ware which it is intended to print. The glue cake being removed, the enamel surface must be rubbed with a little cotton, whereby the metallic colors 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 coloring.—Common stoneware is colored 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 color 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 *tournasin*, till the ornamental figure produced by the stamp be laid bare; in which case merely the color appears at the bottom of the impression. By passing in this manner several layers of clay liquor of different colors over each other with the blowing-pot, net-work, and decorations of different colors 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 color. These open at the top of the vessel in a common orifice, terminated by small quill tubes. On inclining the vessel, the three colors flow out at once in the same proportion at the one orifice, and are let fall upon the piece while it is being slowly turned upon the lathe; whereby curious serpent-like ornaments may be readily obtained. The clay liquor ought to be in keeping with the stoneware paste. The blues succeed best when the ornaments are made with the finer pottery mixtures given above.

Metallic lustres applied to stoneware.—The metallic lustre being applied only to the outer surface of vessels, can have no bad effect on health, whatever substances be employed for the purpose; and as the glaze intended to receive it is sufficiently fusible, from the quantity of lead it contains, there is no need of adding a flux to the metallic coating. The glaze is in this case composed of 60 parts of litharge, 36 of feldspar, 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 colored ground. The dark-colored stoneware is, however, preferable, as it shows off the colors to most advantage; and thus the shades may be varied by varying the colors of the ornamental figures applied by the blowing-pot.

The gold and platina lustre is almost always applied to a paste body made on purpose, and coated with the above-described lead glaze. This paste is brown, and consists of 4 parts of clay, 4 parts of flints, an equal quantity of kaolin (china clay), and 6 parts of feldspar. To make brown figures in relief upon a body of white paste, a liquor is mixed up with this paste, which ought to weigh 26 ounces per pint, in order to unite well with the other paste, and not to exfoliate after it is baked.

Preparation of gold lustre.—Dissolve first in the cold, and then with heat, 48 grains of fine gold in 288 grains of an aqua regia, composed of 1 ounce of nitric acid and 3 ounces of muriatic acid; add to that solution $4\frac{1}{2}$ 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 color with platina, this metal must be dissolved in an aqua regia composed of 2 parts of muriatic acid, and 1 part of nitric. The solution being cooled, and poured into a capsule, there must be added to it, drop by drop, with continual stirring with a glass rod, a *spirit of tar*, composed of equal parts of tar and sulphur boiled in linseed oil and filtered. If the platina solution be too strong, more spirit of tar must be added to it; but if too weak, it must be concentrated by boiling. Thus being brought to the proper pitch, the mixture may be spread over the piece, which being put into the muffle, will take the aspect of steel.

The oxyde of platina, by means of which the silver lustre is given to stoneware, is prepared as follows:—After having dissolved to saturation the metal in an aqua regia composed of equal parts of nitric and muriatic acid, the solution is to be poured into a quantity of boiling water. At the same time a capsule, containing solution of sal-ammoniac, is placed upon a sand-bath, and the platina solution being poured into it, the metal will fall down in the form of the well-known yellow precipitate, which is to be washed with cold water till it is perfectly edulcorated, then dried, and put up for use.

This metallic lustre is applied very smoothly by means of a flat camel's hair brush. It is then to be passed through the muffle kiln; but it requires a second application of the platinum to have a sufficient body of lustre. The articles sometimes come black out of the kiln, but they get their proper appearance by being rubbed with cotton.

Platina and *gold lustre;* by other recipes.

Platina lustre.—Dissolve 1 ounce of platinum in aqua regia formed of 2 parts of muriatic acid and 1 part of nitric acid, with heat upon a sand-bath, till the liquid is reduced to two thirds of its volume; let it cool; decant into a clean vessel, and pour into it, drop by drop, with constant stirring, some distilled tar, until such a mixture is produced as will give a good result in a trial upon the ware in the kiln. If the lustre be too intense, more tar must be added; if it be too weak, the mixture must be concentrated by further evaporation.

Gold lustre.—Dissolve four shillings' worth of gold in aqua regia with a gentle heat.

To the solution, when cool, add 2 grains of grain tin, which will immediately dissolve. Prepare a mixture of half an ounce of balsam of sulphur with a little essence of turpentine, beating them together till they assume the appearance of milk. Pour this mixture into the solution of gold and tin, drop by drop, with continual stirring; and place the whole in a warm situation for some time.

It is absolutely necessary to apply this lustre only upon an enamel or glaze which has already passed through the fire, otherwise the sulphur would tarnish the composition.

These lustres are applied with most advantage upon chocolate and other dark grounds. Much skill is required in their firing, and a perfect acquaintance with the quality of the glaze on which they are applied.

An iron lustre is obtained by dissolving a bit of steel or iron in muriatic acid, mixing this solution with the spirit of tar, and applying it to the surface of the ware.

Aventurine glaze.—Mix a certain quantity of silver leaf with the above-described soft glaze, grind the mixture along with some honey and boiling water, till the metal assume the appearance of fine particles of sand. The glaze, being naturally of a yellowish hue, gives a golden tint to the small fragments of silver disseminated through it. Molybdena may also be applied to produce the aventurine aspect.

The granite-like gold lustre is produced by throwing lightly with a brush a few drops of oil of turpentine upon the goods already covered with the preparation for gold lustre. These cause it to separate and appear in particles resembling the surface of granite. When marbling is to be given to stoneware, the lustres of gold, platina, and iron are used at once, which blending in the fusion, form veins like those of marble.

Pottery and stoneware of the Wedgewood color.—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 colors, are composed of 47 parts of sulphate of barytes, 15 of feldspar, 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 oxydes and of the ochrous metallic earths. Manganese produces the dark purple color; gold precipitated by tin, a rose color; antimony, orange; cobalt, different shades of blue; copper is employed for the browns and the dead-leaf greens; nickel gives, with potash, greenish colors.

One per cent. of oxyde 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 oxyde of manganese with the black oxyde 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 color 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. Feldspar, 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 colored 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 colored 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 vapor; a part of this is condensed upon the surfaces of the contiguous articles; so as to give them the desired brilliancy.

Mortar body is a paste composed of 6 parts of clay, 3 of feldspar, 2 of silex, and 1 of china clay.

White and yellow figures upon dark-colored 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 colors, upon brown or other colored stoneware, which shows off the light hues.

English porcelain or china.—Most of this belongs to the class called tender or soft porcelain by the French and German manufacturers. It is not, therefore, composed simply of *kaolin* and *petuntse.* The English china is generally baked at a much lower heat than that of Sèvres, Dresden, and Berlin; and it is covered with a mere glass. Being manufactured upon a prodigious scale, with great economy and certainty, and little expenditure of fuel, it is sold at a very moderate price compared with the foreign porcelain, and in external appearance is now not much inferior.

Some of the English porcelain has been called ironstone china. This is composed usually of 60 parts of Cornish stone, 40 of china clay, and 2 of flint glass; or of 42 of the feldspar, 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 feldspar, 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 feldspar, 40 of white lead, and 20 of silex (ground flints.)

The English manufacturers employ three sorts of compositions for the porcelain biscuit; namely, two compositions not fritted; one of them for the ordinary table service; another for the dessert service and tea dishes; the third, which is fritted, corresponds to the paste used in France for sculpture; and with it all delicate kinds of ornaments are made.

	First composition.	Second composition.		Third composition.	
Ground flints - - -	75	- -	66	Lynn sand	150
Calcined bones - -	180	- -	100	- -	300
China clay - - -	40	- -	96	- -	100
Clay - - - - -	70	Granite	80	Potash -	10

The glaze for the first two of the preceding compositions consists of, feldspar 45, flints 9, borax 21, flint glass 20, nickel 4. After fritting that mixture, add 12 parts of red lead. For the third composition, which is the most fusible, the glaze must receive 12 parts of ground flints, instead of 9; and there should be only 15 parts of borax, instead of 21.

PLAN OF AN ENGLISH POTTERY.

A stoneware manufactory should be placed by the side of a canal or navigable river, because the articles manufactured do not well bear land carriage.

A Staffordshire pottery is usually built as a quadrangle, each side being about 100 feet long, the walls 10 feet high, and the ridge of the roof 5 feet more. The base of the edifice consists of a bed of bricks, 18 inches high, and 16 inches thick; upon which a mud wall in a wooden frame, called *pisé*, is raised. Cellars are formed in front of the buildings, as depots for the pastes prepared in the establishment. The wall of the yard or court is 9 feet high, and 18 inches thick.

Fig. 899, A, is the entrance door; B, the porter's lodge; C, a particular warehouse; D, workshop of the plaster-moulder; E, the clay depot; 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 depot 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, depot 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 miscel-

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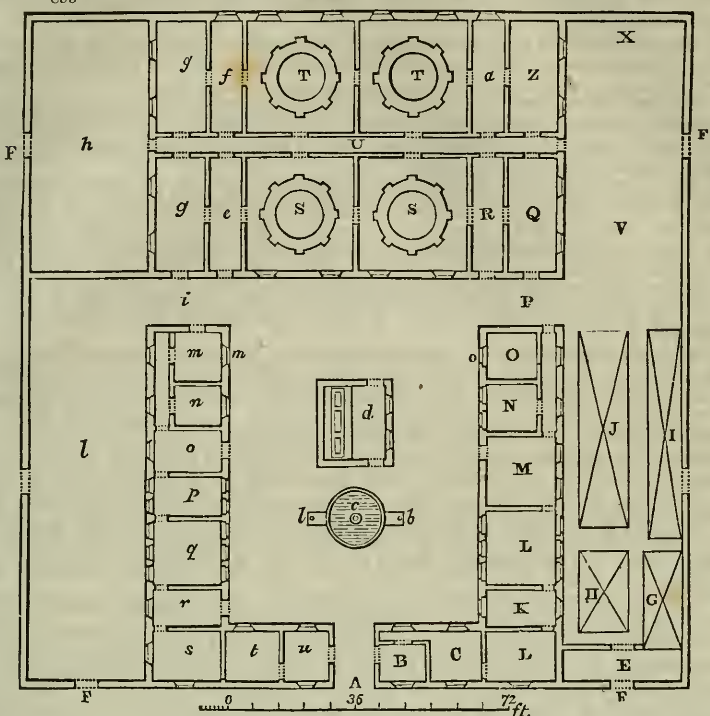


laneous articles; *m*, room for putting the biscuit into the saggers; *m'*, a long window; *n*, workshop with lathes and fly-wheels; o, drying-room; *p*, room for mounting or furnishing the pieces; *q*, repairing-room; *r*, drying-room of the goods roughly turned; *s*, rough turning or blocking-out room; *t*, room for beating the paste or dough; *u*, counting-house.

The declared value of the earthenware exported in 1836, was 837,774*l.*; in 1837, 558,682*l.*

There are from 33,000 to 35,000 tons of clay exported annually from Poole, in Dorsetshire, to the English and Scotch potteries. A good deal of clay is also sent from Devonshire and Cornwall.

The Spanish *alcarazzas*, or cooling vessels, are made porous, to favor 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 proportion of sand, and very moderately fired.

OF PORCELAIN.

Porcelain is a kind of pottery ware whose paste is fine grained, compact, very hard, and faintly translucid; and whose biscuit softens slightly in the kiln. Its ordinary whiteness cannot form a definite character, since there are porcelain pastes variously colored. 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 feldspar rock, called *pe-tun-tse*. The glaze of this porcelain, likewise earthy, admits of no metallic substance or alkali.

Tender porcelain, styled also vitreous porcelain, has no relation with the preceding in its composition; it always consists of a vitreous frit, rendered opaque and less fusible by the addition of a calcareous or marly clay. Its glaze is an artificial glass or crystal, into which silica, alkalis, and lead enter.

This porcelain has a more vitreous biscuit, more transparent, a little less hard, and less fragile, but much more fusible than that of the hard porcelain. Its glaze is more glossy, more transparent, a little less white, much tenderer, and more fusible.

The biscuit of the hard porcelain made at the French national manufactory of Sèvres is generally composed of a kaolin clay, and of a decomposed feldspar rock; analogous to the china clay of Cornwall, and Cornish stone. Both of the above French materials come from Saint Yriex-la-perche, near Limoges.

After many experiments, the following composition has been adopted for the *service paste* of the royal manufactory of Sèvres; that is, for all the ware which is to be glazed; silica, 59; alumina, 35·2; potash, 2·2; lime, 3·3. The conditions of such a compound are pretty nearly fulfilled by taking from 63 to 70 of the washed kaolin or china clay, 22 to 15 of the feldspar, nearly 10 of flint powder, and about 5 of chalk. The glaze is composed solely of solid feldspar, 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 feldspar rock used for this purpose, should contain neither dark mica nor iron, either as an oxyde or sulphuret. It is calcined to make it crushable, under stamp-pestles driven by machinery, then ground fine in hornstone mills, as represented in *figs.* 897, 898, 899, and 900. This pulverulent matter, being diffused through water, is mixed in certain proportions, regulated by its quality, with the argillaceous *slip.* The mixture is deprived of the chief part of its water in shallow plaster pans without heat; and the resulting paste is set aside to ripen, in damp cellars, for many months.

When wanted for use, it is placed in hemispherical pans of plaster, which absorb the redundant moisture; after which it is divided into small lumps, and completely dried. It is next pulverized, moistened a little, and laid on a floor, and trodden upon by a workman marching over it with bare feet in every direction; the parings and fragments of soft moulded articles being intermixed, which improve the plasticity of the whole. When sufficiently tramped, it is made up into masses of the size of a man's head, and kept damp till required.

The dough is now in a state fit for the potter's lathe; but it is much less plastic than stoneware paste, and is more difficult to fashion into the various articles; and hence one cause of the higher price of porcelain.

The round plates and dishes are shaped on plaster moulds; but sometimes the paste is laid on as a crust, and at others it is turned into shape on the lathe. When a crust is to be made, a moistened sheep-skin is spread on a marble table; and over this the dough is extended with a rolling-pin supported on two guide-rules. The crust is then transferred over the plaster mould, by lifting it upon the skin; for it wants tenacity to bear raising by itself. When the piece is to be fashioned on the lathe, a lump of the dough is thrown on the centre of the horizontal wooden disc, and turned into form as directed in treating of stoneware, only it must be left much thicker than in its finished state. After it dries to a certain degree on the plaster mould, the workman replaces it on the lathe, by moistening it on its base with a wet sponge, and finishes its form with an iron tool. A good workman at Sèvres makes no more than from 15 to 20 porcelain plates in a day; whereas an English potter, with two boys, makes from 1000 to 1200 plates of stoneware in the same time. The pieces which are not round, are shaped in plaster moulds, and finished by hand. When the articles are very large, as wash-hand basins, salads, &c., a flat cake is spread above a skin on the marble slab, which is then applied to the mould with the sponge, as for plates; and they are finished by hand.

The projecting pieces, such as handles, beaks, spouts, and ornaments, are moulded and adjusted separately; and are cemented to the bodies of china-ware with slip, or porcelain dough thinned with water. In fact, the mechanical processes with porcelain and the finer stoneware are substantially the same; only they require more time and greater nicety. The least defect in the fabrication, the smallest bit added, an unequal pressure, the cracks of the moulds, although well repaired, and seemingly effaced in the clay shape, re-appear after it is baked. The articles should be allowed to dry very slowly; if hurried but a little, they are liable to be spoiled. When quite dry, they are taken to the kiln.

The kiln for hard porcelain at Sèvres, is a kind of tower in two flats, constructed of fire-bricks; and resembles, in other respects, the stoneware kiln already figured and described. The fuel is young aspin wood, very dry, and cleft very small; it is put into the apertures of the four outside furnaces or fire-mouths, which discharge their flame into the inside of the kiln; each floor being closed in above, by a dome pierced with holes. The whole is covered in by a roof with an open passage, placed at a proper distance from the uppermost dome. There is, therefore, no chimney proper so called. See Stone, artificial.

The raw pieces are put into the upper floor of the kiln; where they receive a heat of about the 60th degree of Wedgewood's pyrometer, and a commencement of baking which, without altering their shape, or causing a perceptible shrinking of their bulk, makes them completely dry, and gives them sufficient solidity to bear handling. By this preliminary baking, the clay loses its property of forming a paste with water; and the pieces become fit for receiving the glazing coat, as they may be dipped in water without risk of breakage.

The glaze of hard porcelain is a feldspar 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 feldspar 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 favor the draught of the fires. The whole being arranged with these precautions, and several others, too minute to be specified here, the door of the kiln is built up with 3 rows of bricks, leaving merely an opening 8 inches square, through which there is access to a sagger with the nearest side cut off. In this sagger are put fragments of porcelain intended to be withdrawn from time to time, in order to judge of the progress of the baking. These are called time-pieces or watches (*montres*). This opening into the watches is closed by a stopper of stoneware.

The firing begins by throwing into the furnace-mouths some pretty large pieces of white wood, and the heat is maintained for about 15 hours, gradually raising it by the addition of a larger quantity of the wood, till at the end of that period the kiln has a cherry-red color within. The heat is now greatly increased by the operation termed *covering the fire*. Instead of throwing billets vertically into the four furnaces, there is placed horizontally on the openings of these furnaces, aspin wood of a sound texture, cleft small, laid in a sloping position. The brisk and long flame which it yields dips into the tunnels, penetrates the kiln, and circulates round the sagger-piles. The heat augments rapidly, and, at the end of 13 or 15 hours of this firing, the interior of the kiln is so white, that the watches can hardly be distinguished. The draught, indeed, is so rapid at this time, that one may place his hand on the slope of the wood without feeling incommoded by the heat. 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 gray-white porcelain with coarser and somewhat cheaper materials, for the other sources of expense above detailed, and which are of most consequence, would still exist; while the porcelain, losing much of its brightness, would lose the main part of its value.

Its pap or dough, which requires tedious grinding and manipulation, is also more difficult to work into shapes, in the ratio of 80 to 1, compared to fine stoneware. Each porcelain plate requires a separate sagger; so that 12 occupy in the kiln a space sufficient for at least 38 stoneware plates. The temperature of a hard porcelain kiln being very high, involves a proportionate consumption of fuel and waste of saggers. With 40 *steres* (cubic metres) of wood, 12,000 stoneware plates may be completely fired, both in the biscuit and glaze kilns; while the same quantity of wood would bake at most only 1000 plates of porcelain.

To these causes of high price, which are constant and essential, we ought to add the numerous accidents to which porcelain is exposed at every step of its preparation, and particularly in the kiln; these accidents damage upwards of one third of the pieces, and frequently more, when articles of singular form and large dimensions are adventured.

The best English porcelain is made from a mixture of the Cornish kaolin (called china clay), ground flints, ground Cornish stone, and calcined bones in powder, or bone-ash, besides some other materials, according to the fancy of the manufacturers. A liquid pap is made with these materials, compounded in certain proportions, and diluted with water. The fluid part is then withdrawn by the absorbent action of dry stucco basins or pans. The dough, brought to a proper stiffness, and perfectly worked and kneaded on the principles detailed above, is fashioned on the lathe, by the hands of modellers, or by pressure in moulds. The pieces are then baked to the state of biscuit in a kiln, being enclosed, of course, in saggers.

This biscuit has the aspect of white sugar, and being very porous, must receive a vitreous coating. The glaze consists of ground feldspar or Cornish stone. Into this, diffused in water, along with a little flint-powder and potash, the biscuit ware is dipped, as already described, under stoneware. The pieces are then fired in the glaze-kiln, care being taken, before putting them into their saggers, to remove the glaze powder from their bottom parts, to prevent their adhesion to the fire-clay vessel.

TENDER PORCELAIN.

Tender porcelain, or soft china-ware, is made with a vitreous frit, rendered less fusible and opaque by an addition of white marl or bone-ash. The frit is, therefore, first prepared. This, at Sèvres, is a composition, made with some nitre, a little sea salt, Alicant barilla, alum, gypsum, and much silicious sand or ground flints. That mixture is subjected to an incipient pasty fusion in a furnace, where it is stirred about to blend the materials well; and thus a very white spongy frit is obtained. It is pulverized, and to every three parts of it, one of the white marl of Argenteuil is added; and when the whole are well ground, and intimately mixed, the paste of tender porcelain is formed.

As this paste has no tenacity, it cannot bear working till a mucilage of gum or black soap be added, which gives it a kind of plasticity, though even then it will not bear the lathe. Hence it must be fashioned in the press, between two moulds of plaster. The pieces are left thicker than they should be; and when dried, are finished on the lathe with iron tools.

In this state they are baked, without any glaze being applied; but as this porcelain softens far more during the baking than the hard porcelain, it needs to be supported on every side. This is done by baking on earthen moulds all such pieces as can be treated in this way, namely, plates, saucers, &c. The pieces are reversed on these moulds, and undergo their shrinkage without losing their form. Beneath other articles, supports of a like paste are laid, which suffer in baking the same contraction as the articles, and of course can serve only once. In this operation 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, silicious sand, a little potash or soda, and about two fifth parts of lead oxyde. 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.

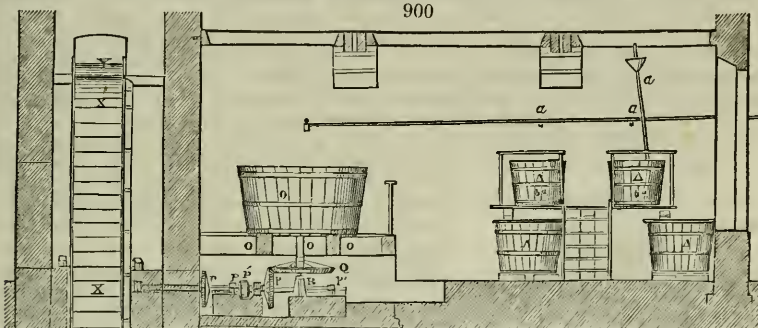
The pieces are encased once more each in a separate sagger, but without any supports; for the heat of the upper floor of the kiln, though adequate to melt the glaze, is not strong enough to soften the biscuit. But as this first vitreous coat is not very equal, a second one is applied, and the pieces 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.

DESCRIPTION OF THE PORCELAIN MILL.

1. The following figures of a feldspar and flint mill are taken from plans of apparatus lately constructed by Mr. Hall of Dartford, and erected by him in the royal manufactory of Sèvres. There are two similar sets of apparatus, *fig.* 900, which may be employed together or in succession; composed each of an elevated tub A, and of three successive vats

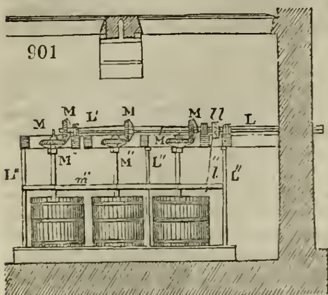
900



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 deposite, into the zinc pipe which conveys it into one of the tubs A′; but as this semi-liquid matter may still contain some granular substances, it must be passed through a sieve before it is admitted into the tub. There is, therefore, at the spot upon the tub where the zinc pipe terminates, a wire-cloth sieve, of an extremely close texture, to receive the liquid paste. This sieve is shaken upon its support, in order to make it discharge the washed argillaceous kaolin. After the clay has subsided, the water is drawn off from its surface by a zinc syphon. The vats A′ have covers, to protect their contents from dust. In the pottery factories of England, the agitation is produced by machinery, instead of the hand. A vertical shaft, with horizontal or oblique paddles, is made to revolve in the vats for this purpose.

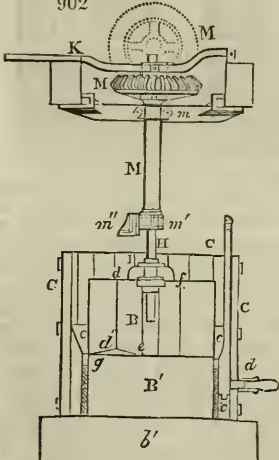
The small triturating mill is represented in *fig.* 901. There are three similar grinding-tubs on the same line. The details of the construction are shown in *figs.* 902, 903, where it is seen to consist principally of a revolving millstone B (*fig.* 902), of a fast or sleeper millstone B′, and of a 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.* 903; 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.

901



The turning horn-stone 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.* 901, where the horizontal axis L, which receives its impulsion from the great water-wheel, turns the prolonged shaft L′, or leaves it at rest, according as the clutch *l*, *l′*, is locked or opened. This second shaft bears the three bevel wheels M, M, M. These work in three corresponding bevel wheels M′ M′ M′, made fast respectively to the 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.* 902. 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.* 901. The guide tubes M″ are bored smooth for a small distance from each of their extremities, and their interjacent calibre is wider, so that the vertical shafts touch only at two places. It is obvious, that whenever the shaft L′ is set a-going, it necessarily turns the wheels M and M′, and their guide tubes M″; but the vertical shaft may remain either at rest, or revolve, according to the position of the lever click or catch 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.

902



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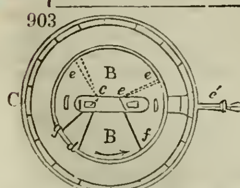
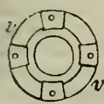


These stones make upon an average 11 or 12 turns in a minute, corresponding to three revolutions of the water-wheel, which moves through a space of 3 feet 4 inches in the second, its outer circumference being 66 feet. The weight of the upper stone, with its iron mountings, is about 6 cwts., when new. The charge of each mill in dry material is 2 cwts.; 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 cwts.; the stone, by displacement of the magma, loses fully 400 pounds of its weight, and weighs therefore in reality only 2 cwts. It is charged in successive portions, but it is discharged all at once. When the grinding of the silicious or feldspar 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 mamga 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 deposite 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.* 901, is not a locking crab, fixed in the common way, upon the shaft L; but it is composed, as shown in *figs.* 904, 905, 906, 907, 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.* 905 represents the collar *v* seen in front; that is, by the face which carries the clutch teeth; and *fig.* 906 represents its other face, which receives the flat ring *x*, *fig.* 907, 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.* 904; and now as the collar *coupling-box*, *v*, slides pretty freely upon the ring *u*, it is obvious that by tightening more or less the screw bolts *y*, these washers will become as it were a lateral brake, to tighten more or less the bearing of the ring *u*, to which they are applied; by regulating this pressure, 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 carbonized, and require replacement.

905



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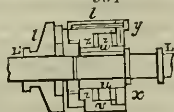

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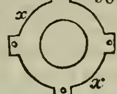


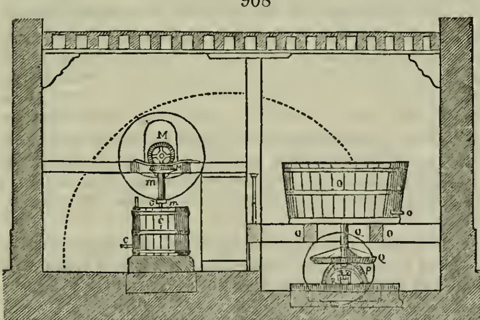
This safety clutch may be recommended to the notice of mechanicians, as susceptible of beneficial application in a variety of circumstances.

GREAT PORCELAIN MILL.

The large feldspar 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 are, as usual, a spigot and faucet at the side, for drawing off the liquid paste. The whole system of the mechanism is very substantial, and is supported by wooden beams.

The following is the manner of turning the upper blocks. In *fig.* 900 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.* 908 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 moveable portion of that box, and an upright bevel wheel P″. Lastly, in *figs.* 900 and 908, 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.* 902. At the lower end of the shaft Q, there is the bevel wheel Q″, which receives motion from the wheel P″, *fig.* 900.

908



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.* 900; its base is solidly fixed by four strong bolts. Four set screws above R, *fig.* 900, serve to set the shaft Q truly perpendicular; thus supported, and held securely at its lower end, in the step at R, *figs.* 900 and 908, 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 bed-stone; 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.* 900 and 908, 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 $141\frac{1}{3}$ 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 cwts., there would remain an effective weight of less than $\frac{1}{2}$ 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 cwts. of hard kaolin or feldspar gravel, in 24 hours, into a proper pap.

To the preceding methodical account of the porcelain manufacture, I shall now subjoin some practical details relative to certain styles of work, with comparisons between the methods pursued in this country and upon the Continent, but chiefly by our jealous rivals the French.

The blue printed ware of England has been hitherto a hopeless object of emulation in France. M. Alexandre Brongniart, membre de l'Institut, and director of the *Manufacture Royal de Sèvres*, characterizes the French imitations of the *Fayence fine, ou Anglaise*, in the following terms: "Les défauts de cette poterie, qui tiennent à sa nature, sont de ne pouvoir aller sur le feu pour les usages domestiques, et d'avoir un vernis tendre, qui se laisse aisément entamer par les instruments d'acier et de fer. Mais lorsque cette poterie est mal fabriquée, ou fabriquée avec une économie mal entendue, ses défauts deviennent bien plus graves; son vernis jaunâtre et tendre tressaille souvent; il se laisse entamer ou user avec la plus grande facilité par les instruments de fer, ou par l'usage ordinaire. Les fissures que ce tressaillement ou ces rayures ouvrent dans le vernis permettent aux matières grasses de pénétrer dans le biscuit, que dans les poteries affectées de ce défaut, a presque toujours une texture lâche; les pièces se salissent, s'empuantissent, et se brisent même avec la plus grande facilité."*

What a glaze, to be scratched or grooved with soft iron; to fly off in scales, so as to let grease soak into the biscuit or body of the ware; to become foul, stink, and break with the utmost ease! The refuse crockery of the coarsest pottery works in the United Kingdom would hardly deserve such censure.

In the minutes of evidence of the *Enquête Ministérielle*, published in 1835, MM. de Saint Cricq and Lebeuf, large manufacturers of pottery-ware at Creil and Montereau, give a very gratifying account of the English stoneware manufacture. They declare that the English possess magnificent mines of potter's clay, many leagues in extent; while those of the

* Dict. Technologique, tom. xvii., article Poteries, p. 253.

French are mere patches or *pots*. Besides, England, they say, having upwards of 200 potteries, can constantly employ a great many public flint-mills, and thereby obtain that indispensable material of the best quality, and at the lowest rate. "The mill erected by M. Brongniart, at Sèvres, does its work at twice the price of the English mills. The fuel costs in England one fourth of what it does in France. The expense of a kiln-round, in the latter country, is 200 francs; while in the former it is not more than 60." After a two-months tour among the English potteries, these gentlemen made the following additional observations to their first official statement:—

"The clay, which goes by water carriage from the counties of Devon and Dorset, into Staffordshire, to supply more than 200 potteries, clustered together, is delivered to them at a cost of 4 francs (3*s.* 2*d.*) the 100 kilogrammes (2 cwt.); at Creil, it costs 4*f.* 50*c.*, and at Mintereau, only 2*f.* 40*c.* There appears, therefore, to be no essential difference in the price of the clay; but the quality of the English is much superior, being incontestably whiter, purer, more homogeneous, and not turning red at a high heat, like the French." The grinding of the flints costs the English potter 4½*d.* per 100 kilos., and the French 6*d.*; but as that of the latter is in general ground dry, it is a coarser article. The kaolin, or china clay, is imported from Cornwall for the use of many French potteries; but the transport of merchandise is so ill managed in France, that while 2 cwts. cost in Staffordshire only 8*f.* 75*c.* (about 7*s.* 1*d.*), they cost 12*f.* at Creil, and 13*f.* 50*c.* at Montereau. The white lead and massicot, so much employed for glazes, are 62 per cent. dearer to the French potters than the English. As no French mill has succeeded in making unsized paper fit for printing upon stoneware, our potters are under the necessity of fetching it from England; and, under favor of our own custom-house, are allowed to import it at a duty of 165*f.* per 100 kilogrammes, or about 8*d.* per pound English. No large stock of materials need be kept by the English, because every article may be had when wanted from its appropriate wholesale dealers; but the case is quite different with the French, whose stocks, even in small works, can never safely be less in value than 150,000*f.* or 200,000*f.*; constituting a loss to them, in interest upon their capital, of from 7,500*f.* to 10,000*f.* per annum. The capital sunk in buildings is far less in England than in France, in consequence of the different styles of erecting stoneware factories in the two countries. M. de Saint Cricq informs us, that Mr. Clewes, of Shelton, rents his works for 10,000*f.* (380*l.*) per annum; while the similar ones of Creil and Montereau, in France, have cost each a capital outlay of from 500,000*f.* to 600,000*f.*, and in which the products are not more than one half of Mr. Clewes'. "This forms a balance against us," says M. St. C., "of about 20,000*f.* per annum; or nearly 800*l.* sterling. Finally, we have the most formidable rival to our potteries in the extreme dexterity of the English artisans. An enormous fabrication permits the manufacturers to employ the same workmen during the whole year upon the same piece; thus I have seen at Shelton a furnisher, for sixpence, turn off 100 pieces, which cost at Creil and Montereau 30 sous (1*s.* 2½*d.*); yet the English workman earns 18*f.* 75*c.* a week, while the French never earns more than 15*f.* I have likewise seen an English moulder expert enough to make 25 waterpots a day, which, at the rate of 2*d.* a piece, bring him 4*s.* 2*d.* of daily wages; while the French moulder, at daily wages also of 4*s.* 2*d.*, turns out of his hands only 7, or at most 8 pots. In regard to hollow wares, the English may be fairly allowed to have an advantage over us, in the cost of labor, of 100 per cent.; which they derive from the circumstance, that there are in Staffordshire 60,000 operatives, men, women, and children, entirely dedicated to the stoneware manufacture; concentrating all their energies within a space of 10 square leagues. Hence a most auspicious choice of good practical potters, which cannot be found in France."

M. Saint Amans, a French gentleman, who spent some years in Staffordshire, and has lately erected a large pottery in France, says the English surpass all other nations in manufacturing a peculiar stoneware, remarkable for its lightness, strength, and elegance; as also in printing blue figures upon it of every tint, equal to that of the Chinese, by processes of singular facility and promptitude. After the biscuit is taken out of the kiln, the fresh impression of the engraving is transferred to it from thin unsized paper, previously immersed in strong soap water; the ink for this purpose being a compound of arseniate of cobalt with a flux, ground up with properly boiled linseed oil. The copper-plates are formed by the graving tool with deeper or shallower lines, according to the variable depth of shades in the design. The cobalt pigment, on melting, spreads so as to give the soft effect of water-color drawing. The paper, being still moist, is readily applied to the slightly rough and adhesive surface of the biscuit, and may be rubbed on more closely by a dossil of flannel. The piece is then dipped in a tub of water, whereby the paper gets soft, and may be easily removed, leaving upon the pottery the pigment of the engraved impression. After being gently dried, the piece is dipped into the glaze mixture, and put into the enamel oven.

Composition of the Earthy Mixtures.

The basis of the English stoneware is, as formerly stated, a bluish clay, brought from Dorsetshire and Devonshire, which lies at the depth of from 25 to 30 feet beneath the surface. It is composed of about 24 parts of alumina, and 76 of silica, with some other ingredients in very small proportions. This clay is very refractory in high heats, a property which, joined to its whiteness when burned, renders it peculiarly valuable for pottery. It is also the basis of all the yellow biscuit-ware called *cream color*, 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, that clay, the powder of calcined flints, and of the decomposed feldspar 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 color*,	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 feldspar must be increased. The substances are mixed separately with water into the consistence of a thick cream, which weighs per pint, for the flints 32 ounces, and for the Cornish stone 28. The china clay of Cornwall is added to the same mixture of flint and feldspar, when a finer pottery or porcelain is required. That clay cream weighs 24 ounces per pint. These 24 ounces in weight are reduced to one third of their bulk by evaporation. The pint of dry Cornish clay weighs 17 ounces, and in its first pasty state 24, as just stated. The dry flint powder weighs $14\frac{1}{2}$ ounces per pint; which when made into a cream weighs 32 ounces. To 40 measures of Devonshire clay-cream there are added,

13 measures of flint liquor.
12 — Cornish clay ditto.
1 — Cornish stone ditto.

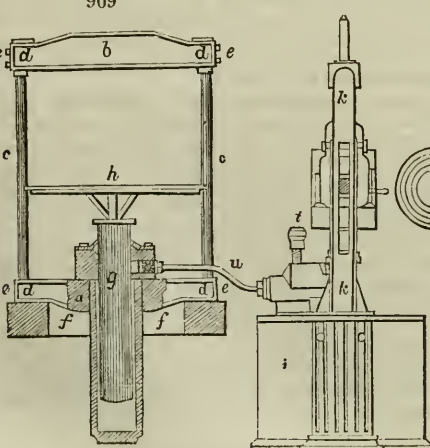
The whole are well mixed by proper agitation, half dried in the *troughs* of the slip-kiln, and then subjected to the machine for cutting up the clay into junks. The above paste, when baked, is very white, hard, sonorous, and susceptible of receiving all sorts of impressions from the paper engravings. When the silica is mixed with the alumina in the above proportions, it forms a compact ware, and the impression remains fixed between the biscuit and the glaze, without communicating to either any portion of the tint of the metallic color employed in the engraver's press. The feldspar 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.

PRECIPITATE, is any matter separated in minute particles from the bosom of a fluid, which subsides to the bottom of the vessel in a pulverulent form.

PRECIPITATION, is the actual subsidence of a precipitate.

PRESS, HYDRAULIC. Though the explanation of the principles of this powerful machine belongs to a work upon mechanical engineering, rather than to one upon

909



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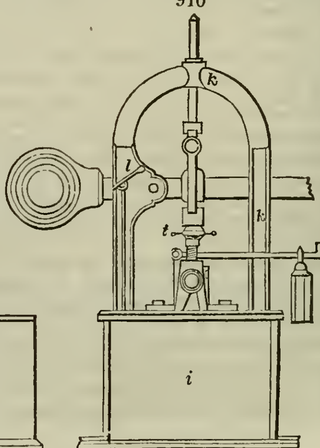
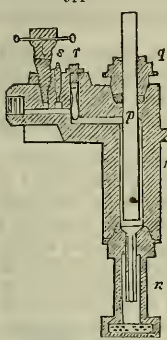


manufactures, yet as it is often referred to in this volume, a brief description of it cannot be unacceptable to many of my readers.

The framing consists of two stout cast iron plates *a*, *b*, which are strengthened by projecting ribs, not seen in the section, *fig*. 909. 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 inside of the cylinder, and the tighter does the joint become. This was Bramah's beautiful invention.

Upon the top of the ram, the press-plate or table, strengthened with projecting ridges, rests, which is commonly called the follower, because it follows the ram closely in its descent. This plate has a half-round hole at each of its four corners, corresponding to the shape of the four iron columns along which it glides in its up-and-down motions of compression and relaxation.

911



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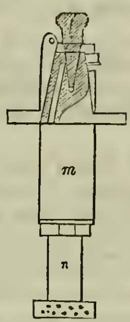


k, *k*, *figs*. 909 and 910, is the framing of a force pump with a narrow barrel; *i* is the well for containing water to supply the pump. To spare room in the engraving, the pump is set close to the press, but it may be removed to any convenient distance by lengthening the water-pipe *u*, which connects the discharge of the force pump with the inside of the cylinder of the press. *Fig*. 911 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*. 910, 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*. 912. *u* is the tube which conveys the water from the pump into the press-cylinder. In *fig*. 910 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 Stearine Press.

PRINCE'S METAL, or Prince Rupert's metal, is a modification of brass.

PRINTING INK. (*Encre d'imprimerie*, Fr.; *Buchdruckerfarbe*, Germ.) After reviewing the different prescriptions given by Moxon, Breton, Papillon, Lewis, those in Nicholson's and the Messrs. Aikins' Dictionaries, in Rees' Cyclopædia, and in the French Printer's Manual, Mr. Savage* says, that the Encyclopædia Britannica is the only work, to his knowledge, which has given a recipe by which a printing ink might be made, that could be used, though it would be of inferior quality, as acknowledged by the editor; for it specifies neither the qualities of the materials, nor their due proportions. The fine black ink made by Mr. Savage, has, he informs us, been pronounced by some of our first printers to be unrivalled; and has procured for him the large medal from the Society for the Encouragement of Arts.

1. *Linseed oil.*—Mr. Savage says, that the linseed oil, however long boiled, unless set fire to, cannot be brought into a proper state for forming printing ink; and that the flame may be most readily extinguished by the application of a pretty tight tin cover to the top of the boiler, which should never be more than half full. The French prefer nut oil to linseed; but if the latter be old, it is fully as good, and much cheaper, in this country at least.

2. *Black rosin* is an important article in the composition of good ink; as by melting

* In his work on the Preparation of Printing Ink; 8vo., London. 1832.

it in the oil, when that ingredient is sufficiently boiled and burnt, the two combine, and form a compound approximating to a natural balsam, like that of Canada, which is itself one of the best varnishes that can be used for printing ink.

3. *Soap.*—This is a most important ingredient in printers' 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 leys, and it skins over very soon in the pot. Yellow rosin soap is the best for black inks; for those of light and delicate shades, white curd soap is preferable. Too much soap is apt to render the impression irregular, and to prevent the ink from drying quickly. The proper proportion has been hit, when the ink works clean, without clogging the surface of the types.

4. *Lamp black.*—The vegetable lamp black, sold in firkins, takes by far the most varnish, and answers for making the best ink. See BLACK.

5. *Ivory black* is too heavy to be used alone as a pigment for printing ink; but it may be added with advantage by grinding a little of it upon a muller with the lamp black, for certain purposes; for instance, if an engraving on wood is required to be printed so as to produce the best possible effect.

6. *Indigo* alone, or with an equal weight of Prussian blue, added in small proportion, takes off the brown 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*, as sold by Mr. Allen, Plough-court, Lombard-street, mixed, by a stone and a muller, with a due proportion of soap and pigment, forms an extemporaneous ink, which the printer may employ very advantageously when he wishes to execute a job in a peculiarly neat manner. Canada balsam does not answer quite so well.

After the smoke begins to rise from the boiling oil, a bit of burning paper stuck in the cleft end of a long stick should be applied to the surface, to set it on fire, as soon as the vapor will burn; and the flame should be allowed to continue (the pot being meanwhile removed from over the fire, or the fire taken from under the pot), till a sample of the varnish, cooled upon a pallet-knife, draws out into strings of about half an inch long between the fingers. To six quarts of linseed oil thus treated, six pounds of rosin should be gradually added, as soon as the froth of the ebullition has subsided. Whenever the rosin is dissolved, one pound and three quarters of dry brown soap, of the best quality, cut into slices, is to be introduced cautiously, for its water of combination causes a violent intumescence. Both the rosin and soap should be well stirred with the spatula. The pot is to be now set upon the fire, in order to complete the combination of all the constituents.

Put next of well ground indigo and Prussian blue, each $2\frac{1}{2}$ 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 colored 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, lustre, umber, sepia, browns mixed with Venetian red, &c.

PRINTING MACHINE. (*Typographie mécanique*, Fr.; *Druckmaschine*, Germ.) In reviewing those great eras of national industry, when the productive arts, after a long period of irksome vassalage, have suddenly achieved some new conquest over the inertia of matter, the contemplative mind cannot fail to be struck with the insignificant part which the academical philosopher has generally played in such memorable events.

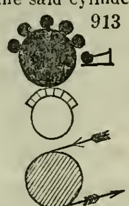
Engrossed with barren syllogisms, or equational theorems, often little better than truisms in disguise, he nevertheless believes in the perfection of his attainments, and disdains to soil his hands with those handicraft operations at which all improvements in the arts must necessarily begin. He does not deem a manufacture worthy of his regard, till it has worked out its own grandeur and independence with patient labor and consummate skill. In this spirit the men of speculative science neglected for 60 years the steam engine of Newcomen, till the artisan Watt transformed it into an automatic prodigy; they have never deigned to illustrate by dynamical investigations the factory mechanisms of Arkwright, yet nothing in the whole compass of art deserves it so well; and though perfectly aware that revolvency is the leading law in the system of the universe, they have never thought of showing the workman that this was also the true principle of every automatic machine.

These remarks seem to be peculiarly applicable to book-printing, an art invented for the honor of learning and the glory of the learned, though they have done nothing for its advancement; yet by the overruling bounty of Providence it has eventually served as the great teacher and guardian of the whole family of man.

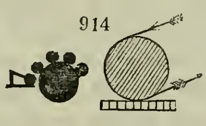
It has been justly observed by Mr. Cowper, in his ingenious lecture,* that no improvement had been introduced in this important art, from its invention till the year 1798, a period of nearly 350 years. In Dr. Dibdin's interesting account of printing, in the Bibliographical Decameron, may be seen representations of the early printing-presses, which exactly resemble the wooden presses in use at the present day. A new era has, however, now arrived, when the demands for prompt circulation of political intelligence require powers of printing newspapers beyond the reach of the most expeditious hand presswork.

For the first essential modification of the old press, the world is indebted to the late Earl Stanhope.† His press is formed of iron, without any wood; the table upon which the form of types is laid, as well as the platen or surface which immediately gives the impression, is of cast iron, made perfectly level; the platen being large enough to print a whole sheet at one pull. The compression is applied by a beautiful combination of levers, which give motion to the screw, cause the platen to descend with progressively increasing force, till it reaches the type, when the power approaches the maximum; upon the infinite lever principle, the power being applied to straighten an obtuse-angled jointed lever. This press, however, like all its flat-faced predecessors, does not act by a continuous, but a reciprocating motion, and can hardly be made automatic; nor does it much exceed the old presses in productiveness, since it can turn off only 250 impressions per hour.

The first person who publicly projected a self-acting printing-press, was Mr. William Nicholson, the able editor of the Philosophical Journal, who obtained a patent in 1790-1, for imposing types upon a cylindrical surface; this disposition of types, plates, and blocks, being a new invention (see *fig.* 913); 2, for applying the ink upon the surface of the types, &c., by causing the surface of a cylinder smeared with the coloring-matter to roll over them; or else causing the types to apply themselves to the said cylinder. For the purpose of spreading the ink evenly over this cylinder, he proposed to apply three or more distributing rollers longitudinally against the inking cylinder, so that they might be turned by the motion of the latter. 3. "I perform," he says, "*all my impressions by the action* of a cylinder, or cylindrical surface; that is, I cause the paper to pass between two cylinders, one of which has the form of types attached to it, and forming part of its surface; and the other is faced with cloth, and serves to press the paper so as to take off an impression of the color previously applied; or otherwise I cause the form of types, previously colored, to pass in close and successive contact with the paper wrapped round a cylinder with woollen." (See *figs.* 913 and 914.) ‡


913

Nicholson's for arched type.


914

Nicholson's for common type.

In this description Mr. Nicholson indicates pretty plainly the principal parts of modern printing machines; and had he paid the same attention to any one part of his invention which he fruitlessly bestowed upon attempts to attach types to a cylinder, or had he bethought himself of curving stereotype plates, which were then beginning to be talked of, he would in all probability have realized a working apparatus, instead of scheming merely ideal plans.

The first operative printing machine was undoubtedly contrived by, and constructed under the direction of, M. König, a clockmaker from Saxony, who, so early as the year 1804, was occupied in improving printing-presses. Having failed to interest the continental printers in his views, he came to London soon after that period, and submitted his plans to Mr. T. Bensley, our celebrated printer, and to Mr. R. Taylor, now one of the editors of the Philosophical Magazine.

* On the recent improvements in printing, first delivered at the Royal Institution, February 22, 1828.

† Lord Stanhope is the only man of learning whose name figures in the annals of typography.

‡ The black parts in these little diagrams, 913—922, indicate the inking apparatus; the diagonal lines, the cylinders upon which the paper to be printed is applied; the perpendicular lines, the plates or types; and the arrows show the track pursued by the sheet of paper.

These gentlemen afforded Mr. König and his assistant Bauer, a German mechanic, liberal pecuniary support. In 1811, he obtained a patent for a method of working a common hand-press by power; but after much expense and labor 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, some time 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 equalizing rollers terminated in two which applied the ink to the types. (See *fig.* 915.) This plan of inking evidently involved a rather complex mechanism, was hence difficult to manage, and sometimes required two hours to get into good working trim. It has been superseded by a happy invention of Mr. Cowper, to be presently described.

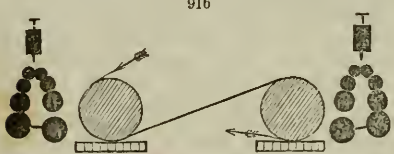
915

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.* 916.

916



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 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.* 917.) It was a beautiful specimen of ingenious contrivance and good workmanship. Though it was found to be too complicated for common operatives, and defective in the mechanism of the inking process; yet it exhibited for the first time the elastic inking rollers, composed of glue combined with treacle, which alone constitute one of the finest inventions of modern typography. In König's machine the rollers were of metal covered with leather, and never answered their purpose very well.

917

Donkin and Bacon's for type.

Before proceeding further, I may state that the above elastic composition, which resembles caoutchouc not a little, but is not so firm, is made by dissolving with heat in two pounds of ordinary treacle, one pound of good glue, previously soaked during a night in cold water.

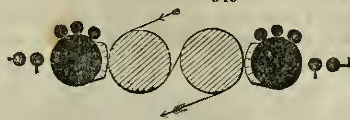
In the year 1815, Mr. Cowper turned his scientific and inventive mind to the subject of printing machines, and has since, in co-operation with his partner, Mr. Applegath, carried them to an unlooked-for degree of perfection. In 1815 Mr. Cowper obtained a patent for curving stereotype plates, for the purpose of fixing them on a cylinder

Several machines so mounted, capable of printing 1000 sheets per hour upon both sides, are at work at the present day; twelve machines on this principle having been made for the Directors of the Bank of England a short time previous to their re-issuing gold. See *figs.* 918, and 919.

918

Cowper's single, for curved stereotype.

919



Cowper's double, for both sides of the sheet.

It deserves to be remarked here, that the same object seems to have occupied the attention of Nicholson, Donkin, Bacon, and Cowper; viz., the revolution of the form of types. Nicholson sought to effect this by giving to the shank of a type a shape like the stone of an arch; Donkin and Bacon by attaching types to the sides of a revolving prism; and Cowper, more successfully, by curving a stereotype plate. (See *fig.* 918.) 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.

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 colored varnish; and as the cylinder continues to revolve, the plates come into contact with a sheet of paper on the first paper cylinder, which is then carried by means of tapes to the second paper cylinder, where it receives an impression upon its opposite side from the plates upon the second cylinder.

Thus the printing of the sheet is completed. Though the above machine be applicable only to stereotype plates, it has been of general importance, because it formed the foundation of the future success of Messrs. Cowper and Applegath's printing machinery, by showing them the best method of serving out, distributing, and applying the colored varnish to the types.

In order to adapt this method of inking to a flat type-form machine, it was merely requisite to do the same thing upon an extended flat surface or table, which had been performed upon an extended cylindrical surface. Accordingly, Messrs. Cowper and Applegath constructed a machine for printing both sides of the sheets from type, including the inking apparatus, and the mode of conveying the sheet from the one paper cylinder to the other, by means of drums and tapes. It is highly creditable to the scientific judgment of these patentees, that in new modelling the printing machine they dispensed with forty wheels, which existed in Mr. König's apparatus, when Mr. Bensley requested them to apply their improvements to it

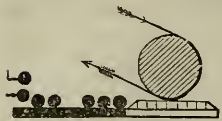
The distinctive advantages of these machines, and which have not hitherto been equalled, are the uniform distribution of the ink, the equality as well as delicacy with which it is laid upon the types, the diminution in its expenditure, amounting to one half upon a given quantity of letter-press, and the facility with which the whole mechanism is managed. The band inking-roller and distributing-table, now so common in every printing-office in Europe and America, is the invention of Mr. Cowper, and was specified in his patent. The vast superiority of the inking apparatus in his machines, over the balls used of old, induced him to apply it forthwith to the common press, and most successfully for the public; but with little or no profit to the inventor, as the plan was unceremoniously infringed throughout the kingdom, by such a multitude of printers, whether rich or poor, as to render all attempts at reclaiming his rights by prosecution hopeless. See *fig.* 920.

920

Cowper's inking table and roller.

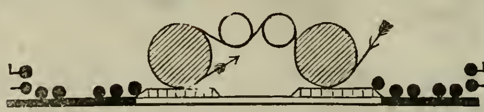
To construct a printing machine which shall throw off two sides at a time with exact register, that is, with the second side placed precisely upon the back of the first, is a very difficult problem, which was first practically solved by Messrs. Applegath and Cowper. It is comparatively easy to make a machine which shall print the one side of a sheet of paper first, and then the other side, by the removal of one form, and the introduction of another; and thus far did Mr. König advance. A correct register requires the sheet, after it has received its first impression from one cylinder, to travel

921



Applegath and Cowper's single.

922

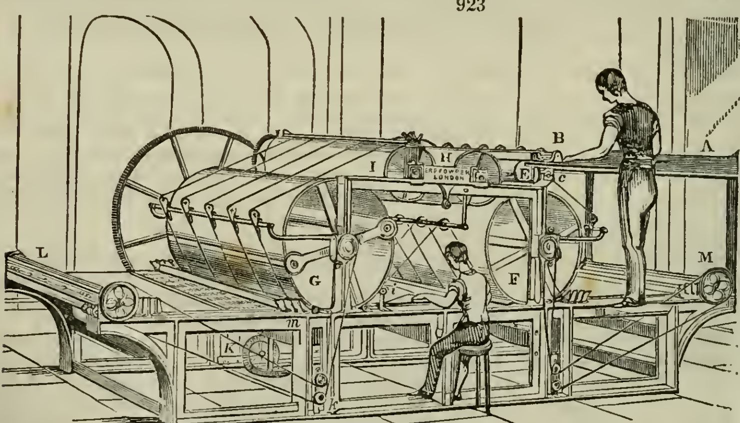


Applegath and Cowper's double.

round the peripheries of the cylinders and drums, at such a rate as to meet the types of the second side at the exact point which will ensure this side falling 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 letter-press. See *figs.* 921, 922.

The machines represented in *figs.* 923, 924, 925, are different forms of those which have been patented by Messrs. Applegath and Cowper. That shown in *figs.* 923 and 925, 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 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

923

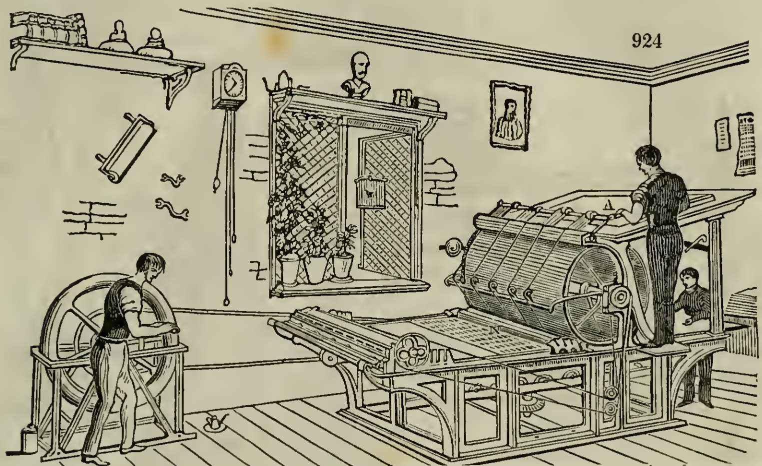


machine. These bearings, or plummer blocks, are susceptible of any degree of adjustment, by set screws. The drums H and I are made of wood; they serve to conduct the sheet evenly from the one printing cylinder to the other.

One series of tapes commences at the upper part of the entering drum E, proceeds in contact with the right-hand side and under surface of the printing cylinder F, passes

* I have witnessed with much pleasure the turning of these great cylinders in Messrs. Cowper's factory at Manchester.

next over the carrier-drum H, and under the carrier-drum I; then encompassing the left-hand side and under portion of the printing drum G, it passes in contact with the



small tension rollers *a*, *b*, *c*, *d*, *fig.* 925, 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.* 925, 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.* 923, where they separate, after having continued in contact, except at the places where the sheets of paper are held between them. The tapes descend from the roller *i*, to a roller at *k*, and, after passing in contact with rollers at *l*, *m*, *n*, they finally arrive at the roller *h*, where they were supposed to commence. Hence two series of tapes act invariably in contact, without the least mutual interference, as may be seen by inspection of the *figs.* 923, 924, 925.

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 *suprà*), called the vibrating roller, is made to travel between the ductor roller and the inking table; the vibrating roller, as it rises, touches the ductor roller for an instant, abstracts a film of ink from it, and then descends to transfer it to the table. There are 3 or 4 small rollers of distribution, placed somewhat diagonally across the table at M, (inclined only 2 inches from a parallel to the end of the frame,) furnished with long slender axles, resting in vertical slots, whereby they are left at liberty to revolve and to traverse at the same time; by which compound movement they are enabled to efface all inequality in the surface of the varnish, or to effect a perfect 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.* 924, imparts to them a uniform

925

film of ink, to be immediately transferred by them to the types. Hence each time that the forms make a complete traverse to and fro, which is requisite for the printing of every sheet, they are touched no less than eight times by the inking rollers. Both the distributing and inking rollers turn in slots, which permit them to rise and fall so as to bear with their whole weight upon the inking table and the form, whereby they never stand in need of any adjustment by screws, but are always ready for work when dropped into their respective places.

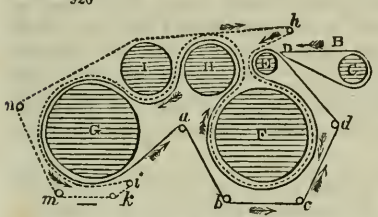
Motion is given to the whole system of apparatus by a strap from a steam engine going round a pulley placed at the end of the axle at the back of the frame; one steam-horse power being adequate to drive two double printing machines; while a single machine may be driven by the power of two men acting upon a fly-wheel. In Messrs. Clowes' establishment, in Stamford-street, two five-horse engines actuate nineteen of the above described machines.

The operation of printing is performed as follows:—See *fig.* 926.

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.

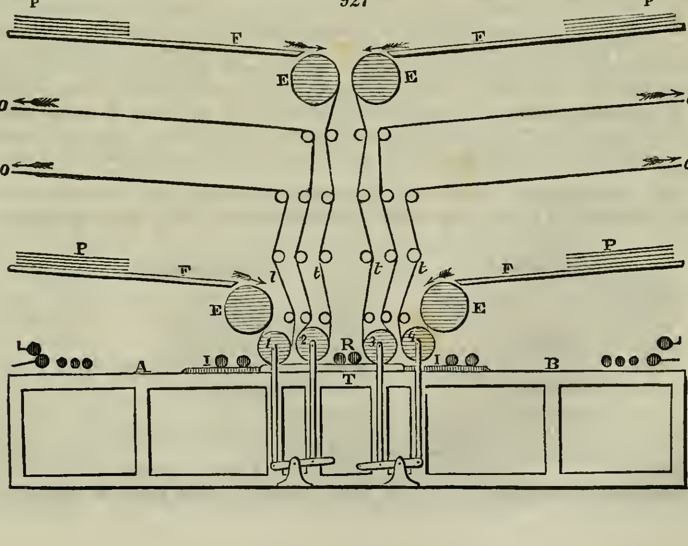
The diagram, *fig.* 926, shows the arrangement of the tapes, agreeably to the preceding description; the feeder B, with the rollers C and D, is seento have an independent endless girth.

926



The diagram, *fig.* 927, explains the structure of the great machine contrived by Messrs. Applegath and Cowper for printing the *Times* newspaper. Here there are four places to lay on the sheets, and four to take them off; consequently, the assistance of eight lads is required. P, P, P, P, are the four piles of paper; F, F, F, F, are the four feeding-boards; E, E, E, E, are the four entering drums, upon which the sheets are introduced between the tapes *t*, *t*, *t*, *t*, whence they are conducted to the

927



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 at 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 noble mechanism is so perfectly equipped, that it is generally in full work within four minutes after the form is brought into the machine-room. The speed of König's machine, by which the *Times* was formerly printed, was such as to turn out 1800 papers per hour; that of Applegath and Cowper throws off 4200 per hour, and it has been daily in use during eight years.

PRUSSIAN BLUE, and PRUSSIATE OF POTASH, are two important articles of chemical manufacture, which must be considered together. The first is called by English chemists, *Ferrocyanodide of iron, the Cyanure ferroso-ferrique* of Berzelius; *Eisenblausaures eisenoxyd*, or *eisencyanür* + *eisencyanid*, Germ.; the second is called *Ferrocyanodide of potassium*, the *Cyanure ferroso-potassique* of Berzelius; *Eisencyanur-kalium, cyaneisen* + *cyankalium* or *Blausaures eisenoxydul-kali*, Germ.

Prussian blue (*Berliner-blau*, Germ.), is a chemical compound of iron and cyanogen. When organic matters, abounding in nitrogen, as dried blood, horns, hair, skins, or hoofs of animals, are triturated along with potash in a strongly ignited iron pot, a dark gray mass is obtained, that affords to water the liquor originally called *lixivium sanguinis*, or blood-ley, which, by evaporation, yields lemon-colored crystals in large rectangular tables, bevelled at the edges. This salt is called in commerce, prussiate of potash, and has for its ultimate constituents, potassium, iron, oxygen, and hydrogen (the latter two in such proportions as to form water), and the peculiar compound CYANOGEN, the *blaustoff* of the Germans.

These crystals consist, in 100 parts, of potassium 37·02, iron 12·82, cyanogen 37·40, water 12·76; or, cyanide of potassium 61·96, cyanide of iron 25·28, and water 12·76. They may be represented also by the following composition: 44·58 of potassa, 38·82 of hydrocyanic or prussic acid, and 16·60 of oxyde of iron, in 100 parts; but the first appears to be their true chemical constitution. Dry ferrocyanodide of potassium is a compound of one atom of cyanide of iron, $54 = (28 + 26)$, and 2 atoms of cyanide of potassium, $132, = (26 \times 2 + 40 \times 2)$; the sum being 186; hydrogen being 1·0 in the scale of equivalents. The crystals of prussiate of potash are nearly transparent, soft, of a sweetish saline and somewhat bitterish taste, soluble in 4 parts of water at 52° F., and in 1 part of boiling water, but insoluble in alcohol. They are permanent in the air at ordinary temperatures, but in a moderately warm stove-room they part with $12\frac{3}{4}$ per cent. of water, without losing their form or coherence, and becomes thereby a white friable anhydrous ferrocyanodide of potassium, consisting of 42·44 potassium, 42·87 cyanogen, and 14·69 iron, in 100 parts.

This salt is an excellent reagent for distinguishing metals from each other, as the following TABLE of the precipitates which it throws down from their saline solutions will show:—

Metallic solutions.	Color of precipitate.
Antimony	white.
Bismuth	white.
Cadmium	white, a little yellowish.
Cerium (protoxyde)	white, soluble in acids.
Cobalt	green, soon turning reddish-gray.
Copper (protoxyde)	white, changing to red.
Do. (peroxyde)	brown-red.
Iron (protoxyde)	white, rapidly turning blue.
Do. (peroxyde)	dark blue.
Lead	white, with a yellowish cast.
Manganese (protoxyde)	white, turning quickly peach or blood-red.

Metallic solutions.	Colors of precipitate.
Manganese (deutoxyde) - -	greenish-gray.
Mercury (protoxyde) - - -	white.
Do. (peroxyde) - - -	white, turning blue.
Molybdenum - - - -	dark brown.
Nickel (oxyde) - - -	white, turning greenish.
Palladium (protoxyde) - -	green (gelatinous.)
Silver - - - - -	white, turning brown in the light.
Tantalum - - - -	yellow, dark burned color.
Tin (protoxyde) - - -	white, (gelatinous.)
Do. (peroxyde) - - -	yellow, do.
Uranium - - - -	red-brown.
Zinc - - - - -	white.

No precipitations ensue with solutions of the alkaline or earthy salts, except that of yttria, which is white; nor with those of gold, platinum, rhodium, iridium, osmium, (in concentrated solutions) tellurium, chromium, tungstenium. All the precipitates by the ferrocyanodide of iron, are double compounds of cyanide of iron with cyanide of the metal thrown down, which is produced by the reciprocal decomposition of the cyanide of potassium and the peculiar metallic oxyde present in the solution. The precipitate from the sulphate of copper has a fine brown color, and has been used as a pigment; but it is somewhat transparent, and therefore does not cover well. The precipitate from the peroxyde salts of iron is a very intense Prussian blue, called on the continent, Paris blue. It may be regarded as a compound of prussiate of protoxyde and prussiate of peroxyde of iron; or as a double cyanide of the protoxyde and peroxyde of iron, as the denomination *cyanure ferroso-ferrique* denotes. In numbers, its composition may be therefore stated thus: prussic or hydrocyanic acid, 48·48; protoxyde of iron, 20·73; peroxyde of iron, 30·79; or cyanogen, 46·71; iron, 37·36; water, 15·93; which represent its constitution when it is formed by precipitation with the prussiate of potash or a salt of iron that contains no protoxyde. If the iron be but partially peroxydized in the salt, it will afford a precipitate, at first pale blue, which turns dark blue in the air, consisting of a mixture of prussiate of protoxyde and prussiate of peroxyde. In fact, the white cyanide of iron (the prussiate of the pure protoxyde), 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 peroxyde of iron, since it contains an excess of the peroxyde 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 color when treated with disoxydizing reagents. When Prussian blue is digested in warm water along with potash, soda, or lime, peroxyde 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 oxyde of mercury, it parts with all its oxyde 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 $52=(26\times2)$ cyanogen. When this salt is gently ignited, it affords gaseous cyanogen. Hydrocyanic or prussic acid, which consists of 1 atom of cyanogen $= 26$, $+ 1$ of hydrogen $= 1$, is prepared by distilling the mercurial bi-cyanide in a glass retort with the saturating quantity of dilute muriatic acid. Prussic acid may also be obtained by precipitating the mercury by sulphureted hydrogen gas from the solution of its cyanide; as also by distilling the ferrocyanide of potassium along with dilute sulphuric acid. Prussic acid is a very volatile light fluid, eminently poisonous, and is spontaneously decomposed by keeping, especially when somewhat concentrated.

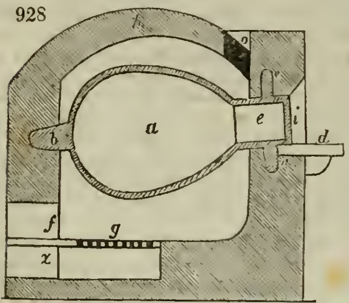
Having expounded the chemical constitution of Prussian blue and prussiate of potash, I shall now treat of their *manufacture upon the commercial scale.*

1. *Of blood-ley*, the phlogisticated alkali of Scheele. Among the animal substances used for the preparation of this lixivium, blood deserves the preference, where it can be had cheap enough. It must be evaporated to perfect dryness, reduced to powder, and sifted.

Hoofs, parings of horns, hides, old woollen rags, and other animal offals, are, however, generally had recourse to, as condensing most azotized matter in the smallest bulk. Dried funguses have been also prescribed. These animal matters may either be first carbonized in cast iron cylinders, as for the manufacture of *sal ammoniac* (which see), and the residual charcoal may be then taken for making the ferroprussiate; or the dry animal matters may be directly employed. The latter process is apt to be exceedingly offensive to the workmen and neighborhood, from the nauseous vapors 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 $1\frac{1}{2}$ to 2 parts of charcoal, or to about eight parts of hard animal matter. Gautier has proposed to calcine three parts of dry blood with one of nitre; with what advantage to the manufacturer, I cannot discover.

The pot for calcining the mixture of animal and alkaline matter is egg-shaped as represented at *a*, *fig.* 928, 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.

928



The calcining process is different, according as the animal substances are fresh or carbonized. In the first case, the pot must remain open, to allow of diligent stirring of its contents, with a slightly bent flat iron bar or scoop, and of introducing more of the mixture as the intumescence subsides, during a period of five or six hours, till the nauseous vapors cease to rise, till the flame becomes smaller and brighter, and till a smell of ammonia be perceived. At this time, the heat should be increased, the mouth of the pot should be shut, and opened only once every half hour, for the purpose of working the mass with the iron paddle. When on opening the mouth of the pot, and stirring the pasty mixture, no more flame rises, the process is finished.

If the animal ingredients are employed in a carbonized state, the pot must be shut as soon as its contents are brought to ignition by a briskly urged fire, and opened for a few seconds only every quarter of an hour, during the action of stirring. At first, a body of flame bursts forth every time that the lid is removed; but by degrees this ceases, and the mixture soon agglomerates, and then softens into a paste. Though the fire be steadily kept up, the flame becomes less and less each time that the pot is opened; and when it ceases, the process is at an end. The operation, with a mass of 50 pounds of charcoal and 50 pounds of purified pearlash, lasts about 12 hours, the first time that the furnace is kindled; but when the pot has been previously brought to a state of ignition, it takes only 7 or 8 hours. In a well-appointed factory, the fire should be invariably maintained at the proper pitch, and the pots should be worked with relays of operatives.

The molten mass is now to be scooped out with an appropriate iron shovel, having a long shank, and caused to cool in small portions, as quickly as possible; but not by throwing it into water, as has sometimes been prescribed; for in this way a good deal of the cyanogen is converted into ammonia. If it be heaped up and kept hot in contact with air, some of the ferrocyanide is also decomposed, with diminution of the product. The crude mass is to be then put into a pan with cold water, dissolved by the application of a moderate heat, and filtered through cloths. The charcoal which remains upon the filter possesses the properties of decoloring sirups, vinegars, &c., and of destroying smells in a pre-eminent degree. It may also serve, when mixed with fresh animal coal, for another calcining operation.

As the iron requisite for the formation of the ferrocyanide is in general derived from the sides of the pot, this is apt to wear out into holes, especially at its under side, where the heat is greatest. In this event, it may be taken out of the furnace, patched up with iron-rust cement, and re-inserted with the sound side undermost. The erosion of the pot may be obviated in some measure by mixing iron borings or cinder (hammerschlag) with the other materials, to the amount of one or two hundredths of the potash.

The above lixivium is not a solution of pure 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 crystallized ferroprussiate of potash. The mother-water is again evaporated and crystallized, whereby a somewhat inferior ferroprussiate is obtained. Before evaporating the ley, 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, neutralizing 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 crystallizing the precipitated salt twice over in water. The sulphate of potassa may be decomposed by acetate of baryta, and the resulting acetate of potassa removed by alcohol.

2. *The precipitation of Prussian blue.*—Green sulphate of iron is always employed by the manufacturer, on account of its cheapness, for mixing with solution of the 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 protoxyde, to convert into ferrocyanide any cyanide of potassium that may happen to be present in the uncrystallized lixivium. The carbonate of potash in that lixivium might be saturated with sulphuric acid before adding the solution of sulphate of iron; but it is more commonly done by adding a certain portion of alum; in which case, alumina falls along with the Prussian blue; and though it renders it somewhat paler, yet it proportionally increases its weight; whilst the acid of the alum saturates the carbonate of potash, and prevents its throwing down iron-oxyde, 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 ley 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 neutralize them. The mixed solutions of alum and copperas should be progressively added to the ley as long as they produce any precipitate. This is not at first a fine blue, but a greenish gray, in consequence of the admixture of some white cyanide of iron; it becomes gradually blue by the absorption of oxygen from the air, which is favored by agitation of the liquor. Whenever the color seems to be as beautiful as it is likely to become, the liquor is to be run off by a spigot or cock from the bottom of the precipitation vats, into flat cisterns, to settle. The clear supernatant fluid, which is chiefly a solution of sulphate of potash, is then drawn off by a syphon; more water is run on with agitation to wash it, which after settling is again drawn off; and whenever the washings become tasteless, the sediment is thrown upon filter sieves, and exposed to dry, first in the air of a stove, but finally upon slabs of chalk or Paris plaster. But for several purposes, Prussian blue may be best employed in the fresh pasty state, as it then spreads more evenly over paper and other surfaces.

A good article is known by the following tests: it feels light in the hand, adheres to the tongue, has a dark lively blue color, 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 peroxyde salt of iron, displays, when rubbed, a copper-red lustre, like indigo. Prussian blue, degraded in its color by an admixture of free oxyde 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 color.

Sulphureted hydrogen passed through Prussian blue diffused in water, whitens it; while prussic acid is eliminated, sulphur is thrown down, and the sesquicyanide of iron is converted into the single cyanide. Iron and tin operate in the same way. When Prussian blue is made with two atoms of ferrocyanide of potassium, instead of one, it becomes soluble in water.

For the mode of applying this pigment in dyeing, see CALICO-PRINTING.

Sesquiferrocyanate of potash is prepared by passing chlorine gas through a solution of ferrocyanide of potassium, till it becomes red, and ceases to precipitate the peroxyde salts of iron. The liquor yields, by evaporation, prismatic crystals, of a ruby-red transparency. They are soluble in 38 parts of water, and consist of 40·42 parts of sesquicyanide of iron, and 59·58 of cyanide of potassium. The solution of this salt precipitates the following metals, as stated in the table:—

Bismuth - -	pale yellow.	Mercury (peroxyde) -	yellow.
Cadmium - -	yellow.	Molybdenum - -	red-brown.
Cobalt - -	dark brown-red.	Nickel - - -	yellow-green.
Copper (protoxyde)	red-brown.	Silver - - -	red-brown.
Do. (peroxyde)	yellow-green.	Tin (protoxyde) -	white.
Iron, protoxyde salts of	blue.	Uranium - - -	red-brown.
Manganese - -	brown.	Zinc - - -	orange-yellow.
Mercury (protoxyde)	red-brown.		

PUMICE-STONE (*Pierre-ponce*, Fr.; *Bimstein*, Germ.), is a spongy, vitreous-looking mineral, consisting of fibres of a silky lustre, interlaced with each other in all directions. It floats upon water, is harsh to the touch, having in mass a mean sp. grav. of 0·914; though brittle, it is hard enough to scratch glass and most metals. Its color is usually grayish white; but it is sometimes bluish, greenish, reddish, or brownish. It fuses without addition at the blowpipe into a white enamel. According to Klaproth, it is composed of, silica, 77·5; alumina, 17·5; oxyde of iron, 2; potassa and soda, 3; in 100 parts. The acids have hardly any action upon pumice-stone. It is used for polishing ivory, wood, marble, metals, glass, &c.; as also skins and parchment. Pumice-stone is usually reckoned to be a volcanic product, resulting, probably, from the action of fire upon obsidians. The chief localities of this mineral are the islands of Lipari, Ponza, Ischia, and Vulcano. It is also found in the neighborhood of Andernach, upon the banks of the Rhine, in Teneriffe, Iceland, Auvergne, &c. It is sometimes so spongy as to be of specific gravity 0·37.

PUOZZOLANA is a volcanic gravelly product, used in making hydraulic mortar. See CEMENTS and MORTARS.

PURPLE OF CASSIUS, *Gold purple* (*Pourpre de Cassius*, Fr.; *Gold-purpur*, Germ.), is a vitrifiable pigment, which stains glass and porcelain of a beautiful red or purple hue. Its preparation has been deemed a process of such nicety, as to be liable to fail in the most experienced hands. The following observations will, I hope, place the subject upon a surer footing.

The proper pigment can be obtained only by adding to a neutral muriate of gold a mixture of the protochloride and perchloride of tin. 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 crystallized protochloride of tin, with 2 parts of crystallized perchloride, produces, with 1 part of crystallized chloride of gold (all being in solution), a beautiful purple-colored 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 sesquioxyde of tin in muriatic acid, or of the sesquichloride in water, serves the same purpose, when dropped into a very dilute solution of gold.

Buisson prepares gold-purple in the following way. He dissolves, first, 1 gramme of the best tin in a sufficient quantity of muriatic acid, taking care that the solution is neutral; next, 2 grammes of tin in aqua regia, composed of 3 parts of nitric acid, and 1 part of muriatic, so that the solution can contain no protoxyde; 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 three 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. Muriatic acid takes the tin out of the fresh-made precipitate, and leaves the gold either in the state of metal or of a blue powder. At a temperature between 212° and 300° Fahr., mercury dissolves out all the gold from the ordinary purple of Cassius.

Relative to the constitution of gold-purple, two views are entertained: according to the first, the gold is associated in the metallic state along with the oxyde of tin; according to the second, the gold exists as a purple oxyde along with the sesquioxyde or peroxyde of tin. Its composition is differently reported by different chemists. The constituents, according to—

	Gold.	Tin oxyde
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 MOLLUSCA is a viscid liquor, secreted by certain shell-fish, the *Buccinum lapillus*, and others, which dyes wool, &c. of a purple color, and is supposed to be the substance of the Tyrian dye, so highly prized in ancient Rome for producing the imperial purple. See DYEING.

PURPURIC ACID is an acid obtained by treating uric or lithic acid with dilute nitric acid. It has a fine purple color; but has hitherto been applied to no use in the arts.

PURPURINE is the name of a coloring principle, supposed by Robiquet and Colin to exist in madder. Its identity is questionable.

PUTREFACTION, *and its Prevention.* The decomposition of animal bodies, or of such plants as contain azote in their composition, which takes place spontaneously when they are exposed to the air, under the influence of moisture and warmth, is called putrefaction. During this process, there is a complete transposition of the proximate principles, the elementary substances combining in new and principally gaseous compounds. Oxygen is absorbed from the atmosphere, and converted into carbonic acid; one portion of the hydrogen forms water with the oxygen; another portion forms, with the azote, the carbon, the phosphorus, and the sulphur respectively, ammonia, carbureted, phosphureted, and sulphureted hydrogen gases, which occasion the nauseous smell evolved by putrefying bodies. There remains a friable earthy-looking residuum, consisting of rotten mould and charcoal. Vegetables which contain no azote, like the ligneous part of plants, suffer their corresponding decomposition much more slowly, and with different modifications, but they are finally converted into vegetable mould. In this process, the juices with which the plants are filled first enter into the acetous fermentation under the action of heat and moisture; the acid thereby generated destroys the cohesion of the fibrous matter, and thus reduces the solids to a pulpy state. In the progress of the decomposition, a substance is lastly produced which resembles oxydized extractive, is soluble in alkalis, and is sometimes called *mould.* This decomposition of the plants which contain no azote, goes on without any offensive smell, as none of the above-named nauseous gases are disengaged. When vegetable matters are mixed with animal, as in the dung of cattle, this decomposition proceeds more rapidly, because the animalized portion serves as a ferment to the vegetable. Vegetable acids, resins, fats, and volatilized oils, are not of themselves subject to putrefaction.

The object of the present article is to detail the principles and processes, according to which, for various purposes in the arts, the destruction of bodies by putrefaction may be prevented, and their preservation in a sound state secured for a longer or a shorter time.

I. CONDITIONS OF THE PREVENTION OF PUTREFACTION.

The circumstances by which putrefaction is counteracted, are, 1. the chemical change of the azotized juices; 2. the abstraction of the water; 3. the lowering of the temperature; and 4. the exclusion of oxygen.

1. *The chemical change of the azotized juices.*—The substance which in dead animal matter is first attacked with putridity, and which serves to communicate it to the solid fibrous parts, is albumen, as it exists combined with more or less water in all the animal fluids and soft parts. In those vegetables also which putrefy, it is the albumen which first suffers decomposition; and hence those plants which contain most of that proximate principle, are most apt to become putrid, and most resemble, in this respect, animal substances; of which fact, mushrooms, cabbages, coleworts, &c., afford illustrations. The albumen, when dissolved in water, very readily putrefies in a moderately warm air; but when coagulated, it seems as little liable to putridity as fibrin itself. By this change, it throws off the superfluous water, becomes solid, and may then be easily dried. Hence, those means which by coagulation make the albumen insoluble, or form with it a new compound, which does not dissolve in water, but which resists putrefaction, are powerful antiseptics. Whenever the albumen is coagulated, the uncombined water may be easily evaporated away, and the residuary solid matter may be readily dried in the air, so as to be rendered unsusceptible of decomposition.

In this way acids operate, which combine with the albumen, and fix it in a coagulated state, without separating it from its solution: such is the effect of vinegar, citric acid, tartaric acid, &c.

Tannin combines with the albuminous and gelatinous parts of animals, and forms insoluble compounds, which resist putrefaction; on which fact the art of tanning is founded.

Alcohol, oil of turpentine, and some other volatile oils, likewise coagulate albumen, and thereby protect it from putrescence. The most remarkable operation of this kind is exhibited by wood vinegar, in consequence of the *creosote* contained in it, according to the discovery of Reichenbach. This peculiar volatile oil has so decided a power of coagulating albumen, that even the minute portion of it present in pyroligneous vinegar is sufficient to preserve animal parts from putrefaction, when they are simply soaked in it. Thus, also, flesh is cured by wood smoke. Wood tar likewise protects animal matter from change, by the creosote it contains. The ordinary pyroligneous acid sometimes contains 5 per cent. of creosote.

In circumstances where a stronger impregnation with this antiseptic oil may be necessary, common wood vinegar may be heated to 167° F., and saturated with effloresced Glauber's salts, by which expedient the oil is separated and made to float upon the surface of the warm liquid; whence it should be immediately skimmed off; because, by cooling and crystallizing, the solution would so diminish in density as to allow the oil to sink to the bottom; for its specific gravity is considerably greater than that of water. This oil, which contains, besides creosote, some other volatile constituents, may be kept dissolved ready for use in strong vinegar or alcohol. Water takes up of pure creosote only $1\frac{3}{4}$ per cent.; but alcohol dissolves it in every proportion.

The earthy and metallic salts afford likewise powerful means for separating albumen from its watery solution, their bases having the property of forming insoluble compounds with it. The more completely they produce this separation, the more effectually do they counteract putrefaction. The alkaline salts also, as common salt, sal ammoniac, saltpetre, and tartar, operate against putrescence, though in a smaller degree, because they do not precipitate the albumen; but, by abstracting a part of its water, they render it less liable to become putrid. Among the earthy salts, alum is the most energetic, as it forms a subsalt which combines with albumen; it is three times more antiseptic than common salt, and from seven to eight times more so than saltpetre. Muriate of soda, however, may be employed along with alum, as is done in the tawing of sheepskins.

The metallic salts operate still more effectually as antiseptics, because they form with albumen still more intimate combinations. Under this head we class the green and red sulphates of iron, the 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. For the albumen itself runs so much more slowly into putrefaction, the less water it is dissolved in; and in the desiccated state, it is as little susceptible of alteration as any other dry vegetable or animal matter. Hence, the proper drying of an animal substance becomes a universal preventive of putrescence. In this way fruits, herbs, cabbages, fish, flesh,

may be preserved from corruption. If the air be not cold and dry enough to cause the evaporation of the fluids before putrescence may come on, the organic substance must be dried by artificial means, as by being exposed in thin slices in properly constructed air-stoves. At temperatures under 140° F., the albumen dries up without coagulation, and may then be re-dissolved in cold water, with its valuable properties unaltered. By such artificial desiccation, if flesh is to be preserved for cooking or boiling, it must not be exposed, however, to so high a degree of heat, which would harden it permanently, like the baked mummies of Egypt. Mere desiccation, indeed, can hardly ever be employed upon flesh. Culinary salt is generally had recourse to, either alone or with the addition of saltpetre or sugar.

These alkaline salts abstract water in their solution, and, consequently, concentrate the aqueous solution of the albumen; whence, by converting the simple watery fluid into salt water, which is in general less favorable to the fermentation of animal matter than pure water, and by expelling the air, they counteract putridity. On this account, salted meat may be dried in the air much more speedily and safely than fresh meat. The drying is promoted by heating the meat merely to such a degree as to consolidate the albumen, and eliminate the superfluous water.

Alcohol operates similarly, in abstracting the water essential to the putrefaction of animal substances, taking it not only from the liquid albumen, but counteracting its decomposition, when mixed among the animal solids. Sugar acts in the same way, fixing in an unchangeable sirup the water which would otherwise be accessory to the fermentation of the organic bodies. The preserves of fruits and vegetable juices are made upon this principle. When animal substances are rubbed with charcoal powder or sand, perfectly dry, and are afterwards freely exposed to the air, they become deprived of their moisture, and will keep for any length of time.

3. *Defect of warmth.*—As a certain degree of heat is requisite for the vinous fermentation, so is it for the putrefactive. 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 supended altogether at that point. The elephants preserved in the polar ices are proofs of the antiseptic influence of low temperature. In temperate climates, ice-houses serve the purpose of keeping meat fresh and sweet for any length of time.

4. *Abstraction of oxygen gas.*—As the putrefactive decomposition of a body first commences with the absorption of oxygen from the atmosphere, so it may be retarded by the exclusion of this gas. It is not, however, enough to remove the aerial oxygen from the surface of the body, but we must expel all the oxygen that may be diffused among the vessels and other solids, as this portion suffices in general to excite putrefaction, if other circumstances be favorable. The expulsion is most readily accomplished by a moderate degree of heat, which, by expanding the air, evolves it in a great measure, and at the same time favors the fixation of the oxygen in the extractive matter, so as to make it no longer available towards the putrefaction of the other substances. Milk, soup, solution of gelatine, &c., may be kept long in a fresh state, if they be subjected in an air-tight vessel every other day to a boiling heat. Oxygenation may be prevented in several ways: by burning sulphur or phosphorus in the air of the meat receiver; by filling this with compressed carbonic acid; or with oils, fats, sirups, &c., and then sealing it hermetically. Charcoal powder recently calcined is efficacious in preserving meat, as it not only excludes air from the bodies surrounded by it, but intercepts the oxygen by condensing it. When butcher-meat is enclosed in a vessel filled with sulphurous acid, it absorbs the gas, and remains for a considerable time proof against corruption. The same result is obtained if the vessel be filled with ammoniacal gas. At the end of 76 days such meat has still a fresh look, and may be safely dried in the atmosphere.

II. PECULIAR ANTISEPTIC PROCESSES.

Upon the preceding principles and experiments depend the several processes employed for protecting substances from putrescence and corruption. Here we must distinguish between those bodies which may be preserved by any media suitable to the purpose, as anatomical preparations or objects of natural history, and those bodies which, being intended for food, can be cured only by wholesome and agreeable means.

A common method for preserving animal substances unchanged in property and texture, is to immerse them in a spirituous liquor containing about 65 or 70 per cent. of real alcohol. Camphor may also be dissolved in it, and as much common salt as its water will take up. A double fold of ox-bladder should be bound over the mouth of the vessel, in order to impede the evaporation of the watery portion of the liquid, and its upper surface should be coated with a turpentine varnish. Undoubtedly a little creosote would be of use to counteract the decomposing influence of the alcohol upon the animal substances. With such an addition, a weaker spirit, containing no more than 30 per cent. of alcohol, would answer the purpose.

Instead of alcohol, a much cheaper vehicle is water saturated with sulphurous acid; and if a few drops of creosote be added, the mixture will become very efficacious. A solution of red sulphate of iron is powerfully antiseptic; but after some time it gives a deposite of the oxyde, which disguises the preparation in a great degree.

According to Tauffier, animal substances may be preserved more permanently by a solution of one part of chloride of tin in 20 parts of water, sharpened with a little muriatic acid, than even by alcohol.

For preserving animal bodies in an embalmed form, mummy-like, a solution of chloride of mercury and wood vinegar is most efficacious. As there is danger in manipulating with that mercurial salt, and as in the present state of our knowledge of creosote we have it in our power to make a suitably strong solution of this substance in vinegar or spirit of wine, I am led to suppose that it will become the basis of most antiseptic preparations for the future. From the statements of Pliny, it is plain that wood vinegar was the essential means employed by the ancient Egyptians in preparing their mummies, and that the odoriferous resins were of inferior consequence.

CURING OF PROVISIONS.

Flesh.—The ordinary means employed for preserving butcher meat are, drying, smoking, salting, and pickling or souring.

Drying of animal fibre.—The best mode of operating is as follows:—The flesh must be cut into slices from 2 to 6 ounces in weight, immersed in boiling water for 5 or 6 minutes, and then laid on open trellis-work in a drying-stove, at a temperature kept steadily about 122° F., with a constant stream of warm dry air. That the boiling water may not dissipate the soluble animal matters, very little of it should be used, just enough for the meat to be immersed by portions in succession, whereby it will speedily become a rich soup, fresh water being added only as evaporation takes place. It is advantageous to add a little salt, and some spices, especially coriander seeds, to the water. After the parboiling of the flesh has been completed, the soup should be evaporated to a gelatinous consistence, in order to fit it for forming a varnish to the meat after it is dried, which may be completely effected within two days in the oven. By this process two thirds of the weight is lost. The perfectly dry flesh must be plunged piece by piece in the fatty gelatinous matter liquefied by a gentle heat; then placed once more in the stove, to dry the layer of varnish. This operation may be repeated two or three times, in order to render the coat sufficiently uniform and thick. Butcher's meat dried in this way keeps for a year, affords, when cooked, a dish similar to that of fresh meat, and is therefore much preferable to salted provisions. The drying may be facilitated, so that larger lumps of flesh may be used, if they be imbued with some common salt immediately after the parboiling process, by stratifying them with salt, and leaving them in a proper pickling-tub for 12 hours before they are transferred to the stove. The first method, however, affords the more agreeable article.

Smoking.—This process consists in exposing meat previously salted, or merely rubbed over with salt, to wood smoke, in an apartment so distant from the fire as not to be unduly heated by it, and into which the smoke is admitted by flues at the bottom of the side walls. Here the meat combines with the empyreumatic acid of the smoke, and gets dried at the same time. The quality of the wood has an influence upon the smell and taste of the smoke-dried meat; smoke from beech wood and oak being preferable to that from fir and larch. Smoke from the twigs and berries of juniper, from rosemary, peppermint, &c., imparts somewhat of the aromatic flavor of these plants. A slow smoking with a slender fire is preferable to a rapid and powerful one, as it allows the empyreumatic principles time to penetrate into the interior substance, without drying the outside too much. To prevent soot from attaching itself to the provisions, they may be wrapped in cloth, or rubbed over with bran, which may be easily removed at the end of the operation.

The process of smoking depends upon the action of the wood acid, or the creosote volatilized with it, which operates upon the flesh. The same change may be produced in a much shorter time by immersing the meat for a few hours in pyroligneous acid, then hanging it up in a dry air, which, though moderately warm, makes it fit for keeping, without any taint of putrescence. After a few days exposure, it loses the empyreumatic smell, and then resembles thoroughly smoked provisions. The meat dried in this way is in general somewhat harder than by the application of smoke, and therefore softens less when cooked, a difference to be ascribed to the more sudden and concentrated operation of the wood vinegar, which effects in a few hours what would require smoking for several weeks. By the judicious employment of pyroligneous acid diluted to successive degrees, we might probably succeed in imitating perfectly the effect of smoke in curing provisions.

Salting.—The meat should be rubbed well with common salt, containing about one sixteenth of saltpetre, and one thirty-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.

Pickling with vinegar.—Vinegar dissolves or coagulates the albumen of flesh, and thereby counteracts its putrescence. The meat should be washed, dried, and then laid in strong vinegar. Or it may be boiled in the vinegar, allowed to cool in it, and then set aside with it in a cold cellar, where it will keep sound for several months.

Fresh meat may be kept for some months in water deprived of its air. If we strew on the bottom of a vessel a mixture of iron filings and flowers of sulphur, and pour over them some water which has been boiled, so as to expel its air, meat immersed in it will keep a long time, if the water be covered with a layer of oil, from half an inch to an inch thick. Meat will also keep fresh for a considerable period when surrounded with oil, or fat of any kind, so purified as not to turn rancid of itself, especially if the meat be previously boiled. This process is called potting, and is applied successfully to fish, fowls, &c.

Prechtl says that living fish may be preserved 14 days without water, by stopping their mouths with crumbs of bread steeped in brandy, pouring a little brandy into them, and packing them in this torpid state in straw. When put into fresh water, they come alive again after a few hours! *Prechtl, Encyclop. Technologisches, art. Faülniss Abhaltung.*

Eggs.—These ought to be taken new laid. The essential point towards their preservation is the exclusion of the atmospheric oxygen, as their shells are porous, and permit the external air to pass inwards, and to excite putrefaction in the albumen. There is also some oxygen always in the air-cell of the eggs, which ought to be expelled or rendered inoperative, which may be done by plunging them for 5 minutes in water heated to 140° F. The eggs must be then taken out, wiped dry, besmeared with some oil (not apt to turn rancid) or other unctuous matter, packed into a vessel with their narrow ends uppermost, and covered with sawdust, fine sand, or powdered charcoal. Eggs coated with gum arabic, and packed in charcoal, will keep fresh for a year. Lime water, or rather milk of lime, is an excellent vehicle for keeping eggs in, as I have verified by long experience. Some persons coagulate the albumen partially, and also expel the air by boiling the eggs for 2 minutes, and find the method successful. When eggs are intended for hatching, they should be kept in a cool cellar; for example, in a chamber adjoining an ice-house. Eggs exposed, in the holes of perforated shelves, to a constant current of air, lose about $\frac{3}{4}$ of a grain of their weight daily, and become concentrated in their albuminous part, so as to be little liable to putrefy. For long sea voyages, the surest means of preserving eggs, is to dry up the albumen and yolk, by first triturating them into a homogeneous paste, then evaporating this in an air-stove or a water-bath heated to 125°, and putting up the dried mass in vessels which may be made air-tight. When used, it should be dissolved in three parts of cold or tepid water.

Grain of all kinds, as wheat, barley, rye, &c., and their flour, may be preserved for an indefinite length of time, if they be kiln-dried, put up in vessels or chambers free from damp, and excluded from the air. Well dried grain is not liable to the depredations of insects.

To preserve fruits in a fresh state, various plans are adopted. Pears, apples, plums, &c. should be gathered in a sound state, altogether exempt from bruises, and plucked, in dry weather, before they are fully ripe. One mode of preservation is, to expose them in an airy place to dry a little for eight or ten days, and then to lay them in dry sawdust or chopped straw, spread upon shelves in a cool apartment, so as not to touch each other. Another method consists in surrounding them with fine dry sand in a vessel which should be made air-tight, and kept in a cool place. Some persons coat the fruit, including their stalks, with melted wax; others lay the apples, &c., upon wicker-work shelves in a vaulted chamber, and smoke them daily during 4 or 5 days with vine branches or juniper wood. Apples thus treated, and afterwards stratified in dry sawdust, without touching each other, will keep fresh for a whole year.

The drying of garden fruits in the air, or by a kiln, is a well-known method of preservation. Apples and pears of large size should be cut into thin slices. From 5 to 6 measures of fresh apples, and from 6 to 7 of pears, afford in general one measure of dry fruit, (biffins). Dried plums, grapes, and currants are a common article of commerce.

Herbs, cabbages, &c., may be kept a long time in a cool cellar, provided they are covered with dry sand. Such vegetables are in general preserved for the purposes of food, by means of drying, salting, pickling with vinegar, or beating up with sugar. Cabbages should be scalded in hot water previously to drying; and all such plants, when dried, should be compactly pressed together, and kept in air-tight vessels. 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 sirup, called a rob, in which so much of the water is dissipated as to prevent them from running into fermentation. The fruits must be crushed, squeezed in bags to expel the juices, which must then be inspissated either over the naked fire, or on a water or steam bath, in the air or in vacuo. Sometimes a small proportion of spices is added, which tends to prevent mouldiness. Such extracts may be conveniently mixed with sugar into what are called conserves.

Salting is employed for certain fruits, as small cucumbers or gherkins, capers, olives, &c. Even for peas such a method is had recourse to, for preserving them a certain time. They must be scalded in hot water, put up in bottles, and covered with saturated brine, having a film of oil on its surface, to exclude the agency of the atmospheric air. Before being used, they must be soaked for a short time in warm water, to extract the salt. The most important article of diet of this class, is the *sour kraut* of the northern nations of Europe (made from white cabbage), which is prepared simply by salting; a little vinegar being formed spontaneously by fermentation. The cabbage must be cut into small pieces, stratified in a cask along with salt, to which juniper berries and carui seeds are added, and packed as hard as possible by means of a wooden rammer. The cabbage is then covered with a lid, on which a heavy weight is laid. A fermentation commences, which causes the cabbage to become more compact, while a quantity of juice exudes and floats on the surface, and a sour smell is perceived towards the end of the fermentation. In this condition the cask is transported into a cool cellar, where it is allowed to stand for a year; and indeed, where, if well made and packed, it may be kept for several years.

The excellent process for preserving all kinds of butcher meat, fish, and poultry, first contrived by M. Appert in France, and afterwards successfully practised upon the great commercial scale by Messrs. Donkin and Gamble, for keeping beef, salmon, soups, &c. perfectly fresh and sweet for exportation from this country, as also turtle for importation thither from the West Indies, deserves a brief description.

Let the substance to be preserved be first parboiled, or rather somewhat more, the bones of the meat being previously removed. Put the meat into a tin cylinder, fill up the vessel with seasoned rich soup, and then solder on the lid, pierced with a small hole. When this has been done, let the tin vessel thus prepared be placed in brine and heated to the boiling point, to complete the remainder of the cooking of the meat. The hole of the lid is now to be closed perfectly by soldering, while 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. Mr. Gamble's turtle is delicious.

This preservative process is founded upon the fact, that the small quantity of oxygen contained within the vessel gets into a state of combination, in consequence of the high temperature to which the animal substances are exposed, and upon the chemical principle, that free oxygen is necessary as a ferment to commence or give birth to the process of putrefaction.

I shall conclude this article with some observations upon the means of preserving water fresh on sea voyages. When long kept in wooden casks, it undergoes a kind of putrefaction, contracts a disagreeable sulphurous smell, and becomes undrinkable. The influence of the external air is by no means necessary to this change, for it happens in close vessels even more readily than when freely exposed to the atmospherical oxygen. The origin of this impurity lies in the animal and vegetable juices which the water originally contained in the source from which it was drawn, or from the cask, or insects, &c. These matters easily occasion, with a sufficient warmth, fermentation in the stagnant water, and thereby cause the evolution of offensive gases. It would appear that the gypsum of hard waters is decomposed, and gives up its sulphur, which aggravates the disagreeable odor; for selenitic waters are more apt to take this putrid taint, than those which contain merely carbonate of lime.

As the corrupted water has become unfit for use merely in consequence of the 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 rightly calcined bone-black. The carbon takes away not only the finely diffused corrupt particles, but also the gaseous impurities. By adding to the water a very little sulphuric acid, about 30 drops to 4 pounds, Lowitz says that two thirds of the charcoal may be saved. Undoubtedly the sulphuric acid acts here, as in other similar cases, by the coagulation and separation of the albuminous matters, combining with them, and rendering them more apt to be seized by the charcoal. A more effectual agent for the purification of foul water is to be found in alum. A drachm of pounded alum should be dissolved with agitation in a gallon of the water, and then left to operate quietly for 24 hours. A sediment falls to the bottom, while the water becomes clear above, and may be poured off. The alum combines here with the substances dissolved in the water, as it does with the stuffs in the dyeing copper. In order to decompose any alum which may remain in solution, the equivalent quantity of crystals of carbonate of soda may be added to it.

The red sulphate of iron acts in the same way as alum. A few drops of its solution are sufficient to purge a pound of foul water. The foreign matters dissolved in the water, which occasion putrefaction, become insoluble, in consequence of oxydizement, like vegetable extractive, and are precipitated. On this account, also, foul water may be purified, by driving atmospheric air through it with bellows, or by agitating it in contact with fresh air, so that all its particles are exposed to oxygen. Thus we can explain the influence of streams and winds, in counteracting the corruption of water exposed to them. Chlorine acts still more energetically than the air in purifying water. A little aqueous chlorine added to foul water, or the transmission of a little gaseous chlorine through it, cleanses it immediately.

Water-casks ought to be charred inside, whereby no fermentable stuff will be extracted from the wood. British ships, however, are now commonly provided with iron tanks for holding their water in long voyages.

PYRITES, is the native bisulphuret of iron. Copper pyrites, called vulgarly mundick, is a bisulphuret of copper.

PYRO-ACETIC SPIRIT. (*Esprit pyro-acétique*, *Acétone*, Fr.; *Brennzlicher Essiggeist*, *Mesit*, Germ.) This liquid was discovered and described by Chenevix long before *pyroligneous spirit* was known. It may be obtained by subjecting to dry distillation the acetates of copper, lead, alkalis, and earths; and as it is formed especially during the second half of the process, the liquor which comes over then should be set apart, separated by decantation from the empyreumatic oil, and distilled a second time by the heat of a water-bath. The fine light fluid which now comes over first, is to be rectified along with carbonate of potassa, or chloride of calcium. As pyro-acetic spirit usually retains, even after repeated distillations, a disagreeable empyreumatic smell, like garlic, a little good bone-black should be employed in its final rectification. According to Reichenbach, pyro-acetic spirit may be extracted in considerable quantity from beech tar. (See the next article.) The spirit thus prepared is a colorless limpid liquid, of an acrid and burning taste at first, but afterwards cooling; of a penetrating aromatic smell, different from that of alcohol; of the spec. gravity 0·7921 at 60° F., boiling at 132° F., and remaining fluid at 5°. It consists ultimately of—carbon, 62·148; hydrogen, 10·453; oxygen, 27·329; or, of 1 proportion of carbonic acid + 2 prop. of olefiant gas + 1 prop. of water; or, 1 prop. of acetic acid — 1 prop. of carbonic acid. According to another view, it is composed of, 51·52 parts of concentrated acetic acid, and 48·488 of oil of wine, being double of the quantity in acetic ether. It is very combustible, and burns with a brilliant flame, without smoke. When treated by chlorine, it loses an atom of its hydrogen, and absorbs 2 atoms of chlorine. It is soluble in water, alcohol, ether, and is not convertible into ether by strong sulphuric acid. It is used for dissolving the resins commonly called gums, with which the bodies of hats are stiffened.

PYROLIGNEOUS ACID. In addition to what has been said under ACETIC ACID, I shall here describe the process as conducted upon a great scale at an establishment near Manchester. The retorts are of cast iron, 6 feet long, and 3 feet 8 inches in diameter. Two of these cylinders are heated by one fire, the flame of which plays round their sides and upper surface; but the bottom is shielded by fire-tiles from the direct action of the fire. 2 cwts. of coals are sufficient to complete the distillation of one charge of wood; 36 imperial gallons of crude vinegar, of specific gravity 1·025, being obtained from each retort. The process occupies 24 hours. The retort-mouth is then removed, and the ignited charcoal is raked out for extinction into an iron chest, having a groove round its edges, into which a lid is fitted.

When this pyroligneous acid is saturated with quicklime, and distilled, it yields one per cent. of pyroxilic spirit (sometimes called naptha); which is rectified by two or three successive distillations with quicklime.

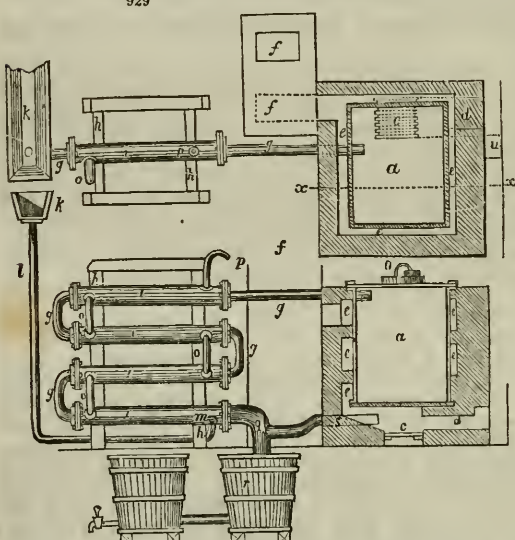
The tarry deposite of the crude pyroligneous acid, being subjected to distillation by itself, affords a crude pyro-acetic ether, which may also be purified by re-distillation with quicklime, and subsequent agitation with water.

The pyrolignite of lime is made by boiling the pyroligneous acid in a large copper, which has a sloping spout at its lip, by which the tarry scum freely flows over, as it froths up with the heat. The fluid compound thus purified is syphoned off into another copper, and mixed with a quantity of alum equivalent to its strength, in order to form the red liquor, or acetate of alumina, of the calico-printer. The acetate of lime, and sulphate of alumina and potash, mutually decompose each other; with the formation of sulphate of lime, which falls immediately to the bottom.

M. Kestner, of Thann, in Alsace, obtains, in his manufactory of pyroligneous acid, 5 hectolitres (112 gallons imperial, nearly) from a cord containing 93 cubic feet of wood. The acid is very brown, much loaded with tar, and marks 5° Baumé; 220 kilogrammes of charcoal are left in the cylinders; 500 litres of that brown acid produce, after several distillations, 375 of the pyroligneous acid of commerce, containing 7 per cent. of acid, with a residuum of 40 kilogrammes of pitch. For the purpose of making a crude acetate of lead (pyrolignite) he dries pyrolignite of lime upon iron plates, mixes it with the equivalent decomposing quantity of sulphuric acid, previously diluted with its own weight of water, and cooled; and transfers the mixture as quickly as possible into a cast-iron cylindric still, built horizontally in a furnace; the under half of the mouth of the cylinder being always cast with a semicircle of iron. The acetic acid is received into large salt-glazed stone bottles. From 100 parts of acetate of lime, he obtains 133 of acetic acid, at 38° Baumé. It contains always a little sulphurous acid from the reaction of the tar and the sulphuric acid.

The apparatus represented in *figs.* 929 and 930 is a convenient modification of that exhibited under acetic acid, for producing pyroligneous acid. *Fig.* 929 shows the furnace in a horizontal section drawn through the middle of the flue which leads to the chimney. *Fig.* 930 is a vertical section taken in the dotted line x, x, of *fig.* 929. 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 vapors and gaseous products from the iron chest to the condenser.

929



This consists of a series of pipes laid zigzag over each other, which rest upon a framework of wood. The condensing tubes are enclosed in larger pipes *i*, *i*; a stream of cold water being caused to circulate in the interstitial spaces between them. The water passes down from a trough *k*, through a conducting tube *l*, enters the lowest cylindrical case at *m*, flows thence along the series of jackets *i*, *i*, *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 vapors 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.* 929, in the brickwork of the furnace. About 60 per cent. of charcoal may be obtained from 100 feet of fir-wood, with a consumption of as much brush-wood for fuel.

Stoltze has ascertained, by numerous experiments, that one pound of wood yields from 6 to 7½ ounces of liquid products; but in acetic acid it affords a quantity varying from 2 to 5, according to the nature of the wood. Hard timber, which has grown slowly upon a dry soil, gives the strongest vinegar. White birch and red beech afford per pound 7⅓ ounces of wood vinegar, 1⅓ ounce of combustible oil, and 4 ounces of charcoal. One ounce of that vinegar saturates 110 grains of carbonate of potassa. Red pine yields per pound 6½ ounces of vinegar, 2¼ ounces of oil, 3¾ ounces of charcoal; but one ounce of the vinegar saturates only 44 grains of carbonate of potassa, and has therefore only two fifths of the strength of the vinegar from the birch. An ounce of the vinegar from the white beech, holly oak (*Ilex*), common ash, and horse chestnut, saturates from 90 to 100 grains of the carbonate. In the same circumstances, an ounce of the vinegar of the alder and white pine saturates from 58 to 60 grains.

PYROLIGNEOUS or PYROXILIC SPIRIT, improperly called naptha. This is employed, as well as pyro-acetic ether, to dissolve the sandarach, mastic, and other resinous substances, which, under the name of gums, are used for stiffening the bodies of hats. I have already described, in the article Pyroligneous Acid, how this spirit is obtained. Berzelius has found that the crude spirit may be best purified by agitating it with a fat oil, in order to abstract the empyreumatic oil; then to decant the spirit, distil it, first with fresh calcined charcoal, and next with chloride of calcium. The pyroligneous spirit, thus purified, is colorless, and limpid like alcohol; has an ethereous smell, somewhat resembling that of ants. Its taste is hot, and analogous to that of oil of peppermint. Its specific gravity, by my experiments, is 0·824. It readily takes fire, and burns with a blue flame, without smoke. It combines with water in any proportion; a property which distinguishes it from pyro-acetic ether and spirit.

It is not easy to say what is the real chemical nature of pyroxilic spirit. There is no ultimate analysis of it that can be depended upon. The properties of the spirit examined by MM. Marcet and Macaire, differ from those of our spirit, in refusing to combine with water, like alcohol. The article on sale in this country readily unites with water, and in all proportions with alcohol.

PYROMETER is the name of an instrument for measuring high degrees of heat above the range of the mercurial thermometer. Wedgewood's is the one commonly referred to by writers upon porcelain and metallurgy; but a better one might be easily contrived.

PYROPHORUS is the generic name of any chemical preparation, generally a powder, which inflames spontaneously when exposed to the air.

PYROTECHNY. See Fire-works.

PYROXILINE is a name which I have ventured to give to a substance detected in pyroxylic spirit, by Mr. Scanlan, while residing in Dublin, and therefore called by him *Eblanin*. I am indebted to that ingenious chemist for the following facts.

If potash water be added to raw wood-spirit (*pyroligneous*), as long as it throws down anything, a precipitate is produced, which is *pyroxiline*, mixed with tarry matter. This precipitate is to be collected on a filter cloth, and submitted to strong pressure between folds of blotting-paper; it is next to be washed with cold alcohol, spec. grav. 0·840, in order to free it from any adhering tarry matter; when the pyroxiline is left nearly pure. If it be dissolved in boiling alcohol, or hot oil of turpentine, it crystallizes regularly on cooling, in right square prisms, of a fine yellow color, that look opaque to the naked eye, but when examined under the microscope, have the transparency and color of ferroprussiate of potash. Its turpentine solution affords crystals of a splendid orange-red color, 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 color is only the effect of aggregation; for when ground to powder, these crystals become yellow; and under the microscope, the difference in color 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 vapor at 400°; it then begins to decompose, and is totally decomposed at 500°. Sulphuric acid decomposes it, producing a beautiful blue color, which passes into crimson, as the acid attracts water from the atmosphere, and it totally disappears on plentiful dilution with water, leaving carbon of a dirty-brown color. Its alcoholic or turpentine solution imparts a permanent yellow dye to vegetable or animal matter.

Pyroxiline consists, according to the analysis of Drs. Apjohn and Gregory, of—carbon, 75·275; hydrogen, 5·609; oxygen, 19·116, in 100 parts.

Q.

QUARTATION is the alloying of one part of gold that is to be refined, along with three parts of silver, so that the gold shall constitute one *quarter* of the whole, and thereby have its particles too far separated to be able to protect the other metals originally associated with it, such as silver, copper, lead, tin, palladium, &c., from the action of the nitric or sulphuric acid employed in the subsequent parting process. See REFINING.

QUARTZ has been described in the article LAPIDARY.

QUASSIA is the wood of the root of the *Quassia excelsa*, a tree which grows in Surinam, the East Indies, &c. It affords to water an intensely bitter decoction, which is occasionally used in medicine, and was formerly substituted by some brewers for hops, but is now prohibited under severe penalties. It affords a safe and efficacious fly-water, or poison for flies.

QUEEN'S WARE. See POTTERY.

QUEEN'S YELLOW is an ancient name of Turbith Mineral, or yellow subsulphate of mercury.

QUERCITRON is the bark of the *Quercus nigra*, or yellow oak, a tree which grows in North America. The coloring 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.

QUININA. This medicine is now prepared in such quantities as to constitute a chemical manufacture. Quinina and cinchonina are two vegetable alkalis, which exist in Peruvian bark or cinchona; the pale or gray bark contains most cinchonina, and the yellow bark most quinina. The methods of extracting these bases are very various. In general, water does not take them out completely, because it transforms the neutral salts in the barks into more soluble acidulous salts, and into less soluble sub-salts. To exhaust the bark completely, one or other of the following solvents is employed:

1. *Alcohol.*—An extract by this menstruum, is to be treated with very dilute warm muriatic acid, in order to dissolve everything thus soluble; the acid liquor is to be saturated with magnesia, by boiling it with an excess of this earth; the precipitate is to be dried, filtered, and then exhausted by boiling-hot alcohol.

2. *Dilute acids.*—Boil the bark, coarsely pounded, with eight times its weight of water, containing 5 per cent. of the weight of the bark of sulphuric acid. This treatment is to be repeated with a fresh quantity of dilute acid. The whole liquors must be filtered, the residuum strained, and the solution mixed with quicklime, equal to one fourth of the bark employed. This mixture, after having been well stirred, is to be strained, whenever it acquires an alkaline reaction, that is, tinges reddened litmus paper blue, or turmeric brown. The calcareous mass is to be now washed with a little water, and dried, and then boiled thrice with spirit of wine of spec. grav. 0·836. This solution being filtered, is to be mixed with a little water, and distilled. The bases, cinchonina and quinina, remain under the form of a brown viscid mass, and must be purified by subsequent crystallization, after being converted into sulphates.

3. *An alkali, and then an acid.*—The object of this process is, to retain the vegetable alkalis in the bark, while with the alkaline water we dissolve out the acids, the coloring matters, the extractive, the gum, &c. Boil for an hour one pound of the bark with six pounds of water, adding by degrees a little solution of potash, so that the liquor may have still an alkaline taste when the boiling is over. Allow it to cool, filter, wash the residuum with a little water, and squeeze it. Diffuse it next in tepid water, to which add by degrees a little muriatic acid, till after a prolonged digestion the mixture shall perceptibly redden litmus paper. Filter the liquor, and boil it with magnesia. The precipitate being washed and dried, is to be treated with hot alcohol, which dissolves the quinina and cinchonina.

Obtained by any of the above methods, the quinina and cinchonina are more or less colored, and may be blanched by dissolving them in dilute muriatic acid, and treating the solution with animal charcoal.

There are several methods of separating these two vegetable alkalis.

1. When their solution in spirit of wine is evaporated by heat to a certain point, the greater part of the cinchonina crystallizes on cooling, while the quinina remains dissolved

2. Digestion in ether dissolves the quinina, and leaves the cinchonina.

3. We may supersaturate slightly the two bases with sulphuric acid. Now as the supersulphate of quinina is sparingly soluble, the liquor need only to be evaporated to a proper point to crystallize out that salt, while the supersulphate of cinchonina continues in solution with very little of the other salt. Even this may be separated by precipitating the bases, and treating them, as above prescribed, with alcohol or ether.

One pound of bark rarely yields more than 2 drachms of the bases. One pound of red bark afforded, to Pelletier and Caventou, 74 grains of cinchonina, and 107 grains of quinina.

Quinina is composed of 75·76 carbon, 7·52 hydrogen, 8·11 azote, and 8·61 oxygen.

The salts of quinina are distinguished by their strong taste of Peruvian bark, and if crystallized, by their pearly lustre. Most of them are soluble in water, and some also in ether and alcohol. The soluble salts are precipitated by the oxalic, gallic, and tartaric acids, and by the salts of these acids. Infusion of nutgalls also precipitates them.

The sulphate of quinina is the only object of manufacturing operations. Upon the brownish viscid mass obtained in any of the above processes for obtaining quinina, pour very dilute sulphuric acid, in sufficient quantity to produce saturation. The solution must be then treated with animal charcoal, filtered, evaporated, allowed to cool, when it deposites crystals. 1000 parts of bark afford, upon an average, 12 parts of sulphate. The sulphate of cinchonina, which is formed at the same time, remains dissolved in the mother-waters.

The neutral sulphate of quinina occurs in small transparent right prismatic needles. By spontaneous evaporation of their solution, larger crystals may be procured. They contain $24\frac{2}{3}$ per cent. of water; and, therefore, melt when exposed to heat. They dissolve in 11 parts of water at ordinary temperatures; are much more soluble in hot spirit of wine, somewhat dilute, than in cold; and are nearly insoluble in anhydrous alcohol. If they be well dried, they possess the property of becoming luminous when heated a little above the boiling point of water, especially when they are rubbed. The sulphate is, in this case, charged with vitreous electricity.

There is a sub-sulphate, but it is applied to no use. The effloresced sulphate, called by some bisulphate, is preferred for medical practice. The extensive sale and high price of sulphate of quinina, have given rise to many modes of adulteration. It has been mixed with boracic acid, margaric acid, sugar, sugar of manna, gypsum, &c. By incinerating a little of the salt upon a slip of platina, the boracic acid and gypsum remain, while the quinine is dissipated; sugar and margaric acid exhale their peculiar smoke and smell; or they may be dissolved out by a few drops of water. Cinchonina may be detected by adding ammonia to the solution, and treating the precipitate with ether, which leaves that vegeto-alkali.

QUINTESSENCE. The alchemists understood by this term, now no longer in scientific use, the solution in alcohol of the principles which this menstruum can extract from aromatic plants or flowers, by digestion, during some days, in the sun, a stove, or upon a sand-bath slightly warmed. A quintessence, therefore, corresponds to the alcoholic tincture or essence (not essential oil) of the present day. See PERFUMERY.

R.

RAISINS, are grapes allowed to ripen and dry upon the vine. The best come from the south of Europe, as from Roquevaire in Provence, Calabria, Spain, and Portugal. Fine raisins are also imported from Smyrna, Damascus, and Egypt. Sweet fleshy grapes are selected for maturing into raisins, and such as grow upon the sunny slopes of hills sheltered from the north winds. The bunches are pruned, and the vine is stripped of its leaves, when the fruit has become ripe; the sun then beaming full upon the grapes, completes their saccharification, and expels the superfluous water. The raisins are plucked, cleansed, and dipped for a few seconds in a boiling ley of wood ashes and quicklime, at 12 or 13 degrees of Baumé's areometer. The wrinkled fruit is lastly drained, dried, and exposed in the sun upon hurdles of basket-work during 14 or 15 days.

The finest raisins are those of the sun, so called; being the plumpest bunches, which are left to ripen fully upon the vine, after their stalks have been half cut through.

The amount of raisins imported for home consumption was, in the year 1836, 156,495 cwts.; in 1837, 152,635 cwts.

RAPE-SEED, imported for home consumption in 1836, 561,457 bushels; in 1837, 937,526 bushels. See OILS, UNCTUOUS.

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 flavoring 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 flavored, when cold, with spirit of *noyau,* made by distilling water off the bruised bitter kernels of apricots, and mixing it with alcohol. Sirup of bay laurel and galango are also added.

REALGAR, *Red Orpiment.* (*Arsenic rouge sulphuré,* 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, at Solfaterra near Naples; or sublimed in the shape of stalactites, in the rents and craters of Etna, Vesuvius, and other volcanoes. Its spec. grav. varies from 3·3 to 3·6. It has a fine scarlet color in mass, but orange-red in powder, whereby it is distinguishable from cinnabar. It is soft, sectile, readily scratched by the nail; its fracture is vitreous and conchoidal. It volatilizes easily before the blowpipe, emitting the garlic smell of arsenic, along with that of burning sulphur. It consists of, arsenic 70, sulphur 30, in 100 parts. It is employed sometimes as a pigment. Factitious orpiment is made by distilling, in an earthen retort, a mixture of sulphur and arsenic, of orpiment and sulphur, or of arsenious acid, sulphur, and charcoal. It has not the rich color of the native pigment, and is much more poisonous; since, like factitious orpiment, it always contains more or less arsenious acid.

RECTIFICATION, is a second distillation of alcoholic liquors, to free them from whatever impurities may have passed over in the first.

RED LIQUOR, is a crude acetate of alumina, employed in calico-printing, and prepared from pyroligneous acid; which see.

REED, is the well-known implement of the weaver, made of parallel slips of metal or reeds, called dents. A thorough knowledge of the adaption 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 $\frac{1}{4}$, $\frac{4}{4}$, $\frac{5}{4}$, $\frac{6}{4}$; 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 a hundred.

In Lancashire and Cheshire a different mode is adopted, both as to the measure and divisions of the reed. The Manchester and Bolton reeds are counted by the number of splits, or, as they are there called, dents, contained in $24\frac{1}{4}$ inches of the reed. These dents, instead of being arranged in hundreds, porters, and splits, as in Scotland, are calculated by what is there termed *hares* or *bears,* each containing 20 dents, or the same number as the porter in the Scotch reeds. The Cheshire or Stockport reeds, again, receive their designation from the number of ends or threads contained in one inch, two ends being allowed for every *dent,* that being the almost universal number in every species and description of plain cloth, according to the modern practice of weaving, and also for a great proportion of fanciful articles.

The number of threads in the warp of a web is generally ascertained with considerable precision by means of a small magnifying glass, fitted into a socket of brass, under which is drilled a small round hole in the bottom plate of the standard. The number of threads visible in this perforation, ascertains the number of threads in the standard measure of the reed. Those used in Scotland have sometimes four perforations, over any one of which the glass may be shifted. The first perforation is $\frac{1}{4}$ 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; and thus the quality of the fabric may be ascertained with considerable precision, even after the cloth has undergone repeated wettings, either at the bleaching-ground or dye-work. By counting the other way, the proportion which the woof bears to the warp is also known, and this forms the chief use of the glass to the manufacturer and operative weaver, both of whom are previously acquainted with the exact measure of the reed.

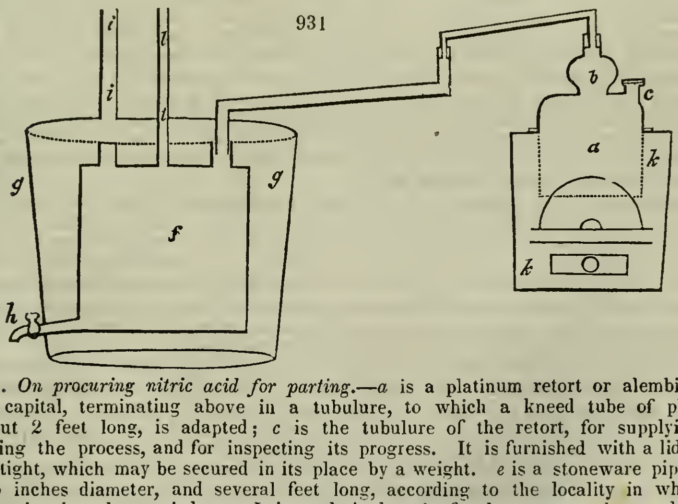
Comparative TABLE of 37-inch reeds, being the standard used throughout Europe, for linens, with the Lancashire and Cheshire reeds, and the foreign reeds used for holland and cambric.

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 also been adopted as the regulator of her cotton manufactures.

REFINING OF GOLD AND SILVER; called also *Parting*. (*Affinage d'argent*, *Départ*, Fr.; *Scheidung in die quart*, Germ.) For several uses in the arts, these precious metals are required in an absolutely pure state, in which alone they possess their malleability and peculiar properties in the most eminent degree. Thus, for example, neither gold nor silver leaf can be made of the requisite fineness, if the metals contain the smallest portion of copper alloy. Till within these ten or twelve years, the parting of silver from gold was effected everywhere by nitric acid; it is still done so in all the establishments of this country, except the Royal Mint; and in the small refining-houses abroad. The following apparatus may be advantageously employed in this operation. It will serve the double purpose of manufacturing nitric acid of the utmost purity, and of separating silver from gold by its means.

931



1. *On procuring nitric acid for parting.*—*a* is a platinum retort or alembic; *b* is its capital, terminating above in a tubulure, to which a kneed tube of platinum, about 2 feet long, is adapted; *c* is the tubulure of the retort, for supplying acid during the process, and for inspecting its progress. It is furnished with a lid ground air-tight, which may be secured in its place by a weight. *e* is a stoneware pipe, about two inches diameter, and several feet long, according to the locality in which the operation is to be carried on. It is made in lengths fitted to one another, and secured at the joints with loam-lute. The one bend of this earthenware hard salt-glazed pipe is adapted to receive the platinum tube, and the other bend is inserted into a tubulure in the top of the stoneware drum *f*. The opening *l*, *l*, in the middle of the top of *f*, is

for inspecting the progress of the condensation of acid; and the third tubulure terminates in a prolonged pipe *i*, *i*, consisting of several pieces, each of which enters from above conically into the one below. The joinings of the upper pieces need not be tightly luted, as it is desirable that some atmospherical oxygen should enter, to convert the relatively light nitrous gas into nitrous or nitric acid vapor, which when supplied with moisture will condense and fall down in a liquid state. To supply this moisture in the most diffusive form, the upright stoneware pipes *i*, *i*, *l*, *l*, (at least 3 inches diameter, and 12 feet high), should be obstructed partially with flint nodules, or with silicious pebbles; and water should be allowed to trickle upon the top pebble from a cistern placed above. Care must be taken to let the water drop so slowly as merely to preserve the pebbles in a state of humidity. *h* is a stopcock, of glass or stoneware, for drawing off the acid from the cistern *f*. *k* is a section of a small air-furnace, covered in at top with an iron ring, on which the flat iron ring of the platinum frame rests.

g, *g*, is a tub in which the stoneware cistern stands, surrounded with water, kept constantly as cold as possible by passing a stream through it; the spring water entering by a pipe that dips near to the bottom, and the hot water escaping at the upper edge.

With the above apparatus, the manufacture of pure nitric acid is comparatively easy and economical. Into the alembic *a*, 100 pounds (or thereby) of pure nitre, coarsely bruised if the crystals be large, are to be put; the capital is then to be adapted, and the platinum tube (the only moveable one) luted into its place. Twenty pounds of strong sulphuric acid are now to be introduced by the tubulure *c*, and then its lid must be put on. No heat must yet be applied to the alembic. In about an hour, another ten pounds of acid may be poured in, and so every hour, till 60 pounds of acid have been added. A few hours after the affusion of the last portion of acid, a slight fire may be kindled in the furnace *k*.

By judicious regulation of the heat, the whole acid may be drawn off in 24 hours; its final expulsion being aided by the dexterous introduction of a quart or two of boiling water, in small successive portions, by the tubulure *c*, whose lid must be instantly shut after every inspersion. The most convenient strength of acid for the parting process, is when its specific gravity is about 1·320, or when a vessel that contains 16 ounces of pure water, will contain 21⅛ of the aquafortis. To this strength it should be brought very exactly by the aid of a hydrometer.

Its purity is easily ascertained by letting fall into it a few drops of solution of silver; and if no perceptible milkiness ensues, it may be accounted good. Should a white cloud appear, a few particles of silver may be introduced, to separate whatever muriatic acid may be present, in the form of chloride of silver. Though a minute quantity of sulphuric acid should exist in the nitric, it will be of no consequence in the operation of parting.

2. *On parting by the nitric acid, called by the Mexicans, "Il apartado."*—The principle on which this process is founded, is the fact of silver being soluble in nitric acid, while gold is insoluble in that menstruum. If the proportion of gold to that of silver be greater than one to two, then the particles of the former metal so protect or envelop those of the latter, that the nitric acid, even at a boiling heat, remains quite inactive on the alloy. It is indispensable, therefore, that the weight of the silver be at least double that of the gold. 100 pounds of silver take 38 pounds of nitric acid, of specific gravity 1·320, for oxydizement, and 111 for solution of the oxyde; being together 149; but the refiner often consumes, in acid of the above strength, more than double the weight of silver, which shows great waste, owing to the imperfect means of condensation employed for recovering the vapors of the boiling and very volatile acid.

By the apparatus above delineated, the 38 pounds of acid expended in oxydizing the silver, become nitrous gas in the first place, and are afterwards reconverted in a great measure into nitric acid by absorption of atmospherical oxygen; so that not one fifth need be lost, under good management. As the acid must be boiled on the granulated *garble*, or alloy, to effect the solution of the silver, by proper arrangements the vapors may be entirely condensed, and nearly the whole acid be recovered, except the 111 parts indispensable to constitute nitrate of silver. Hence, with economical management, 120 pounds of such acid may be assigned as adequate to dissolve 100 of silver associated with 50 of gold.

It must here be particularly observed, that 100 pounds of copper require 130 pounds of the above acid for oxydizement; and 390 for solution of the oxyde; being 520 pounds in whole, of which less than ¼ part could be recovered by the above apparatus. It is therefore manifest that it is desirable to employ silver pretty well freed from copper by a previous process; and always, if practicable, a silver containing some gold.

These data being assumed as the bases of the parting operation, 60 pounds of gold and silver alloy or *garble* finely granulated, containing not less than 40 pounds of silver, are to be introduced into the ten-gallon alembic of platinum, *fig.* 931, and 80 pounds of nitric acid, of 1·320, is to be poured over the alloy; a quantity which will measure 6 gallons imperial. As for the bulk of the alloy, it is considerably less than half a gallon. Abundance of space therefore remains in the alembic for effervescence and ebullition, provided the fire be rightly tempered.

By the extent of stoneware conducting pipe *e*, which should not be less than 40 feet, by the dimensions and coldness of the cistern *f*, and by the regenerating influence of the vertical aerial pipe filled with moist pebbles *i*, *i*, it is clear, that out of the 80 pounds of nitric acid, specific gravity 1·320, introduced at first, from 20 to 30 will be recovered.

Whenever the effervescence and disengagement of nitrous red fumes no longer appear on opening the orifice *c*, the fire must be removed, and the vessel may be cooled by the application of moist cloths. The alembic may be then disengaged from the platinum tube, and lifted out of its seat. Its liquid contents must be cautiously decanted off, through the orifice *c*, into a tub nearly filled with soft water. On the heavy pulverulent gold which remains in the vessel, some more acid should be boiled, to carry off any residuary silver. This metallic powder, after being well washed with water, is to be dried, fused along with a little nitre or borax, and cast into ingots.

Plates of copper being immersed in the nitric solution contained in wooden or stoneware cisterns, will throw metallic silver down, while a solution of nitrate of copper, called blue water, will float above. The pasty silver precipitate is to be freed from the nitrate of copper, first, by washing with soft water, and next, by strong hydraulic pressure in cast iron cylinders. The condensed mass, when now melted in a crucible along with a little nitre and borax, is fine silver.

The above apparatus has the further advantage of enabling the operator to recover a great portion of his nitric acid, by evaporating the blue water to a state approaching to dryness, with the orifices at *c*, and at the top of the capital, open. In the progress of this evaporation, nothing but aqueous vapor escapes. Whenever the whole liquid is dissipated, the pipe *d* is to be re-adjusted, and the lid applied closely to *c*. The heat being now continued, and gradually increased, the *whole* nitric acid will be expelled from the copper oxyde, which will remain in a black mass at the bottom of the alembic. The contrivance for letting water trickle upon the pebbles, must be carefully kept in play, otherwise much of the evolved acid would be dissipated in nitrous fumes. With due attention to the regenerative plan, a great part of the acid may be recovered, at no expense but that of a little fuel.

The black oxyde of copper thus obtained, is an economical form of employing that metal for the production of the sulphate; 100 pounds of it, with 122½ of sulphuric acid diluted with water, produce 312½ pounds of crystallized sulphate of copper. A leaden boiler is best adapted for that operation. 100 pounds of silver are precipitable from its solution in nitric acid, by 29 of copper. If more be needed, it is a proof that a wasteful excess of acid has existed in the solution.

In parting by nitric acid, the gold generally retains a little silver; as is proved by the cloud of chloride of silver which it affords, at the end of some hours, when dissolved in aqua regia. And on the other hand, the silver retains a little gold. These facts induced M. Dizé, when he was inspector of the French mint, to adopt some other process, which would give more accurate analytical results; and after numerous experiments, he ascertained that sulphuric acid presented great advantages in this point of view, since with it he succeeded in detecting, in silver, quantities of gold which had eluded the other plan of parting. The suggestion of M. Dizé has been since universally adopted in France. M. Costell, about nine or ten years ago, erected in Pomeroy-street, Old Kent-road, a laboratory upon the French plan, for parting by sulphuric acid; but he was not successful in his enterprise; and since he relinquished the business, Mr. Matheson introduced the same system into our Royal Mint, under the management of M. Costell's French operatives. In the Parisian refineries, gold, to the amount of one thousandth part of the weight, has been extracted from all the silver which had been previously parted by the nitric acid process; being 3500 francs in value upon every thousand kilogrammes of silver.

I shall give first a general outline of the method of parting by sulphuric acid, and then describe its details as I have lately seen them executed upon a magnificent scale in an establishment near Paris.

The most suitable alloy for refining gold, by the sulphuric acid process, is the compound of gold, silver, and copper, having a standard quality, by the cupel, of from 900 to 950 milliėmes, and containing one fifth of its weight of gold. The best proportions of the three metals are the following:—silver, 725; gold, 200; copper, 75; = 1000. It has been found that alloys which contain more copper, afford solutions that hold some anhydrous sulphate of that metal in solution, which prevents the gold from being readily separated; and that alloys containing more gold, are not acted on easily by the sulphuric acid. The refiner ought, therefore, when at all convenient, to reduce the alloys that he has to treat to the above-stated proportions. He may effect this purpose either by fusing the coarser alloys with nitre in a crucible, or by adding finer alloy, or even fine silver, or finally, by subjecting the coarser alloys to a previous cupellation with lead on the great scale. As to gold or silver bullion, which contains lead and other easily oxydizable metals besides copper, the refiner ought always to avoid treating them by sulphuric acid; and should separate, first of all, these foreign metals by the agency of nitre, if they exist in minute quantity; but if in larger, he should have recourse to the cupel. Great advantage will therefore be derived from the judicious preparation of the alloy to be refined.

For an alloy of the above description, the principal Parisian refiners are in the habit of employing thrice its weight of sulphuric acid, in order to obtain a clear solution of sulphate of silver, which does not too suddenly concrete on cooling, so as to obstruct its discharge from the alembic by decantation. A small increase in the quantity of copper, calls for a considerable increase in the quantity of acid.

Generally speaking, one half of the sulphuric acid strictly required for converting the silver and copper into sulphates, is decomposed into sulphurous acid, which is lost to the manufacturer, unless he has recourse to the agency of nitrous acid.

The process for silver containing but little gold, consists of five different operations.

1. Upon several furnaces, one foot in diameter, egg-shaped alembics of platinum are mounted, into each of which are put 3 kilogrammes (8 lbs. troy) of the granulated silver, containing a few grains of gold per pound, and 6 kilogrammes of concentrated sulphuric acid. The alembics are covered with conical capitals, ending in bent tubes, which conduct the acid vapors into lead pipes of condensation; and the furnaces are erected under a proper hood. As the cold acid is inoperative, it must be set a boiling, at which temperature it gives up one atom of its oxygen to the metal, and is transformed into sulphurous acid, which escapes in a gaseous state. Some of the undecomposed sulphuric acid immediately combines with the oxyde into a sulphate, which subsides, in the state of a crystalline powder, to the bottom of the vessel. The solution goes on vigorously, with a copious disengagement of sulphurous acid gas, only during the two or three first hours; after which it proceeds slowly, and is not completed till after a digestion of nearly twelve hours more. During the ebullition a considerable quantity of sulphuric acid vapor escapes along with the sulphurous acid gas; the former of which is readily condensed in a large leaden receiver immersed in a cistern of cold water, if need be. It has been proposed to condense the sulphurous acid, by leading it over extensive surfaces of lime-pap, as in the coal-gas purifiers.

2. When the whole silver has been converted into sulphate, this is to be emptied out of the alembic into water contained in a round-bottomed receiver lined with lead, and diluted till the density of the solution marks from 15° to 20° Baumé. The small portion of gold, in the form of a brown powder, which remains undissolved, having been allowed to settle to the bottom, the supernatant solution of silver is to be decanted carefully off into a leaden cistern, and the powder being repeatedly edulcorated with water, the washings are to be added to it. The silver is now to be precipitated by plunging plates of copper in the solution, and the magma which falls is to be well washed, and freed from the residuary particles of sulphate of copper by powerful compression.

3. The silver, precipitated and dried as above described, is melted in a crucible, and cast into an ingot.

4. The gold powder is also dried and cast into an ingot, a little nitre being added in the fusion, to oxydize and separate any minute particles of copper that may perchance have been protected from the solvent action of the acid.

5. As the sulphate of copper is of considerable value, its solution is to be neutralized, evaporated in leaden pans to a proper strength, and set aside to crystallize in leaden cisterns. The farmers throughout France consume an immense quantity of this salt. They sprinkle a weak solution of it (at 2° or 3° Baumé) over their grain before sowing it, in order to protect it against the ravages of birds and insects.

The pure gold, at the instant of its separation from the alloy by the action of sulphuric acid, being in a very fine powder, and lying in close contact with the platinum, under the influence of a boiling menstruum, which brightens the surfaces of the two metals, and raises their temperature to fully the 600th degree of Fahrenheit's scale, tends to become partially soldered to the platinum, and may thus progressively thicken the bottom of the still. The importance of preserving this vessel entire, and of economizing the fuel requisite to heat its contents, induces the refiner to detach the crust of gold from time to time, by passing over the bottom of the still, in small quantities, a dilute nitro-muriatic acid, which acts readily on gold, but not on platinum. But as this operation is a very delicate one, it must be conducted with great circumspection. The danger of such adhering deposites is much increased by using too high a heat, and too small a body of acid, relatively to the metals dissolved. Hence it is advantageous to employ alembics of large size. Should any lead or tin get into the platinum still, while the hot acid is in it, the precious vessel would be speedily destroyed; an accident which has not unfrequently happened. Each operation may be conveniently finished in twelve hours;

so that each alembic may refine with ease 160 marcs daily. Some persons work more rapidly, but such haste is hazardous.

The Parisian refiners restore to the owners the whole of the gold and silver contained in the ingots, reserving to themselves the copper which formed the alloy, and charging only the sum of 5½ francs per kilogramme (2·68 lbs. troy) for the expense of the parting of the metals.

If they are employed to refine an ingot of silver containing less than one tenth of gold, they retain for themselves a two thousandth part of the gold, and all the copper, existing in the alloy; return all the rest of the gold, with the whole of the silver, in the ingot; and give, besides, to the owners a *premium* or *bonus*, which amounted lately to ¾ of a franc on the kilogramme of metal. Should the owner desire to have the whole of the gold and silver contained in his ingot, the refiner then demands from him 2 francs and 68 centimes per kilogramme, retaining the copper of the alloy. As to silver ingots of low standard, the perfection of the refining processes is such, that the mere copper contained in them pays all the costs; for in this case, the refiner restores to the proprietor of the ingot as much fine silver as the assay indicated to exist in the ingot, contenting himself with the copper of the alloy. See *infrà*.

The chemical works of M. Poizat, called *affinage d'argent*, on the bank of the *canal de l'Ourcq*, in the vicinity of Paris, are undoubtedly the most spacious and best arranged for refining the precious metals, which exist in the world. On being introduced to this gentleman, by my friend and companion M. Clement-Desormes, he immediately expressed his readiness to conduct me through his *fabrique*, politely alluding to the French translation of my Dictionary of Chemistry, which lay upon the desk of his *bureau*. The principal room is 240 feet long, 40 feet wide, and about 30 feet high. A lofty chimney rises up through the middle of the apartment, and another at each of its ends. The one space, 120 feet long, to the right of the central chimney, is allotted to the processes of dissolving the silver, and parting the gold; the other, to the left, to the evaporation and crystallization of the sulphate of copper, and the concentration of the recovered sulphuric acid.

M. Poizat melts his great masses of silver in pots made of malleable iron, capable of holding several cwts. each; and granulates it by pouring it into water contained in large iron pans. The granulated silver is dried with heat, and carried into a well lighted office enclosed by glazed casements, to be weighed, registered, and divided into determinate portions. Each of these is put into a cast-iron pot, of a flattened hemispherical shape, about 2 feet in diameter, covered with an iron lid, made in halves, and hinged together in the middle line. From the top of the fixed lid a bent pipe issues, and proceeds downwards into an oblong leaden chest sunk beneath the floor. Four of the above cast-iron pots stand in a line across the room, divided into two ranges, with an intervening space for passing between them. The bottoms of the pots are directly heated by the flame, one fire serving for two pots. Two parts of concentrated sulphuric acid by weight are poured upon every part of granulated silver, and kept gently boiling till the whole silver be converted into a pasty sulphate.

From the underground leaden chests, a leaden, pipe 4 inches in diameter, rises vertically, and enters the side of a leaden chamber, which is supported upon strong cross-beams or rafters, a little way beneath the roof of the apartment. This chamber, which is 30 feet long, 10 feet wide, and 6 feet high, is intended to condense the sulphuric acid vapors, along with some of the sulphurous acid; that of the latter being promoted by the admission of nitrous gas and air, which convert it into sulphuric acid. From the further end of this chamber, a large square leaden pipe returns with a slight slope towards the middle of the room, and terminates at the right-hand side of the central chimney, in a small leaden chest, for receiving the drops of acid which are condensed in the pipe. From that chest a pipe issues, to discharge into the high central chimney the incondensable gases, and also to maintain a constant draught through the whole series of leaden chambers back to the cast-iron hemispherical pots.

Besides the above cast-iron pots, destined to dissolve only the coarse cupreous silver, containing a few grains of gold per pound, there are, in the centre of the apartment, at the right-hand side of the chimney, 6 alembics of platinum, in which the rich alloys of gold and silver are treated in the process of refining gold.

The pasty sulphate of silver obtained in the iron pots, is transferred by cast-iron ladles with long handles into large leaden cisterns, adjoining the pots, and there diluted with a little water to the density of 36° Baumé. Into this liquor, steam is admitted through a series of upright leaden pipes arranged along the side of the cistern, which speedily causes ebullition, and dilutes the solution eventually to the 22d degree of Baumé. In this state, the liquid supersulphate is run off by leaden syphons into large oblong leaden cisterns, rounded at the bottom; and is there exposed to the action of ribands of copper, like thin wood shavings. The metallic silver precipitates in a pasty form; and the supernatant sulphate of copper is then run off into a cistern, upon a somewhat lower level, where it is left to settle and become clear.

The precipitate of silver, called by the English, water-silver, and by the French, *chaux d'argent*, is drained, then strongly squeezed in a square box of cast-iron, by the action of a hydraulic press; in which 60 pounds of silver are operated upon at once.

The silver lumps are dried, melted in black lead crucibles, in a furnace built near the silver end of the room, where the superintendent sits in his *bureau*—a closet enclosed by glazed casements, like a green-house. The whole course of the operations is so planned, that they are made to commence near the centre with the mixed metals, and progressively approach towards the office end of the apartment as the parting processes advance. Here the raw material, after being granulated and weighed, was given out, and here the pure gold and silver are finally eliminated in a separate state.

In the other half of the hall, the solutions of sulphate of copper are evaporated in large shallow leaden pans, placed over a range of furnaces; from which, at the proper degree of concentration, they are run off by syphons into crystallizing pans of the same metal. From the mother-waters, duly evaporated, a second crop of crystals is obtained; and also a third, the last being anhydrous, from the great affinity for water possessed by the strong sulphuric acid with which they are now surrounded. The acid in this way parts with almost the whole of the cupreous oxyde, and is then transferred into a large alembic of platinum (value 1000*l.*), to be rendered fit, by re-concentration, for acting upon fresh portions of granulated silver. The capital of that alembic is connected with a leaden worm, which traverses an oblong vessel, through which a stream of cold water flows.

The crystallized sulphate of copper fetched, two years ago, 30*l.* a ton. It is almost all sold to the grocers in the towns of the agricultural districts of France. In the above establishment of M. Poizat, silver to the value of 10,000*l.* can be operated upon daily.

There is a steam engine of 6-horse power placed in a small glazed chamber at one side of the parting hall, which serves to work all his leaden pumps for lifting the dilute sulphuric acid and acidulous solutions of copper into their appropriate cisterns of concentration, as also to grind his old crucibles, and drive his amalgamation mill, consisting of a pair of vertical round-edged wheels, working upon one shaft, in a groove formed round a central hemisphere—of cast-iron. After the mercury has dissolved out of the ground crucibles all the particles of silver which it can find, the residuary earthy matter is sold to the *sweep-washers*. The floor of the hall around the alembics, pots, and cisterns, is covered with an iron grating, made of bars having one of their angles uppermost, to act as scrapers upon the shoes of the operatives. The dust collects in a vacant space left beneath the grating, whence it is taken to the amalgamation mill. The processes are so well arranged and conducted by M. Poizat, that he can execute as much business in his establishment with 10 workmen as is elsewhere done with from 40 to 50; and with less than 3 grains of gold, in one Paris pound or 7561 grains of silver, he can defray the whole expenses of the parting or refining.

Since 26 parts of copper afford 100 of the crystallized sulphate, the tenth of copper present in the dollars, and most foreign coins, will yield nearly four times its weight of blue vitriol; a subsidiary product of considerable value to the refiner.

The works of M. Poizat are so judiciously fitted up as to be quite salubrious, and have not those "very mischievous effects upon the trachea," which Mr. Matheson states as being common in his refinery works in the Royal Mint.* But, in fact, as refining by sulphuric acid is always a nuisance to a neighborhood, it is not suffered in the *Monnaie Royale* of Paris; but is best and most economically performed by private enterprise and fair competition, which is impossible in London, on account of the anomalous privilege, worth at least 2000*l.* a year, possessed by Mr. Matheson, who works most extensively for private profit on a public plant, fitted up with a lofty chimney, platinum vessels to the value of 3000*l.*, and other apparatus, at the cost of the government. His charge to the crown for refining gold per lb. troy, is 6*s.* 6*d.*; that of the refiners in London, who are obliged, for fear of prosecution, to employ the more expensive, but more condensable, nitric acid, is only 4*s.* That of the Parisian refiners is regulated as follows. For the dealers in the precious metals: —

For gold bullion containing silver, and more than $\frac{100}{1000}$ of gold, 6 fr. 12 c. per kilogramme, = 2 fr. 29 c. per lb. troy.

For silver bullion, containing from $\frac{1}{1000}$ to $\frac{100}{1000}$ of gold (called *dorés*), 3 fr. 27 c. per kilogramme, = 1 fr. 22 c. per lb. troy.

For the *Monnaie*, the charges are—

For gold refined by sulphuric acid, when alloyed with copper only, from $\frac{898}{1000}$ to $\frac{1}{1000}$, 5 fr. per kilogramme, = 1 fr. 86 c. per lb. troy.

For gold alloyed with copper and silver, whatever be the quantity of silver, 5 fr. 75 c. per kilogramme, = 2 fr. 12 c. per lb. troy.

* Report of Committee of House of Commons on the Mint, in 1837, p. 91.

There are about ten bullion refiners by sulphuric acid in the environs of Paris; two of whom, M. Poizat St. André, and M. Chauvière, are by far the most considerable; the former working about 300 kilogrammes (= 804 lbs. troy) daily, and the latter about two thirds of that quantity. In former times, when competition was open in London, Messrs. Browne and Brinde were wont to treat 6 cwts. of silver, or 9 cwts. of gold alloy, daily, for several months in succession.

The result of *free trade* in refining bullion at Paris is, that the silver bars imported into London from South America, &c., are mostly sent off to Paris to be stripped of the few grains of gold which they may contain, and are then brought back to be sold here. Three grains of gold in one Paris lb. of silver, pay the refiners there for taking them out. What a disgrace is thus brought upon our manufacturing industry and skill, by the monopoly charges in refining and assaying granted to two individuals in our Royal Mint.

Mr. Bingley's charges for assaying at the Royal Mint in London, are—

For an assay of gold, 4*s.*; for a parting assay of gold and silver, 6*s.*; for a silver assay, 2*s.* 6*d.*—charges which absorb the profits of many a transaction.

The charges at the Royal Mint of Paris, for assays made under the following distinguished chemical *savants*—Darcet, *Directeur*; Bréant, *Verificateur;* Chevillot and Pelouze, *Essayeurs*; are—

For an assay of gold, or *doré* (a parting assay), 3 francs.

— silver — — 0· 80 c. = 8*d.* English.

M. Gay Lussac is the assayer of the *Bureau de Garantie* at the *Monnaie Royale*, an office which corresponds to the Goldsmiths' Hall at London. The silver assays in all the official establishments of Europe, except the two in London, are made by the *humid* method, and are free from those errors and blunders which daily annoy and despoil the British bullion merchant, who is compelled by the Mint and Bank of England to buy and sell by the *cupellation* assay of Mr. Bingley. See Assay and Silver.

REFRIGERATION OF WORTS, &c. In August, 1826, Mr. Yandall obtained a patent for an apparatus designed for cooling worts and other hot fluids, without exposing them to evaporation. Utensils employed for this purpose, are generally called refrigerators, and are so constructed, that a quantity of cold water shall be brought in contact with the vessel which contains the heated fluid. But in every construction of refrigerator heretofore used, the quantity of cold water necessarily employed in the operation, greatly exceeded the quantity of the fluid cooled, which, in some situations, where water cannot be readily obtained, was a serious impediment and objection to the use of such apparatus.

The inventor has contrived a mode of constructing a refrigerator, so that any quantity of wort or other hot fluid may be cooled by an equal quantity of cool water; the process being performed with great expedition, simply by passing the two fluids through very narrow passages, in opposite directions, the result of which is, that the cold liquor imbibes the heat from the wort, or other fluid, and the temperature of the hot fluid is reduced in the same ratio.

Figs. 932, 933, and 934 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.

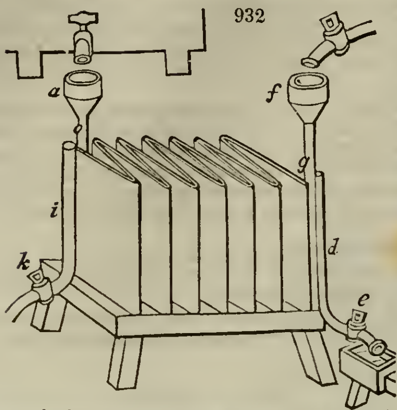
Fig. 935 is the section of a portion of the apparatus shown at *figs.* 932 and 933 upon an enlarged scale; it is made by connecting three sheets of copper or any other thin metallic plates together, leaving parallel spaces between each plate for the passage of the fluids, represented by the black lines.

These spaces are formed by occasionally introducing between the plates thin straps, ribs, or portions of metal, by which means very thin channels are produced, and through these channels the fluids are intended to be passed, the cold liquor running in one direction, and the hot in the reverse direction.

Supposing that the passages for the fluids are each one eighth of an inch thick, then the entire length for the run of the fluid should be about 80 feet, the breadth of the apparatus being made according to the quantity of fluid intended to be passed through it in a given time. If the channels are made a quarter of an inch thick, then their length should be extended to 160 feet; and any other dimensions in similar proportions; but a larger channel than one quarter of an inch, the patentee considers would be objectionable. It is, however, to be observed, that the length here recommended, is under the consideration, that the fluids are driven through the apparatus by some degree of hydrostatic pressure from a head in the delivery-vats above; but if the fluids flow without pressure, then the lengths of the passages need not be quite so great.

In the apparatus constructed as shown in perspective at *fig.* 932, and further developed by the section, *fig.* 935, 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.* 935), 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* (see *fig.* 935), and from thence proceeds horizontally into the discharge-pipe *i*.

932

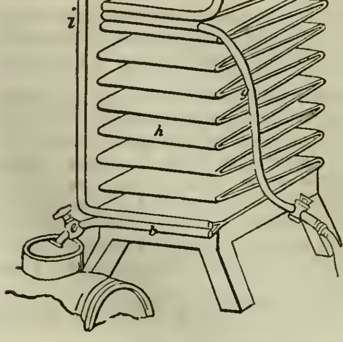


The two cocks *e* and *k*, being now opened, the wort or other liquor is drawn off, or otherwise conducted away through the cock *k*, and the water through *e*. If the apertures of the two cocks *e* and *k* are equal, and the channels equal also, it follows that the same quantity of wort, &c., will flow 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. 933 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.* 935), 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.

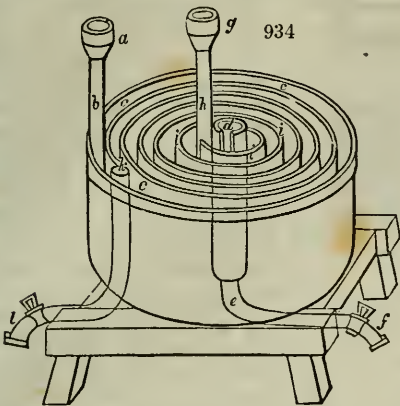
933



The passages of this apparatus for heating and cooling fluids, may be bent into various contorted figures; one form found particularly convenient under some applications, is that represented at *fig.* 934, which is contained in a cylindrical case. The passages here run in convolute curves, the one winding in a spiral to the centre, the other receding from the centre.

The wort or other hot liquor intended to be cooled, is to be introduced at the funnel *a*, and passing down the pipe *b*, is delivered into the open passage *c*, which winds round to the central chamber *d*, and is thence discharged through the pipe *e*, at the cock *f*. The cold water enters the apparatus at the funnel *g*, and proceeding down the pipe *h*, enters the closed channel *i*, and after traversing round through the apparatus, is in like manner discharged through the pipe *k*, at the cock *l*. Or the hot liquor may be passed through the closed channel, and the cold through the open one; or these chambers may be both of them open at top, and the apparatus covered by a lid when at work, the principal design of which is to afford the convenience of cleaning them more readily than could be done if they were closed; or they may be both closed.

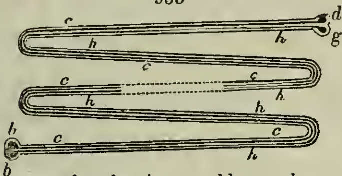
934



A similar ingenious apparatus for cooling brewer's 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.

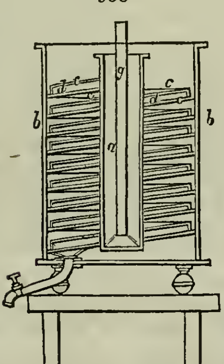
Fig. 936 represents the external appearance of the refrigerator, enclosed in a cylindrical case; *fig*. 937, the same, one half of the case being removed to show the form of the apparatus within; and *fig*. 938, a section cut through the middle of the apparatus perpendicularly, for the purpose of displaying the internal figure of the spiral channels.

935

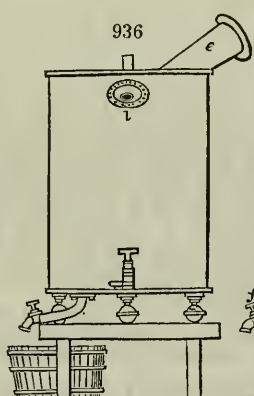


The apparatus is proposed to be made of sheet copper, tinned on its surface, and is formed by cutting circular pieces of thin copper, or segments of circles, and connecting them together by rivets, solder, or by any other convenient means, as coppersmiths usually do; these circular pieces of copper being 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.

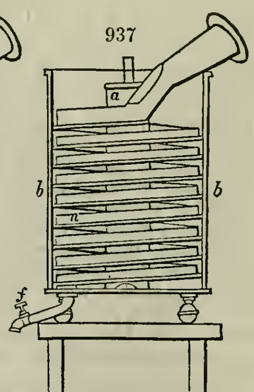
938



936



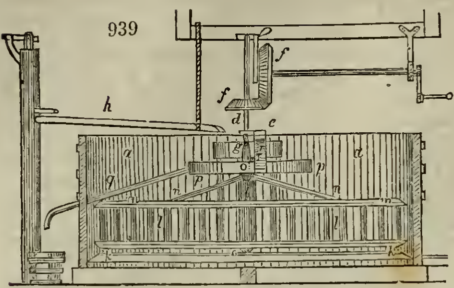
937



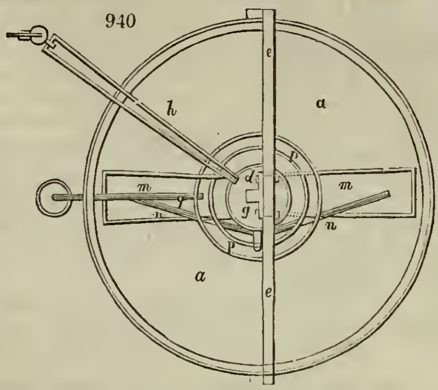
In *figs*. 937 and 938, *a*, *a*, is the central tube or standard (of any diameter that may be found convenient), round which the spiral chambers are to be formed; *b*, *b*, are the sides of the outer case, to which the edges of the spiral fit closely, but need not be attached; *c*, *c*, are two of the 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 *h*, between the coils of the chamber, until it ascends to the top of the vessel, and then it flows away by a spout *i*, seen in *fig.* 936.

939



940



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 temperatures 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.

Fig. 939 is a side view and section of Wagenmann's apparatus for cooling worts; *fig.* 940, a view from above. The preceding contrivances seem to be far preferable.

a, *a*, is the tub for receiving the apparatus, whose central upright shaft *b*, rests upon a step *c*, in the bottom, and revolves at top in a bush at *d*, made fast to a bar *e*, fixed flat across the mouth of the tub. The shaft may be driven by the two bevel wheels *f*, *f*, at right angles to each other, and the horizontal rod turned by hand; or the whole may be impelled by any power. *g*, is an iron basin for receiving the cold water from the spout *h*, supplied by a well; it flows out of the basin through two tubes *i i*, down into the lower part of the cooler *k k*. The cooler consists of two flat vessels, both of which are formed of a flat interior plate, and an arched exterior one, so that their transverse section is plano-convex. The water which flows along the tubes *i i*, spreads itself upon the bottom of the cooler, and then rises through the scabbard-shaped tubes *l l*, &c., into the upper annular vessel *m m*; whence it is urged by hydrostatic pressure, in a now heated state, through the slanting tubes *n n*, which terminate in the common pipe *o*, of the annular basin *p p*, and is thence discharged by the pipe *q*. The basin *p p*, is supported by the two bearers *r*, made fast to the cross-beam *e*. There is in the lowest part of the hollow ring at bottom, a screw plug, which may be opened when it is desired to discharge the whole contents, and to wash it with a stream of water.

REGULUS is a term introduced by the alchemists, now nearly obsolete. It means literally a little king, and refers to the metallic state as one of royalty, compared with the native earthy condition. Antimony is the only metal now known by the name of regulus.

RESINS (*Résines*, Fr.; *Harze*, Germ.), are proximate principles found in most vegetables, and in almost every part of them; but the only resins which merit a particular description, are those which occur naturally in such quantities as to be easily collected or extracted. They are obtained chiefly in two ways, either by spontaneous exudation from the plants, or by extraction by heat and alcohol. In the first case, the discharge of resin in the liquid state is sometimes promoted by artificial incisions made in summer through the bark into the wood of the tree.

Resins possess the following general properties:—They are soluble in alcohol, insoluble in water, and melt by the application of heat, but do not volatilize without partial decomposition. They have rarely a crystalline structure, but, like gums, they seldom affect any peculiar form. They are almost all translucid, not often colorless, but generally brown, occasionally red or green. Any remarkable taste or smell which they sometimes possess, may be ascribed to some foreign matter, commonly an essential oil. Their specific gravity varies from 0·92 to 1·2. Their consistence is also very variable. The greater part are hard, with a vitreous fracture, and so brittle as to be readily pulverized in the coal. Some of them are soft, a circumstance probably dependant 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 carbureted gases, empyreumatic oil of a less disagreeable smell than that emitted by other such oils, a little acidulous water, and a very little shining charcoal. See Rosin Gas.

Resins are insoluble in water, but dissolve in considerable quantities in alcohol, both hot and cold. This solution reddens tincture of litmus, but not sirup of violets; it is decomposed by water, and a milkiness ensues, out of which the particles of the resin gradually agglomerate. In this state it contains water, so as to be soft, and easily kneaded between the fingers; but it becomes hard and brittle again when freed by fusion from the water. The resins dissolve in ether and the volatile oils, and, with the aid of heat, combine with the unctuous oils. They may be combined by fusion with sulphur, and with a little phosphorus. Chlorine water bleaches several colored resins, if they be diffused in a milky state through water. The carburet of sulphur dissolves them.

Resins are little acted upon by acids, except by the nitric, which converts them into artificial tan. They combine readily with the alkalis and alkaline earths, and form what were formerly reckoned soaps: but the resins are not truly saponified; they rather represent the acid constitution themselves, and, as such, saturate the salifiable bases.

Every resin is a natural mixture of several other resins, as is the case also with oils; one principle being soluble in cold alcohol, another in hot, a third in ether, a fourth in oil of turpentine, a fifth in naptha, &c. The soft resins, which retain a certain portion of volatile oil, constitute what are called balsams. Certain other balsams contain benzoic acid. The solid resins are, *amber*, *anime*, *benzoin*, *colophony* (common rosin), *copal*, *dammara*, *dragon's blood*, *elemi*, *guaiac*, *lac*, resin of *jalap*, *ladanum*, *mastic*, *sandarach*, *storax*, *takamahac*.

RESIN, KAURI or COWDEE, is a new and very peculiar substance, recently imported in considerable quantities from New Zealand, which promises to be useful in the arts. It oozes from the trunk of a noble tree called *Dammara australis*, or *Pinus kauri*, which rises sometimes to the height of 90 feet without a branch, with a diameter of 12 feet, and furnishes a log of heart timber of 11 feet. The resin, which is called Cowdee gum by the importers, is brought to us in pieces varying in size from that of a nutmeg to a block of 2 or 3 cwts. The color varies from milk-white to amber, or even deep brown; some pieces are transparent and colorless. In hardness it is intermediate between copal and resin. The white milky pieces are somewhat fragrant, like elemi. Specific gravity, 1·04 to 1·06. It is very inflammable, burns all away with a clear bright flame, but does not drop. When cautiously fused, it concretes into a transparent hard tough mass, like shellac. It affords a fine varnish with alcohol, being harder and less colored than mastic, while it is as soluble, and may be had probably at one tenth of the price. A solution in alcohol, mixed with one fourth of its bulk of a solution in oil of turpentine, forms an excellent varnish, which dries quickly, is quite colorless, clear and hard. It is insoluble in pyro-acetic (pyroxilic ?) spirit. Combined with shellac and turpentine, it forms a good sealing-wax.

REVERBERATORY FURNACE; see Copper, Iron, and Soda.

RETORT. For producing coal gas, there are many modifications, varying in dimension and shape with the caprice of the constructor, and in many cases without any definite idea of the principle to be aimed at.

They may be divided into three general classes:

1st. The circular retort, from twelve to twenty inches in diameter, and from six to nine feet in length. This retort is used in Manchester and some other places, in general for the distillation of cannel, or Scotch parrot coal. It answers for the distillation of a coal which retains its form in lumps, and is advantageous only from the facility with which its position is changed, when partially destroyed by the action of fire on the under side.

2d. The small or London D retort, so called in consequence of its having first been used by the chartered company in London, being still in use at their works, and recommended by their engineer. This retort is 12 inches broad on the base, 11 inches high, and 7 feet long, carbonizing one and a half to two bushels at a charge.

3d. The York D retort, (so called in consequence of its having been introduced by Mr. Outhit, of York,) and the modifications of it, among which I should include the elliptic retort, as having the same general purpose in view. The difference between the London and York D retorts, consists only in an extension of surface upon which the coal is spread. See GAS-LIGHT.

RHODIUM, is a metal discovered by Dr. Wollaston in 1803, in the ore of platinum. It is contained to the amount of three per cent. in the platinum ore of Antioquia in Colombia, near Barbacoas; it occurs in the Ural ore, and, alloyed with gold, in Mexico. The palladium having been precipitated from the muriatic solution of the platinum ore previously saturated with soda, by the cyanide of mercury, muriatic acid is to be poured into the residuary liquid, and the mixture is to be evaporated to dryness, to expel the hydrocyanic acid, and convert the metallic salts into chlorides. The dry mass is to be reduced to a very fine powder, and washed with alcohol of specific gravity 0·837. This solvent takes possession of the double chlorides which the sodium forms with the 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 color. This salt being washed with alcohol, and then exposed to a very strong heat, affords the rhodium. But a better mode of reducing the metal upon the small scale, consists in heating the double chloride gently in a glass tube, while a stream of hydrogen passes over it, and then to wash away the chloride of sodium with water.

Rhodium resembles platinum in appearance. Any heat which can be produced in a chemical furnace is incapable of fusing it; and the only way of giving it cohesive solidity, is to calcine the sulphuret or arseniuret of rhodium in an open vessel at a white heat, till all the sulphur or arsenic be expelled. A button may thus be obtained, somewhat spongy, having the color and lustre of silver. According to Wollaston, the specific gravity of rhodium is 11. It is insoluble by itself in any acid; but when an alloy of it with certain metals, as platinum, copper, bismuth, or lead, is treated with aqua regia, the rhodium dissolves along with the other metals; but when alloyed with gold or silver it will not dissolve along with them. It may, however, be rendered very soluble by mixing it in the state of a fine powder with chloride of potassium or sodium, and heating the mixture to a dull-red heat, in a stream of chlorine gas. It thus forms a triple salt, very soluble in water. The solutions of rhodium are of a beautiful rose color, whence its name. In the dry way, it dissolves by heat in bisulphate of potassa; and disengages sulphurous acid gas in the act of solution. There are two oxydes of rhodium. Rhodium combines with almost all the metals; and, in small quantity, melted with steel, it has been supposed to improve the hardness, closeness, and toughness of this metal. Its chief use at present is for making the inalterable nibs of the so-named rhodium pens.

RIBAND MANUFACTURE, is a modification of WEAVING, which see.

RICE, of Carolina, analyzed by Braconnot, was found to be composed of starch 85·07, of gluten 3·60, of gum 0·71, of uncrystallizable sugar 0·29, of a colorless rancid fat like suet 0·13, of vegetable fibre 4·8, of salts with potash and lime bases 0·4, and 5·0 of water.

The quantity of rice entered for home consumption in the year 1836, was—

Cwts.	81,610.	In 1837, 126,739.
Ditto in the husk, Bushels	292,444.	282,377.

Rice Paper, as it is called, on which the Chinese and Hindoos paint flowers so prettily, is a membrane of the bread-fruit tree, the *Artocarpus incisifolia* of naturalists.

RICE CLEANING. Various machines have been contrived for effecting this purpose, of which the following, secured by patent to Mr. Melvil Wilson, in 1826, may be regarded as a good specimen. It consists of an oblong hollow cylinder, laid in an inclined position, having a great many teeth stuck in its internal surface, and a central shaft also furnished with teeth. By the rapid revolution of the shaft, its teeth are carried across the intervals of those of the cylinder with the effect of parting the grains of rice, and detaching whatever husks or impurities may adhere to them. A hopper is set above to receive the rice, and conduct it down into the cleansing cylinder.

About 80 teeth are supposed to be set in the cylinder, projecting so as to reach very nearly the central shaft; in which there is a corresponding number of teeth, that pass freely between the former.

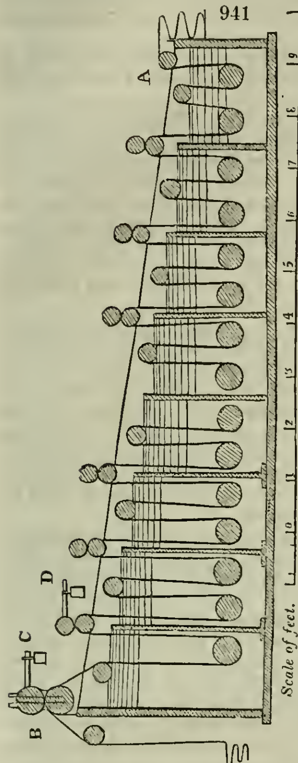
The cylinder is shown inclined in the figure which accompanies the specification; but it may be placed also upright or horizontal, and may be mounted in any convenient frame-work. The central shaft should be put in rapid rotation, while the cylinder receives a slow motion in the opposite direction. The rice, as cleaned by that action, is discharged at the lower end of the cylinder, where it falls into a shute (shoot), and is conducted to the ground. The machine may be driven by hand, or by any other convenient power.

Rice consists chiefly of starch, and therefore cannot by itself make a proper bread. It is used in the cotton factories to form weavers' dressings for warps. The Chinese reduce its flour into a pulp with hot water, and mould it into figures and plates, which they afterwards harden, and ornament with engravings, resembling those of mother-of-pearl. When a decoction of rice is fermented and distilled, it affords the sort of ardent spirit called *arrack* in the East Indies.

RIFLE; see FIRE-ARMS.

RINSING MACHINE is one of those ingenious automatic contrivances for economizing labor, and securing uniformity of action, now so common in the factories of Lancashire. *Fig.* 941 is a longitudinal middle section of an approved mechanism for rinsing pieces of calico dyed with spirit or fancy colors, and which require more delicate treatment than is compatible with hand-washing. A, E, F, B, is a wooden cistern, about 12 feet long, 4 feet high at one end, 2 feet at the other, and of the ordinary width of calico cloth. It is divided transversely into a series of equal compartments by partitions, decreasing in height from the upper to the lower end, the top of each of them, however, being an inch at least under the top of the enclosing side at its line of junction. Above the highest end of the trough, a pair of squeezing rollers is mounted at B; the lower one having a pulley upon the end of its shaft, for turning it, by means of a band from one of the driving-shafts of the factory; and the upper one is pressed down upon it by weighted levers acting on the ends of its axis. The roller above the second highest partition has also a pair of squeezing rollers, with a weighted lever D. The pieces of cloth, stitched endwise, being laid upon a platform to the right hand of the cistern, are introduced over the roller A, passed down under the roller beneath it, and so up and down in a serpent-like path, from the lowest compartment of the cistern to the uppermost, being drawn through the series by the traction of the rotatory roller at B. While the long web is thus proceeding upwards from A to B, a stream of pure water is made to flow along in the opposite direction from B to A, running over the top of each partition in a thin sheet. By this contrivance, the goods which enter at A, having much loose color upon their surface, impregnate the water strongly, but as they advance they continually get cleaner by the immersion, and pressure of the successive rollers, being exposed to purer water, till at last they reach the limpid stream, and are discharged at B perfectly bright. The rinsing operation may be modified by varying the quantity of water admitted, the speed with which the pieces are drawn through the cells, or the pressure upon the series of top rollers.

941



ROCKETS. M. de Montgery, captain of a frigate in the French service, has written a *Traité sur les Fusées de Guerre*, in which he discusses the merits of the Congreve rockets, and describes methods of imitating them. As the subject of military projectiles is foreign to this Dictionary, I refer my readers to the above work, which is commended by the editor of the *Dictionnaire Technologique*.

ROLLING-MILL. See IRON, MINT, and PLATED MANUFACTURE.

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 equably supplied, and that they always enter the twisted parts by their ends, and never by their middle. As soon as he has reached the termination of the walk, a second spinner takes the yarn off the whirl, and gives it to another person to put upon a reel, while he himself attaches his own hemp to the whirl hook, and proceeds down the walk. When the person at the reel begins to turn, the first spinner, who has completed his yarn, holds it firmly at the end, and advances slowly up the walk, while the reel is turning, keeping it equally tight all the way, till he reaches the reel, where he waits till the second spinner takes his yarn off the whirl hook, and joins it to the end of that of the first spinner, in order that it may follow it on the reel.

The next part of the process previous to tarring, is that of warping the yarns, or stretching them all to one length, which is about 200 fathoms in full-length rope-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. In this process, great care must be taken that the tar is boiling neither too fast nor too slow. Yarn for cables requires more tar than for hawser-laid ropes; and for standing and running rigging, it requires to be merely well covered. Tarred cordage has been found to be weaker than what is untarred, when it is new; but the tarred rope is not so easily injured by immersion in water.

The last part of the process of rope-making, is to lay the cordage. For this purpose two or more yarns are attached at one end to a hook. The hook is then turned the contrary way from the twist of the individual yarn, and thus forms what is called a strand. Three strands, sometimes four, besides a central one, are then stretched at length, and attached at one end to three contiguous but separate hooks, but at the other end to a single hook; and the process of combining them together, which is effected by turning the single hook in a direction contrary to that of the other three, consists in so regulating the progress of the twists of the strands round their common axis, that the three strands receive separately at their opposite ends just as much twist as is taken out of them by their twisting the contrary way, in the process of combination.

Large ropes are distinguished into two main classes, the *cable-laid* and *hawser-laid.* The former are composed of nine strands, namely, three great strands, each of these consisting of three smaller secondary strands, which are individually formed with an equal number of primitive yarns. A cable-laid rope eight inches in circumference, is made up of 333 yarns or threads, equally divided among the nine secondary strands. A *hawser-laid* rope consists of only three strands, each composed of a number of primitive yarns, proportioned to the size of the rope; for example, if it be eight inches in circumference, it may have 414 yarns, equally divided among three strands. Thirty fathoms of yarn are reckoned equivalent in length to eighteen fathoms of rope cable-laid, and to twenty fathoms hawser-laid. Ropes of from one inch to two inches and a half in circumference are usually hawser-laid; of from three to ten inches, are either hawser or cable-laid; but when more than ten inches, they are always cable-laid.

Every hand-spinner in the dock-yard is required to spin, out of the best hemp, six threads, each 160 fathoms long, for a quarter of a day's work. A hawl of yarn, in the warping process, contains 336 threads.

The following are Captain Huddart's improved principles of the rope manufacture:—

1. To keep the yarns separate from each other, and to draw them from bobbins revolving upon skewers, so as to maintain the twist while the strand or primary cord is forming.

2. To pass them through a register, which divides them by circular shells of holes; the number in each concave shell being conformable to the distance from the centre of the strand, and the angle which the yarns make with a line parallel to it, and which gives them a proper position to enter.

3. To employ a tube for compressing the strand, and preserving the cylindrical figure of its surface.

4. To use a gauge for determining the angle which the yarns in the outside shell make with a line parallel to the centre of the strand, when registering; because according to the angle made by the yarns in this shell, the relative lengths of all the yarns in the strand will be determined.

5. To harden up the strand, and thereby increase the angle in the outside shell; which compensates for the stretching of the yarns, and the compression of the strands.

A great many patents have been obtained, and worked with various degrees of success, for making ropes. Messrs. Cartwright, Fothergill, Curr, Chapman, Balfour, and Huddart, have been the most conspicuous inventors in this country; but the limits of this work preclude us doing justice to their respective merits.

All the improvements in the manufacture of cordage at present in use, either in her Majesty's yards or in private rope-grounds, owe their superiority over the old method of making cordage to Captain Huddart's invention of the register plate and tube.

Mr. Balfour took out a patent for the manufacture of cordage about a month before Captain Huddart; but the formation of his strand was to be accomplished by what he called a top minor (in the form of a common top, with pins to divide the yarns), which upon trial could not make cordage so good as by the common mode. On seeing Captain Huddart's specification, Mr. Balfour, five years after, procured another patent, in which he included a plate and tube, but which was not sufficiently correct, and experience in the navy proved the insufficiency of the cordage. Captain Huddart's plate and tube were then adopted in the king's yards, and he gave his assistance for the purpose.

Captain Huddart then invented and took a patent for a machine, which by registering the strand at a short length from the tube, and winding it up as made, preserved a uniformity of twist, or angle of formation, from end to end of the rope, which cannot be accomplished by the method of forming the strands down the ground, where the twist is communicated from one end to the other of an elastic body upwards of 300 yards in length. This registering-machine was constructed with such correctness, that when some were afterwards required, no alteration could be made with advantage by the most skilful and scientific mechanic of that day, Mr. Rennie. Thus the cold register was carried to the greatest perfection.

A number of yarns cannot be put together in a cold state, without considerable vacancies, into which water may gain admission; Captain Huddart, therefore, formed the yarns into a strand immediately as they came from the tar-kettle, which he was enabled to do by his registering-machine, and the result was most satisfactory. This combination of yarns was found by experiment to be 14 per cent. stronger than the cold register; it constituted a body of hemp and tar impervious to water, and had great advantage over any other cordage, particularly for shrouds, as after they were settled on the mast-head, and properly set up, they had scarcely any tendency to stretch, effectually secured the mast, and enabled the ship to carry the greatest press of sail.

In order more effectually to obtain correctness in the formation of cables and large cordage, Captain Huddart constructed a laying-machine, which has carried his inventions in rope-making to the greatest perfection, and which, founded on true mathematical principles, and the most laborious calculations, is one of the noblest monuments of mechanical ability since the improvement of the steam-engine by Mr. Watt. By this machine, the strands receive that degree of twist only which is necessary, and are laid at any angle with the greatest regularity; the pressure is regulated to give the required elasticity, and all parts of the rope are made to bear equally. In no one instance has a rope or cable thus formed been found defective in the lay, or stiff, or difficult to coil.

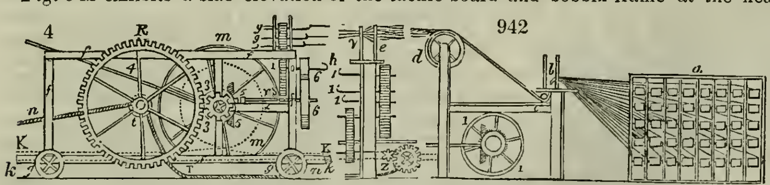
Such a revolution in the manufacture of cordage could not be accomplished without great expense, as the works at Limehouse fully testify; and considerable opposition necessarily arose. Captain Huddart's first invention was, however, generally adopted, as soon as the patent expired; and experience has established the great importance of his subsequent improvements.

His cordage has been supplied in large quantities to her Majesty's navy, and has received the most satisfactory reports.

The following description of one of the best modern machines for making ropes on Captain Huddart's plan, will gratify the intelligent reader.

Fig. 942 exhibits a side elevation of the tackle-board and bobbin-frame at the head

942



of the ropery, and also of the carriage or rope-machine in the act of hauling out and twisting the strands.

Fig. 943 is a front elevation of the carriage.

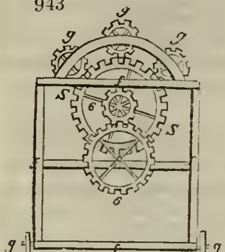
Fig. 944 is a yarn-guide, or board, or plate, with perforated holes for the yarns to pass through before entering the nipper.

Figs. 945 and 946 are side and front views of the nipper for pressing the rope-yarns.

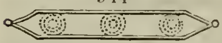
a is the frame for containing the yarn bobbins. The yarns are brought from the frame, and pass through a yarn-guide at *b*. *c* is a small roller, under which the rope-yarns pass; they are then brought over the reel *d*, and through another yarn-guide *e*, after which they enter the nippers at *v*, and 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.

943



944



946

945

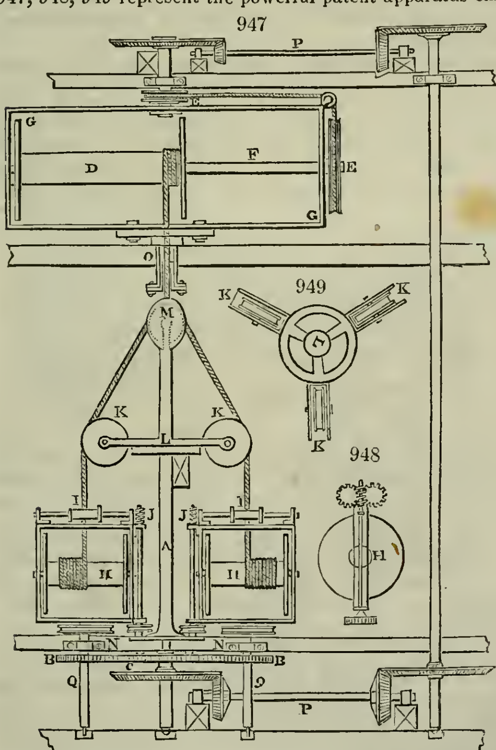
The carriage is drawn out in the following manner. On the end of the shaft of *m*, *m*, is the pinion 3, which, working in the large wheel R, gives motion to the ground-rope shaft upon its axis. In the centre of this shaft is a curved pulley or drum *t*, round which the ground-rope takes one turn. This rope is fixed at the head and foot of the ropery; so that when the machinery of the carriage is set a-going by the endless rope *k*, *k*, and gives motion to the ground-rope shaft, as above described, the carriage will necessarily move along the railway; and the speed may be regulated either by the diameter of the circle formed by the gubs on the wheel *m*, *m*, or by the number of teeth in the pinion 3. At 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.

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 and 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 three-inch strap-laid rope. The spinning is still performed by hand, being found not only to be more economical, but also to make a smoother thread, than has yet been effected by machinery. Various ways have been tried for preparing the yarns for tarring. That which seems now to be most generally in use, is, to warp the yarns upon the stretch as they are spun. This is accomplished by having a wheel at the foot, as well as the head of the walk, so that the men are able to spin both up and down, and also to splice their threads at both ends. By this means, they are formed into a haul, resembling the warp of a common web, and a little turn is hove into the haul, to preserve it from getting foul in the tarring. The advantages of warping from the spinners, as above, instead of winding on winches, as formerly, are, 1st, the saving of this last operation altogether; 2dly, the complete check which the foreman has of the quantity of yarn spun in the day; 3dly, that the quality of the work can be subjected to the minutest inspection at any time. In tarring the yarn, it is found favorable 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, would actually 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 $\frac{2}{3}$ds to $\frac{3}{4}$ths 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.* 947, 948, 949 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.



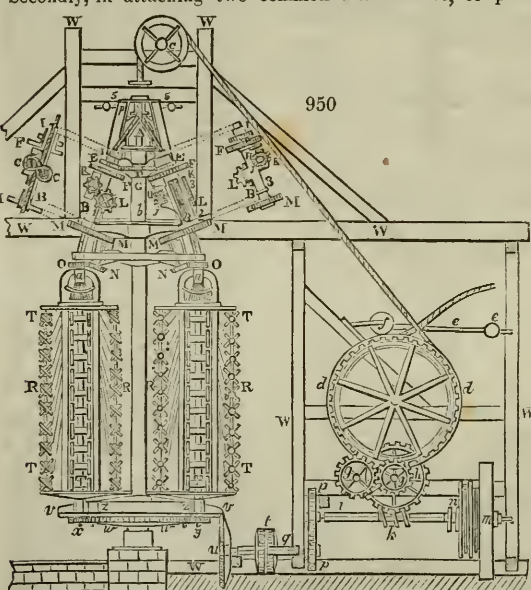
The reel D has thus, like the bobbins H, H, two movements; that in common with its frame, and that upon its axis, produced by the action of the endless band round the pulley E, upon one of its ends, and the pulley E′ above its centre of rotation. The pulley E is driven by the bevel mill-gearing P, P, P, as also the under spur-wheel C. L, in *fig.* 949, is the place of the ring L, *fig.* 947, which bears the three guide pulleys K, K, K. *Fig.* 948 is an end view of the bobbin H, to show the worm or endless screw J, of *fig.* 949, 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 gearing has been substituted with advantage, not being liable to slip, like the pulley-band mechanism. The axis of the great reel is made twice the length of the bobbin 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 in May, 1833, for an improvement adapted to the ordinary machines employed for twisting hempen yarns into strands, affording, it is said, a simpler and more eligible mode of accomplishing that object, and also of laying the strands together, than has been hitherto effected by machinery. The yarns spun from the fibres of hemp are wound upon bobbins, and these bobbins are mounted upon axles, and hung in the frame of the machine, as shown in the elevation, *fig.* 950, from which bobbins the several ends of yarn are passed upwards through slanting tubes; by the rotation of which tubes, and of the carriages in which the bobbins are suspended, the yarns become twisted into strands, and also the strands are laid so as to form ropes.

His improvements consist, first, in the application of three or more tubes, two of which are shown in *fig.* 950, 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′, and B3, are opposite side views; B2, 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.* 950, 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′. 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.

950



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.* 50, 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.

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, being similar to those now in use, 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 sheave, 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.* 951, are applied occasionally for reversing the motion of the said drums, and making what is usually termed left-hand ropes; *u*, *figs.* 950, and 951, 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 motions, or right twists 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.

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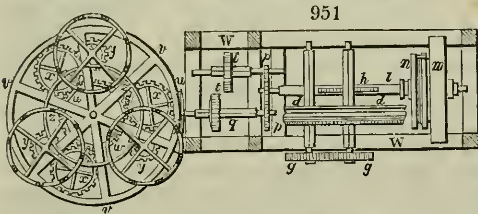

The machine here described, in elevation and plan, is calculated to make ropes from three to seven and one half inches in circumference, and to an indefinite length.

Messrs. Chapman of Newcastle, to whom the art of rope-making is deeply indebted, having observed that rope-yarn is considerably 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 it with water, in order to remove these two soluble constituents. 2. Concentrating the washed tar by heat, till it becomes pitchy, and then restoring the plasticity which it thereby loses, by the addition of tallow, or animal or expressed oils.

In 1807, the same able engineers obtained a patent for a method of making a belt or flat band, of two, three, or more strands of shroud or hawser-laid rope, placed side by side, so as to form a band of any desired breadth, which may be used for hoisting the kibbles and corves in mine-shafts, without any risk of its losing twist by rotation. The ropes should be laid with the twist of the one strand directed to the right hand, that of the other to the left, and that of the yarns the opposite way to the strands, whereby perfect flatness is secured to the band. This parallel assemblage of strands has been found also to be stronger than when they are all twisted into one cylinder. The patentees at the same time contrived a mechanism for piercing the strands transversely, in order to brace them firmly together with twine. Flat ropes are usually formed of hawsers with three strands, softly laid, each containing 33 yarns, which with four ropes, compose a cordage four and a half inches broad, and an inch and a quarter thick, being the ordinary dimensions of the grooves in the whim-pulleys round which they pass.

RELATIVE STRENGTH of CORDAGE, shroud laid.

Size.	Warm Register.				Cold Register.				Common Staple.			
	Tons.	*Cwts.*	*Qrs.*	*Lbs.*	*Tons.*	*Cwts.*	*Qrs.*	*Lbs.*	*Tons.*	*Cwts.*	*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	[illegible]
4½ —	8	13	2	8	7	5	3	1	5	1	2	6
5 —	10	14	1	4	9	3	—	4	6	9	2	8
5½ —	12	19	2	4	11	1	1	25	7	12	—	22
6 —	14	15	2	24	13	3	2	8	8	17	1	20
6½ —	18	2	—	10	15	9	1	9	9	16	3	14
7 —	21	—	—	—	17	18	3	8	11	4	1	21
7½ —	24	2	—	16	20	11	3	9	12	8	3	6
8 —	27	8	1	26	23	8	2	8	13	2	3	12

The above statement is the result of several hundred experiments.

ROSIN, or COLOPHANY (*Galipot*, Fr.; *Fichtenharz*, Germ.), is the rosin left after distilling off the volatile oil from the different species of turpentine. Yellow rosin contains some water, which black rosin does not. See TURPENTINE.

ROSIN GAS. *Fig.* 952 exhibits the retort and its appendages, as erected by Messrs. Taylor and Martineau, under the direction of the patentee, Professor Daniel, F. R. S.

I have introduced this manufacturing project, not as a pattern to imitate, but as an example to deter; as affording a very instructive lesson of the danger of rushing headlong into most extensive enterprises, without fully verifying, upon a moderate scale, the probability of their ultimate success. The capital, labor, and time annually wasted upon visionary schemes of this sort, got up by chamber chemists, are incalculably great. No more essential service could be rendered to the cause of productive industry, than to unmask the thousand and one chimerical inventions which disgrace our lists of patents during the last thirty years. These remarks have been suggested by the circumstance, that 50,000*l.* were squandered upon the rosin-gas concern; a fact communicated to me by an eminent capitalist, who was induced by fallacious statements to embark largely in the speculation. Had 100*l.* been employed beforehand, by a dispassionate practical man, in making judicious trials, and in calculating the chances of eventual profit and loss, it would have been demonstrated, as clearly as noonday, that rosin could never compete with pitcoal in the production of gas-light. Whatever ingenuity was expended in getting up the following apparatus, may be regarded as an additional *ignis fatuus* to mislead the public, and divert their thoughts from the abyss that lay before them. The main preliminary to be settled, in all new undertakings, is the soundness of the principle. By neglecting this point, projectors perpetually realize the expiatory fable of the Danaïds.

The retort *e*, *e*, *fig.* 952, is seen charged with coke, which is in the first instance raised to a bright red heat, by means of the furnace beneath. The common brown rosin of commerce, which is deposited in the tank *a*, is to be mixed with the essential oil (condensed from the rosin vapors in a preceding operation) in the proportion of one hundred pounds of the former to ten gallons of the latter. The influence of the flame and heated air beneath serves to preserve this in a fluid state, and by a damper passing across the aperture in the chimney the temperature of the fluid may be exactly regulated. A wire-gauze screen at *f*, reaches to the bottom of the tank, and prevents the solid rosin, or any impurity with which it may be mixed, from choking the stopcock.

The melted rosin having passed by the stopcock *b*, funnel *c*, and syphon *d*, into the retort, falls on the coke, and in its passage through the ignited mass, becomes decomposed. On arriving at the other end of the retort, a large portion of the oil of turpentine, in the form of condensable vapor, is separated by the refrigerator *g*; this is supplied with water from a cistern above, and the non-condensable vapor or gas passes up the tube *h*, and dips beneath the surface of the fluid in the vessel *i*. This completes the condensation; and the gas proceeds in a perfectly pure state, by the pipe *k*, to the gasometer, or rather to the floating reservoir, for use.

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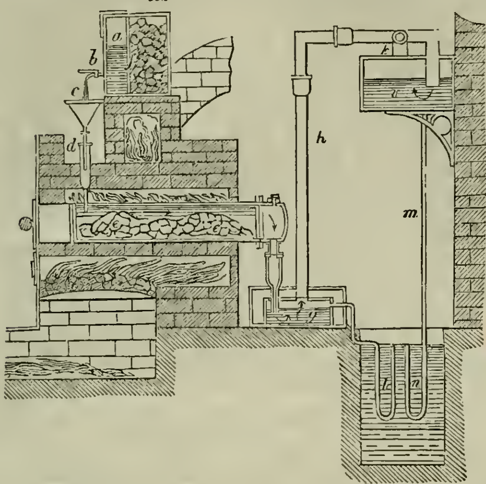

The essential oil, when it leaves the refrigerator, is conveyed, by the syphon *l*, to a cistern beneath. The necessity for employing a syphon will be apparent, when it is borne in mind that the tube prevents the escape of the gas, which would otherwise pass away from the box with the essential oil. Another pipe and syphon *m*, *n*, serve to convey the condensed essential oil from the top cistern.

ROTTEN-STONE. See TRIPOLI.

ROUGE. (*Fard*, Fr.) The only cosmetic which can be applied without injury to brighten a lady's complexion, is that prepared, by the following process, from safflower, (*Carthamus tinctorius.*) The flowers, after being washed with pure water till it comes off colorless, are dried, pulverized, and digested with a weak solution of crystals of soda, which assumes thereby a yellow color. Into this liquor a quantity of finely carded white cotton wool is plunged, and then so much lemon juice or pure vinegar is added as to supersaturate the soda. The coloring matter is disengaged, and falls down in an impalpable powder upon the cotton filaments. The cotton, after being washed in cold water, to remove some yellow coloring particles, is to be treated with a fresh solution of carbonate of soda, which takes up the red coloring matter in a state of purity. Before precipitating this pigment a second time by the acid of lemons, some soft powdered talc should be laid in the bottom of the vessel, for the purpose of absorbing the fine rouge, in proportion as it is separated from the carbonate of soda, which now holds it dissolved. The colored mixture must be finally triturated with a few drops of olive oil, in order to make it smooth and marrowy. Upon the fineness of the talc, and the proportion of the safflower precipitate which it contains, depend the beauty and value of the cosmetic. The rouge of the above second precipitation is received sometimes upon bits of fine-twisted woollen stuff, called *crepons*, which ladies rub upon their cheeks.

RUBY. See LAPIDARY.

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 cwts. 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 sugarhouse; along with twelve, or more, fermenting cisterns or tuns.

Lees that have been used more than three or four times, are not considered to be equally fit for exciting fermentation, when mixed with the sweets, as fresher lees. The wort is made, in Jamaica, by adding to 1000 gallons of dunder, 120 gallons of molasses, 720 gallons of skimmings (= 120 of molasses in sweetness), and 160 gallons of water; so that there may be in the liquid nearly 12 per cent. of solid saccharum. Another proportion, often used, is 100 gallons of molasses, 200 gallons of lees, 300 gallons of skimmings, and 400 of water; the mixture containing, therefore, 15 per cent. of sweets. These two formulæ prescribe so much spent wash, according to my opinion, as would be apt to communicate an unpleasant flavor to the spirits. Both the fermenting and flavoring principles reside chiefly in the fresh cane juice, and in the skimmings of the clarifier; because, after the sirup has been boiled, they are in a great measure dissipated. I have made many experiments upon fermentation and distillation from West India molasses, and always found the spirits to be perfectly exempt from any rum flavor.

The fermentation goes on most uniformly and kindly in very large masses, and requires from 9 to 15 days to complete; the difference of time depending upon the strength of the wort, the condition of its fermentable stuff, and the state of the weather. The progress of the attenuation of the wash should be examined from day to day with a hydrometer, as I have described in the article DISTILLATION. When it has reached nearly to its *maximum*, the wash should be as soon as possible transferred by pumps into the still, and worked off by a properly regulated heat; for if allowed to stand over, it will deteriorate y acetification. Dr. Higgins's plan, of suspending a basket full of limestone in the wash tuns, to counteract the acidity, has not, I believe, been found to be of much use. It would be better to cover up the wash from the contact of atmospheric air, and to add perhaps a very little *sulphite* of lime to it, both of which means would tend to arrest the acetous fermentation. But one of the best precautions against the wash becoming sour, is to preserve the utmost cleanliness among all the vessels in the distillery. They should be scalded at the end of every round with boiling water and quicklime.

About 115 gallons of proof rum are usually obtained from 1200 gallons of wash. The proportion which the product of rum bears to that of sugar, in very rich moist plantations, is rated, by Edwards, at 82 gallons of the former to 16 cwt. of the latter; but the more usual ratio is 200 gallons of rum to 3 hogsheads of sugar. But this proportion will necessarily vary with the value of rum and molasses in the market, since whichever fetches the most remunerating price, will be brought forward in the greatest quantity. In one considerable estate in the island of Grenada, 92 gallons of rum were made for every hogshead (16 cwts.) of sugar. See STILL.

	Rum imported, in			Retained for Home Consumption.—Duty 9s. per Imp. Gallon.		
	1835.	1836.	1837.	1835.	1836.	1837.
Galls.	5,540,170;	4,993,942;	4,612,416.	3,416,966;	3,325,068;	3,184,599.

RUST, is the orange-yellow coat of peroxyde which forms upon the surface of iron exposed to moist air. Oil-paint, varnish, plumbago, or a film of caoutchouc, may be employed, according to circumstances, to prevent the rusting of iron utensils.

RYE, consists, according to the analysis of Einhof, of 24·2 of husk, 65·6 of flour, and 10·2 of water, in 100 parts. This chemist found in 100 parts of the flour, 61·07 of starch, 9·48 of gluten, 3·28 of vegetable albumen, 3·28 of uncrystallizable sugar, 11·09 of gum, 6·38 of vegetable fibre, and the loss was 5·62, including a vegetable acid not yet investigated. Some phosphate of lime and magnesia are also present. See GIN.

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SAFETY LAMP. I have reserved for this place an account of the patented improvement made upon Davy's lamp, by Messrs. Upton and Roberts; the latter of whom, having worked in coal mines from a boy, and having observed, that in peculiar circumstances the Davy was insecure, was led to contrive certain modifications of it, for which he received, some years ago, a reward from the Society of Arts. It appears from undoubted experiments, that if a jet of carbureted hydrogen (coal gas for example) be impelled with very moderate force against the side of the Davy, it will first fill the wire cylinder of the burning lamp with flame, and then take fire itself exteriorly. This passage of the flame of explosive gases through the meshes of wire gauze of the fineness prescribed for safety lamps by Sir H. Davy was demonstrated in several trials before the select committee of the House of Commons on accidents in mines, by Mr. Pereira, at the London University.* While the gas is at rest, relatively to Davy's lamp, the explosion has never been known to pass; but "if," says Mr. Pereira, "a lamp be held before a jet of gas until it becomes hot (a red heat is not essential), and then gently moved, the flame will pass, and the experiment may be repeated successively a number of times in the minute." Two layers of wire gauze, though they greatly impede the transmission of light, will still permit that of flame, in the above circumstances. In Upton and Roberts' lamp, there is but one coat of wire gauze, but it is enclosed in a glass cylinder, in such a manner as to admit the air which feeds the flame only under its bottom, first through an annular range of holes, and next through one disc, or several, of wire gauze, fixed a little way below the wick. The explosive air, after passing up through these wire-gauze discs, enters a little brass cupola, and is reflected inwards from the orifice at its top upon the flame, whereby it is completely burned before it reaches the cavity of the surmounting cylinder. By this reverberatory action of the air upon the wick, the intensity of the light is at the same time greatly augmented. Since the feed orifices of the lamp are small in comparison with the capacity of the surmounting cage, the latter does not get filled with flame on being plunged in an explosive gaseous mixture, as happens to the naked cage of Davy. The wire-gauze can never, therefore, become very hot, far less ignited, in the new lamp. There are, in fact, three impediments to the passage of the flame

*On the 30th of July, 1835

out of the lamp; first, the stratum of carbonic acid round the light; secondly, the wire-gauze cylinder; and thirdly, the glass cylinder. The entrance at the bottom may be made secure in any desired degree, by multiplying the layers of wire cloth. The top is protected, moreover, by a brass hood, through which the currents of carbonic acid and nitrogen gases, continually ascending from the burning wick, oppose certain obstacles to the transmission of flame downwards. Even should the glass be accidentally broken, the lamp is still a complete Davy.

In the experiments made before the honorable committee at the London University, Mr. Pereira showed, first, that when a jet of coal-gas alone, or an explosive mixture of coal-gas and air, impinged upon the wire-gauze cylinder of one of Davy's lamps with a certain force, the flame generally passed through the meshes, of which there were from 950 to 1024 in the square inch. When a mixture of four parts of hydrogen and one of coal-gas was directed in a jet upon the lighted lamps of Davy, Stevenson, Dillon, Wood of Killingworth (called the refrigerating lamp), Robson, and Clanny, the flame readily passed; but when thrown upon the lamp of Upton and Roberts, it did not once pass, causing merely slight detonations within the lamp. When the force of the jet was augmented, it extinguished the light. This lamp was finally subjected to the still severer test of a mixture of four parts of atmospherical air, and one of hydrogen; yet it did not explode it. When exposed to a mixture of two thirds of air, and one of hydrogen, the lamp was immediately extinguished.

The following, out of many certificates, appears to me decisive in favor of this improvement of Davy's lamp. It comes from an experienced pitman, in a very deep and extensive coal mine, which I know to be replete with explosive gas, as I have myself visited it in company with its accomplished engineer, John Buddle, Esq.

"I hereby certify that I have this day tried Messrs. Upton and Roberts' new patent safety lamp, in the Jarrow colliery; and I state, as an experienced pitman, having been thirty-two years master wasteman in that colliery, that I greatly prefer this new lamp to the common Davy lamp. I had it between five and six hours on trial in the pit. I consider that it gives about three times the light of the Davy lamp, as I could see at least ten yards before me in a straight line; and of its great safety I can have no doubt, as it does not fill with flame, as the Davy does. And although I had this extra light, there was much less oil consumed. I consider it a good working lamp."

"Jarrow Colliery, near Newcastle on Tyne, March 31, 1836." (Signed) "ROBERT FAIRLY."

Fig. 953 is a vertical section through the middle of the lamp. *a, a*, is the oil-cistern, showing the fold of the wick; it is covered at top with *b, b*, several layers of wire gauze; *c, c*, is the perforated brass ring, under these layers, for admitting air, which is reverberated upon the burning wick by the cupola c; *d, d*, is the cylinder of glass, surrounding the wire-cloth one; *e, e*, is the safety brass hood, which screws down in the frame, so as to cover in the top of the glass chimney; *f*, is the arched wire for suspending the lamp to the girdle of the miner; *g*, is the bent tube for supplying oil to the cistern; and *h* is the safety-trimmer, shown more distinctly in the figure illustrative of the LAMP of DAVY.

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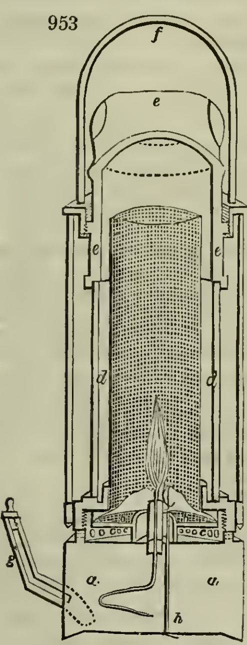

Between the glass and the cage there should be a space of about one tenth of an inch, forming an annular chimney for the free ventilation of the flame; and between the under edge of the hood *e*, and the upper rim of the glass, there should likewise be an interval, as also vent-holes in the top of the hood, for the free escape of the smoke. The orifice of the little tube *g*, should be rather lower than the ring of holes *c*, otherwise the oil, when incautiously poured into it, might overflow them, and prevent the lamp from burning. *The figure is drawn somewhat in perspective.*

As the naked cage of Davy often gets redhot with flame; as it is sometimes used for hours by miners in this most hazardous state; as this lamp gives so little light as to tempt rash men to remove its safety-cage;* as "it is upon record, that taking the average of ten years previous to the introduction of Sir H. Davy's safety lamp, and allowing one clear year for its introduction, and of ten years after it was properly introduced, there had been double the number of accidents, and at least double the number of deaths, of

* At Rown Harraton June 30, 1817, thirty-eight lives were lost by the wilfulness of one man

what took place in the ten years previous to its introduction;* as his lamp in explosive air-courses needs to be carried close upon the bosom, or under the coat of the miner; as it was declared by its illustrious inventor to be dangerous when exposed to such currents of explosive gas; and as the above described modification of it is free from all these defects and dangers, I humbly apprehend that no conscientious proprietor or viewer of coal-mines will delay to substitute the lamp of Upton and Roberts for the naked Davy, for otherwise he will certainly stand in a very painful predicament before a coroner's inquest, at the next mortal casualty from explosion.

The patentees have, I am told, been put to so much trouble and expense in trying to introduce this life-protector into our coal-mines, that they have in a great measure abandoned the business. Messrs. Smith of Birmingham have meanwhile undertaken to make the lamps.

SAFFLOWER. This dye-stuff has been fully described under CARTHAMUS and ROUGE.

SAFFRON (*Saffran*, Fr. and Germ.) is a filamentous cake, composed of the stigmata of the flowers of the *Crocus sativus*. It contains a yellow matter called *polychroïte*, because a small quantity of it is capable of coloring a great body of water. This is obtained by evaporating the watery infusion of saffron to the consistence of an extract, digesting the extract with alcohol, and concentrating the alcoholic solution. The polychroite remains in the form of a brilliant mass, of a reddish-yellow color, transparent, and of the consistence of honey. It has the agreeable smell, with the bitter pungent taste, of saffron. It is very soluble in water; and if it be stove-dried, it deliquesces speedily in the air. According to M. Henry *père*, polychroïte consists of eighty parts of coloring matter, combined with 20 parts of a volatile oil, which cannot be separated by distillation till the coloring matter has been combined with an alkali. By mixing one part of shred saffron with eight parts of saturated brine, and one half part of caustic ley, and distilling the mixture, the oil comes over into the receiver, and leaves the coloring matter in the retort, which may be precipitated from the alkaline solution by an acid. The pure coloring matter, when dried, is of a scarlet hue, and then readily dissolves in alcohol, as also in the fat and volatile oils, but sparingly in water. Light blanches the reddish-yellow of saffron, even when it is contained in a full vial well corked. Polychroïte, when combined with fat oil, and subjected to dry distillation, affords ammonia, which shows that azote is one of its constituents. Sulphuric acid colors the solution of polychroïte indigo blue, with a lilach cast; nitric acid turns it green, of various shades, according to the state of dilution. Protochloride (muriate) of tin produces a reddish precipitate.

Saffron is employed as a seasoning in French cookery. It is also used to tinge confectionary articles, liqueurs, and varnishes; but rarely as a pigment.

SAGO (*Sagou*, Fr. and Germ.) is a species of starch, extracted from the pith of the sago palm, a tree which grows to the height of 30 feet in the Moluccas and the Philippines. The tree is cut down, cleft lengthwise, and deprived of its pith, which being washed with water upon a sieve, the starchy matter comes out, and soon forms a deposite. 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.

SAL AMMONIAC. The manufacture of this salt may be traced to the remotest era. Its name is derived from Ammonia, or the temple of Jupiter Ammon, in Egypt, near to which the salt was originally made. Sal ammoniac exists ready formed in several animal products. The dung and urine of camels contain a sufficient quantity to have rendered its extraction from them a profitable Egyptian art in former times, in order to supply Europe with the article. In that part of Africa, fuel being very scarce, recourse is had to the dung of these animals, which is dried for that purpose, by plastering it upon the walls. When this is afterwards burned in a peculiar kind of furnace, it exhales a thick smoke, replete with sal ammoniac in vapor; the soot of course contains a portion of that salt, condensed along with other products of combustion. In every part of Egypt, but especially in the Delta, peasants are seen driving asses loaded with bags of that soot, on their way to the sal ammoniac works.

Here it is extracted in the following manner. Glass globes coated with loam are filled with the soot pressed down by wooden rammers, a space of only two or three inches being left vacant, near their mouths. These globes are set in round orifices formed in the ridge of a long vault, or large horizontal furnace flue. Heat is gradually applied by a fire of dry camels' dung, and it is eventually increased till the globes become obscurely

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unscrewing it, though he was well forewarned of the danger. He said, "he could not see with that thing," meaning the Davy.—*Buddle, in Report of House of Commons*, p. 215.

* Dr. Reid Clanny, in Report on Accidents in Mines, p. 32. I observe that in Sykes' *Local Records* of the counties of Durham and Northumberland, corrected by J. Buddle, Esq., there are 540 deaths by explosions, between June, 1817, and June, 1835. What a mass of misery to the families of the sufferers

red. As the muriate of ammonia is volatile at a temperature much below ignition, it rises out of the soot in vapor, and gets condensed into a cake upon the inner surface of the top of the globe. A considerable portion, however, escapes into the air; and another portion concretes in the mouth, which must be cleared from time to time by an iron rod. Towards the end, the obstruction becomes very troublesome, and must be most carefully attended to and obviated, otherwise the globes would explode by the uncondensed vapors. In all cases, when the subliming process approaches to a conclusion, the globes crack or split; and when they come to be removed, after the heat has subsided, they usually fall to pieces. The upper portion of the mass is separated, because to it the white salt adheres; and on detaching the pieces of glass with a hatchet, it is ready for the market. At the bottom of each balloon a nucleus of salt remains, surrounded with fixed pulverulent matter. This is reserved, and after being bruised, is put in along with the charge of soot in a fresh operation.

The sal ammoniac obtained by this process is dull, spongy, and of a grayish hue; but nothing better was for a long period known in commerce. Forty years ago, it fetched 2*s*. 6*d*. a pound; now, perfectly pure sal ammoniac may be had at one fifth part of that price.

Various animal offals develop during their spontaneous putrefactive fermentation, or their decomposition by heat, a large quantity of free or carbonated ammonia, among their volatile products. Upon this principle many sal ammoniac works have been established. In the destructive distillation of pitcoal, there is a considerable quantity of ammoniacal products, which are also worked up into sal ammoniac.

The first attempts made in France to obtain sal ammoniac profitably in this manner, failed. A very extensive factory of the kind, which experienced the same fate, was under the superintendence of the celebrated Baumé, and affords one out of a thousand instances where theoretical chemists have shown their total incapacity for conducting operations on the scale of manufacturing economy. It was established at Gravelle near Charenton, and caused a loss to the shareholders in the speculation of upwards of 400,000 francs. This result closed the concern in 1787, after a foolish manipulation of 27 years. For ten years after that event, all the sal ammoniac consumed in France was imported into it from foreign countries. Since then the two works of MM. Payen and Pluvinet were mounted, and seem to have been tolerably successful. Coal soot was, prior to the introduction of the gas-works, a good deal used in Great Britain for obtaining sal ammoniac. In France, bones and other animal matters are distilled in large iron retorts, for the manufacture of both animal charcoal and sal ammoniac.

These retorts are iron cylinders, 2 or 3 feet in diameter, and 6 feet long. *Figs*. 954, and 955, show the form of the furnace, and the manner in which the cylinders are

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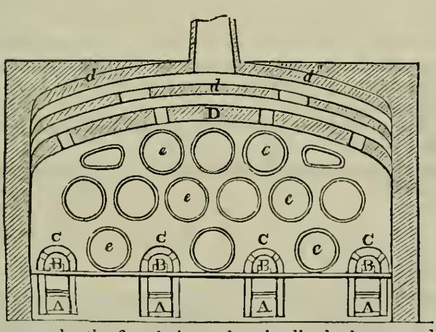

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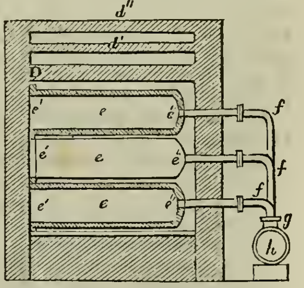

arranged; the first being a longitudinal, the second a transverse section of it. A, the ash-pits under the grates; B, the fireplaces, arched over at top; C, the vault or bench of fire-bricks, perforated inside with eight flues for distributing the flame; D, a great arch, with a triple voussoir D *d*′, *d*″, under which the retorts are set. The first arch D, is perforated with twenty vent-holes; the second, with four vent-holes; through which the flame passes to the third arch, and thence to the common chimney-stalk. The retorts *e*, are shut by the door *e*′ (*fig*. 955), luted, and made fast with screw-bolts. Their other ends *e*″ terminate in tubes *f*, *f*, *f*, which all enter the main pipe *h*. The condensing pipe proceeds slantingly downwards from the further end of *h*, and dips into a large sloping iron cylinder immersed in cold water. See GAS-LIGHT and STOVE, for a better plan of furnace.

The filters used in the large sal ammoniac works in France are represented in *fig*. 956. The apparatus consists—1. of a wooden chest *a*, lined with lead, and which is turned over at the edges; a socket of lead *b*, soldered into the lowest part of the bottom, serves to discharge the liquid; 2. of a wooden crib or grating formed of rounded rods, as shown in the section *c, c,* and the plan *d;* this grating is supported one inch at least above the bottom, and set truly horizontal, by a series of wedges; 3. of an open fabric of canvass or strong calico, laid on the grating, and secured over the edges, so as to keep it tense. A large wooden reservoir *f*, lined with lead, furnished with a

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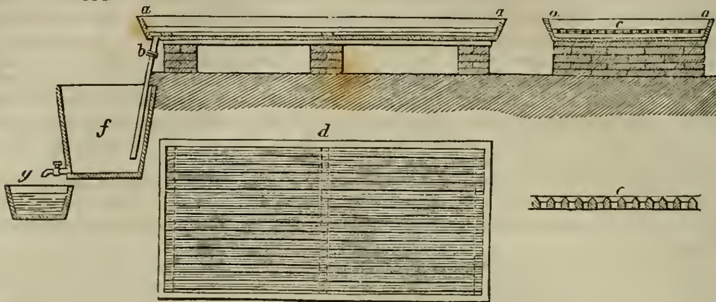

cover, is placed under each of the filters; a pump throws back once or twice upon the filters what has already passed through. A common reservoir *g*, below the others, may be made to communicate at pleasure with one of them, by means of intermediate stop-cocks.

The two boilers for evaporating and decomposing are made of lead, about one quarter of an inch thick, set upon a fire-brick vault, to protect them from the direct action of the flame. Through the whole extent of their bottoms above the vault, horizontal cast-iron plates, supported by ledges and brick compartments, compel the flame and burned air, as they issue from the arch, to percur many sinuosities before they pass up the chimney. This floor of cast iron is intended to support the bottom of the boiler, and to diffuse the heat more equably. The leaden boilers are surrounded with brick-work, and supported at their edges with a wooden frame. They may be emptied at pleasure into lower receivers, called crystallizers, by means of leaden syphons and long-necked funnels.

The crystallizers are wooden chests lined with lead, 15 inches deep, 3 or 4 feet broad, and from 6 to 8 feet long; and may be inclined to one side at pleasure. A round cistern receives the drainings of the mother-waters. The pump is made of lead, hardened with antimony and tin.

The subliming furnace is shown in *figs.* 957 and 958, by a transverse and longitudinal section. *a* is the ash-pit; *b*, the grate and fire-place; *c*, the arch above them. This arch, destined to protect the bottles from the direct action of the fire, is perforated with vent-holes, to give a passage to the products of combustion between the subliming vessels. *d, d*, are bars of iron, upon which the bottoms of the bottles rest; *e*, stoneware bottles, protected by a coating of loam from the flame.

Fig. 959 shows the cast-iron plates, *a, b, c,* which, placed above the vaults, receive each two bottles in a double circular opening.

At the extremity of the above furnace, a second one, called the drier, *fig.* 960, receives the

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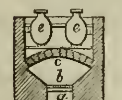

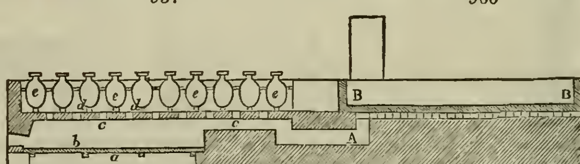

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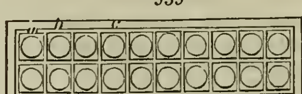
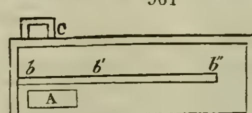




products of the combustion of the first, at A, under horizontal cast-iron plates, and upon which the bottom of a rather shallow boiler B, rests. After passing twice under these plates, round a longitudinal brick partition *b, b′, b″*, the products of combustion enter the smoke chimney C. See plan, *fig.* 961.

The boiler set over this furnace should have no soldered joints. It may be 3½ feet broad, 9 or 10 feet long, and 1 foot deep. The concrete sal ammoniac may be crushed under a pair of edge mill-stones, when it is to be sold in powder.

Bones, blood, flesh, horns, hoofs, woollen rags, silk, hair, scrapings of hides and leather, &c., may be distilled for procuring ammonia. When bones are used, the residuum in the retort is bone black. The charcoal from the other substances will serve for the manufacture of Prussian blue. The bones should undergo a degree of calcination beyond what the ammoniacal process requires, in order to convert them into the best bone black; but the other animal matters should not be calcined up to that point, otherwise they are of little use in the Prussian blue works. If the bones be calcined, however, so highly as to become glazed, their decoloring power on sirups is nearly destroyed. The other substances should not be charred beyond a red-brown heat.

The condensed vapors from the cylinder retorts afford a compound liquor holding carbonate of ammonia in solution, mixed with a large quantity of empyreumatic oil, which floats at top. Lest incrustations of salt should at any time tend to obstruct the tubes, a pipe should be inserted within them, and connected with a steam boiler, so as to blow steam through them occasionally.

The whole liquors mixed have usually a density of 8° or 9° Baumé (1·060). The simplest process for converting their carbonate of ammonia into muriate, is to saturate them with muriatic acid, to evaporate the solution in a leaden boiler till a pellicle appears, to run it off into crystallizers, and to drain the crystals. Another process is, to decompose the carbonate of ammonia, by passing its crude liquor through a layer of sulphate of lime, 3 or 4 inches thick, spread upon the filters, *fig.* 956. The liquor may be laid on with a pump; it should never stand higher than 1 or 2 inches above the surface of the bruised gypsum, and it should be closely covered with boards, to prevent the dissipation of the volatile alkali in the air. When the liquor has passed through the first filter, it must be pumped upon the second; or the filters being placed in a terrace form, the liquor from the first may flow down upon the second, and thus in succession. The last filter should be formed of nearly fresh gypsum, so as to ensure the thorough conversion of the carbonate into sulphate. The resulting layers of carbonate of lime should be washed with a little water, to extract the sulphate of ammonia interposed among its particles. The ammoniacal liquor thus obtained must be completely saturated, by adding the requisite quantity of sulphuric acid; even a slight excess of acid can do no harm. It is then to be evaporated, and the oil must be skimmed off in the course of the concentration. When the liquid sulphate has acquired the density of about 1·160, sea salt should be added, with constant stirring, till the whole quantity equivalent to the double decomposition be introduced into the lead boiler.

The fluid part must now be drawn off by a syphon into a somewhat deep reservoir, where the impurities are allowed to subside; it is then evaporated by boiling, till the sulphate of soda falls down in granular crystals, as the result of the mutual reaction of the sulphate of ammonia and muriate of soda; while the more soluble muriate of ammonia remains in the liquor. During this precipitation, the whole must be occasionally agitated with wooden paddles; the precipitate being in the intervals removed to the cooler portion of the pan, in order to be taken out by copper rakes and shovels, and thrown into draining-hoppers, placed near the edges of the pan. The drained sulphate of soda must be afterwards washed with cold water, to extract all the adhering sal ammoniac.

The liquor thus freed from the greater part of the sulphate, when sufficiently concentrated, is to be drawn off by a lead syphon, into the crystallizers, where, at the end of 20 or 30 hours, it affords an abundant crop of crystals of sal ammoniac. The mother-water may then be run off, the crystallizers set aslope to drain the salt, and the salt itself must be washed, first by a weak solution of sal ammoniac, and lastly with water. It must be next desiccated, by the apparatus *fig.* 960, into a perfectly dry powder, then put into the subliming stoneware balloons, by means of a funnel, and well rammed down. The mouth of the bottle is to be closed with a plate or inverted pot of any kind. The fire must be nicely regulated, so as to effect the sublimation of the pure salt from the under part of the bottle, with due regularity, into a white cake in the upper part. The neck of the bottle should be cleared from time to time with a long steel skewer, to prevent the risk of choking, and consequent bursting; but in spite of every precaution, several of the bottles crack almost in every operation. In Scotland, sal ammoniac is sublimed in cast-iron pots lined with thin fire-tiles, made in segments accommodated to the internal surface of the pots; the vapor being received and condensed into cakes, within balloons of green glass set over their mouths. The salt, when taken out, and freed by scraping from any adhering ochreous or other impurities, is ready for the market, being sold in hollow spherical masses. The residuum in the pots or bottles may be partially worked up in another operation. The greatest evil is produced by the mixture or even contact of iron, because its peroxyde readily rises in vapor with the sal ammoniac, and tinges it of a red or yellow color.

The most ordinary process for converting the ammoniacal liquor of the gas-works into sal ammoniac, is to saturate it with sulphuric acid, and to decompose the sulphate, thus formed, by the processes above described. But muriatic acid will be preferred, where it is as cheap as sulphuric of equivalent saturating power; because a tolerably pure sal ammoniac is thereby directly obtained. As the coal-gas liquor contains a good deal of sulphureted hydrogen, the saturation of it with acid should be so conducted as to burn the disengaged noxious gases in a chimney. Formerly human urine was very extensively employed, both in this country and in France, in the manufacture of sal ammoniac; but since the general establishment of gas-works, it has been, I believe, abandoned. The process was exceedingly offensive.

The best white sal ammoniac is in spheroidal cakes of about one foot diameter, three or four inches thick in the middle, somewhat thinner at the edges, and is semi-transparent or translucent. Each lump weighs about one quarter of a cwt. As it is easily volatilized by heat, it may be readily examined as to its sophistication with other salts. Sal ammoniac has a certain tenacity, and is flexible under the hammer or pestle. It is principally used in tinning of cast-iron, wrought iron, copper, brass, and for making the various ammoniacal preparations of pharmacy.

In a chemical factory near Glasgow, 7200 gallons of ammoniacal liquor, obtained weekly from the gas-works, are treated as follows:—The liquor is first rectified by distillation from a wagon-shaped wrought-iron boiler, into a square cistern of iron lined with lead. 4500 lbs. of sulphuric acid, of specific gravity 1·625, are then slowly added to the somewhat concentrated distilled water of ammonia. The produce is 2400 gallons of sulphate of ammonia, slightly acidulous, of specific gravity 1·150, being of such strength as to deposite a few crystals upon the sides of the lead-lined iron tank in which the saline combination is made. It is decomposed by common salt.

From the 7200 gallons of the first crude liquor, 900 gallons of tar are got by subsidence, and 200 gallons of petroleum are skimmed off the surface. The tar is converted, by a moderate boiling in iron pans, into good pitch.

SALAMSTONE. See Lapidary.

SALEP, or SALOUP, is the name of the dried tuberous roots of the *Orchis*, imported from Persia and Asia Minor, which are the product of a great many species of the plant, but especially of the *Orchis mascula*. Salep occurs in commerce in small oval grains, of a whitish-yellow color, at times semi-transparent, of a horny aspect, very hard, with a faint peculiar smell, and a taste like that of gum tragacanth, but slightly saline. These are composed almost entirely of starchy matter, well adapted for making a thick pap with water or milk, and are hence in great repute in the Levant, as restorers of the animal forces. Their aphrodisiacal properties are apocryphal. If the largest roots of the *Orchis mascula* of our own country were cleaned, scraped, steeped for a short time in hot, and then for a few minutes in boiling water, to extract their rank flavor, afterwards suspended upon strings to dry in the air, they would afford as nourishing and palatable an article as the Turkey saloup, and at a vastly lower price.

SALICINE, is a febrifuge substance, which may be obtained in white pearly crystals from the bark of the white willow (*Salix alba*), of the aspen tree (*Salix helis*), as also of some other willows, and some poplars. It has a very bitter taste.

SAL PRUNELLA, is fused nitre cast into cakes or balls.

SAL VOLATILE, is sesquicarbonate of ammonia.

SALT, EPSOM, is sulphate of magnesia.

SALT, MICROCOSMIC, is the triple phosphate of soda and ammonia.

SALT OF AMBER, is succinic acid.

SALT OF LEMONS, is citric acid.

SALT OF SATURN, is acetate of lead.

SALT OF SODA, is carbonate of soda.

SALT OF SORREL, is bi-oxalate of potassa.

SALT OF TARTAR, is carbonate of potassa.

SALT OF VITRIOL, is sulphate of zinc.

SALT PERLATE, is phosphate of soda.

SALTPETRE, is nitre, or nitrate of potassa.

SALT, SEDATIVE, is boracic acid.

SALTS, are an important class of chemical compounds, anciently studied under the Greek title of *Halurgy*. At one period every inorganic substance readily soluble in water, was regarded as a salt; and afterwards, every substance soluble in five hundred times its weight of water. Thus both acid and alkaline bodies came to be enrolled among salts; but latterly, the combinations of the acids with alkalis, earths, and metallic calces (now styled oxydes), were alone thought to be entitled to the denomination of salts, in consequence of their resemblance in appearance, and supposed analogy in composition, to culinary salt. Since Sir H. Davy demonstrated that this substance contained neither acid nor alkaline matter, but that it consisted of chlorine and the metal sodium, the generality of chemists found it impossible to include salts under one category of constitution; while a few have rashly offered to cut the knot, by excluding from the saline family, chloride of sodium, the patriarch of the whole.

Salts may be justly divided into three orders:

1. The binary, consisting of two single members; such as the bromides, chlorides, cyanides, fluorides, iodides, carburets, phosphurets, sulphurets, &c.

2. The bi-binary, consisting of two double members; such as the borates, bromates, carbonates, chlorates, sulphates, sulphites, hyposulphites, sulphohydrates, &c.

3. The ternary, consisting of two single members of one genus, and one member of another; such as the boro-fluorides, silico-fluorides, sulpho-cyanides, chloriodides, &c.

The species of each order may exist in three states, constituting neutral salts, supersalts, and subsalts; as for example, the chloride of sodium, the bisulphate of potassa, the subnitrate of lead, &c.

In the above arrangement, cyanogen is allowed to represent a simple substance, from its forming analogous compounds with chlorine and iodine. The neutral state of salts is commonly indicated by their solutions not changing the colors of litmus, violets, or red cabbage; the sub-state of salts, by their turning the violet and cabbage green; and the super-state of salts, by their changing the purple of litmus, violets, and cabbage, red; but to the generality of this criterion there are some exceptions. The atomic theory may be advantageously resorted to, in this predicament. 1. When one prime equivalent of the one member (whether single or double) of a salt, combines with one prime of the other member, a neutral salt is the result, as in chloride of sodium or nitrate of potassa. 2. When two primes of the electro-negative member combine with one prime of the electro-positive, a supersalt is formed, as bichloride of tin, or bisulphate of potassa. 3. When one prime of the electro-negative member combines with two or more primes of the electro-positive, a subsalt is produced, as the subacetate and subchromate of lead, &c.

SALT, SEA, or CULINARY; *chloride of sodium; muriate of soda.* (*Hydrochlorate de soude*, Fr.; *Chlornatrium*, Germ.) Sea salt, or rock salt, in a state of purity, consists of 60 of chlorine + 40 of sodium, in 100 parts.

This important species of the saline class possesses, even in mass, a crystalline structure, derived from the cube, which is its primitive form. It has generally a foliated texture, and a distinct cleavage; but it has also sometimes a fibrous structure. The massive salt has a vitreous lustre. It is not so brittle as nitre; it is nearly as hard as alum, a little harder than gypsum, and softer than calcareous spar. Its specific gravity varies from 2·0 to 2·25. When pure, it is colorless, translucent, or transparent. On exposure to heat, it commonly decrepitates; but some kinds of rock salt enter quietly into fusion at an elevated temperature, a circumstance which has been ascribed to their having been originally subjected to the action of fire.

According to M. Gay Lussac, 100 parts of water dissolve—

35·81	parts of the salt, at temperature	57·0° Fahr.
35·88	—	62·5°
37·14	—	140·0°
40·38	—	229·5°

Native chloride of sodium, whether obtained from the waters of the ocean, from saline lakes, from salt springs, or mineral masses, is never perfectly pure. The foreign matters present in it vary with its different origins and qualities. These are, the sulphates of lime, magnesia, soda, muriates of magnesia and potash, bitumen, oxyde of iron, clay in a state of diffusion, &c.

Muriate of potash has been detected, in the waters of the ocean, in the sal-gem of Berchtesgaden in Bavaria, of Hallein in the territory of Salzbourg, and in the salt springs of Rosenheim.

The more heterogeneous the salt, the more soluble is it, by the reciprocal affinity of its different saline constituents; and thus a delicate hydrometer, plunged in saturated brine, may serve to show approximately the quality of the salt. I find that the specific gravity of a saturated solution of large-grained cubical salt, is 1·1962 at 60° F. 100 parts of this brine contain 25½ of salt, (100 w. + 34·2 s.) From mutual penetration, 100 volumes of the aqueous and saline constituents form rather less than 96 of the solution.

Among the varieties in the form of this salt, the octahedral, the cubo-octahedral, and the dodecahedral, have been mentioned; but there is another, called the funnel or hopper-shaped, which is very common. It is a hollow rectangular pyramid, which forms at the surface of the saline solution in the course of its evaporation, commencing with a small floating cube, upon which lines of other little cubes attach themselves to the edges of the upper face; whereby they form and enlarge the sides of a hollow pyramid, whose apex, the single cubic crystal, is downward. This sinks by degrees as the aggregation goes on above, till a pyramidal boat of considerable size is constructed.

A Table of the results of the Analyses of several varieties of Culinary Salt.

Origin of the Salt.	Chloride of Sodium.	Muriate of Magnesia.	Muriate of Lime.	Sulphate of Soda.	Sulphate of Magnesia.	Sulphate of Lime.	Clay and other insoluble bodies.	Oxyde of iron.
Sal-gem of Vic { white	99·30	—	—	—	—	0·005	0·020	
Sal-gem of Vic { red	99·80	—	—	—	—	—	0·002	
——— Cheshire, crushed - -	98·33	0·02	—	—	—	0·65	—	0·002
Salt from Salt Springs :								
Schönbeck, Westphalia	93·90	0·30	—	1·00	—	0·80		
Moutiers { des cordes	97·17	0·25	—	2·00	0·58			
Moutiers { boilers	93·59	0·61	—	5·55	0·25			
Château Salins -	97·82	2·12						
White of Sulz - -	96·88	3·12						
Ludwigshall, middle grained -	99·45	—	—	0·05	—	0·28		
Kœnigsborn, Westphalia	95·90	—	0·27	—	—	1·10		
Sea salt, half white -	97·20	0·004	—	—	0·050	0·120	0·070	
———, of Saint Malo	96·	0·30	—	—	0·45	2·35		
Common Scottish salt	93·55	2·80	—	—	1·75	1·50		
Lymington, common -	93·7	1·1	—	—	3·50	1·50	2·00	
—————, cat -	98·8	0·5	—	—	0·5	0·1		
Cheshire, stoved -	98·25	0·075	0·025	—	—	1·55		

The geological position of rock salt is between the coal formation and the lias. The great rock-salt formation of England occurs within the *red marl*, or new red sandstone, the *bunter-sandstein* of the Germans, so called, because its colors vary from red to salmon and chocolate. This mineral stratum frequently presents streaks of light blue, verdigris, buff, or cream color; and is chiefly remarkable for containing considerable masses or beds of gypsum. At Northwich, in the vale of the Weaver, the rock salt consists of two beds, together not less than 60 feet thick, which are supposed to constitute large insulated masses, about a mile and a half long, and nearly 1300 yards broad. There are other deposites of rock salt in the same valley, but of inferior importance. The uppermost bed occurs at 75 feet beneath the surface, and is covered with many layers of indurated red, blue, and brown clay, interstratified more or less with sulphate of lime, and interspersed with argillaceous marl. The second bed of rock salt lies 31½ feet below the first, being separated from it by layers of indurated clay, with veins of rock salt running through them. The lowest bed of salt was excavated to a depth of 110 feet, several years ago.

The beds or masses of rock salt are occasionally so thick, that they have not been yet bored through, though mined for many centuries. This is the case with the immense mass of Wieliczka, and the lower bed at Northwich. But in ordinary cases, this thickness varies from an inch or two to 12 or 15 yards. When the strata are thin, they are usually numerous; but the beds, layers, or masses never exhibit throughout a great extent any more than an illusory appearance of parallelism; for when they are explored at several points, enlargements are observed, and such diminutions as cause the salt to disappear sometimes altogether. This mineral is not deposited, therefore, in a geological stratum, but rather in lenticular masses, of very variable extent and thickness, placed alongside of each other at unequal distances, and interposed between the courses of the other formations.

Sometimes the rock salt is disseminated in small masses or little veins among the calcareous and argillaceous marls which accompany or overlie the greater deposites. Bitumen, in small particles, hardly visible, but distinguishable by the smell, occurs in all the minerals of the saliferous system.

It has been remarked, that the plants which grow generally on the sea shores, such as the *Triglochinum maritimum*, the *Salicornia*, the *Salsola kali*, the *Aster trifolium*, or farewell to summer, the *Glaux maritima*, &c., occur also in the neighborhood of salt mines and salt springs, even of those which are most deeply buried beneath the surface.

The interior of rock-salt mines, after digging through the strata of clay marl, &c. is extremely dry; so that the dust produced in the workings becomes an annoyance to the miners, though in other respects the excavations are not at all insalubrious.

Salt springs occur nearly in the same circumstances, and in the same geological formation as the salt rock. It has been noticed that salt spings issue, in general, from the upper portion of the saliferous strata, principally from the saline clay marls. Cases however occur, where the salt springs are not accompanied by rock salt, and where the whole saline matter is derived from the marls themselves, which thus constitute the only saliferous beds.

It has been imagined that there are two other periods of geological formation of this substance; one much more ancient, belonging to the transition series of rocks; the other relatively modern, among secondary strata. To the former has been referred the salt formation of Bex, that of Cardonne, &c. But M. Brongniart assigns valid reasons for rejecting this supposition. M. Beudant, indeed, refers to the secondary strata above the chalk, the rock-salt formation of Wieliczka, and of the base of the Carpathians; placing these among the plastic clay and lignites.

The mines of rock salt do not appear to possess any determinate elevation upon the surface of the earth. Immense masses of it are met with at very great depths below the level of the sea, (the mine of Wieliczka is excavated 860 feet beneath the soil,) and others exist at a considerable altitude, as that of Hallein near Salzbourg, which is 3300 feet above the level of the sea, and the saline rock of Arbonne in Savoy, which is nearly 4000 feet higher, situated at the great elevation of 7200 feet above the level of the sea, and consequently in the region of perpetual snow. The rock is a mass of saccharoid and anhydrous gypsum, imbued with common salt, which is extracted by lixiviation; after which the gypsum remains porous and light.

The inland seas, salt lakes, and salt marshes, have their several localities obviously independent of peculiar geological formations. The ocean is, however, the most magnificent mine of salt, since this chloride constitutes about one thirtieth part of its weight; being pretty evenly diffused throughout its waters, when no local cause disturbs the equilibrium. The largest proportion of salt held in solution in the open sea, is 38 parts in 1000, and the smallest 32. In a specimen taken by Mr. Wilkinson, out of the Red Sea, at Berenice, I found 43 parts of salt in 1000. The specific gravity of the water was 1·035.

Were it requisite to extract the chloride of sodium from sea-water by fuel alone, many countries, even maritime, would find the process too costly. The salt is therefore obtained from it in two different manners; 1. by natural evaporation alone; 2. by natural and artificial evaporation combined. The first method is employed in warm regions, under the form of saline tanks, or brine reservoirs, called also brine-pits. These are large shallow basins, the bottom of which is very smooth, and formed of clay. They are excavated along the sea-shore, and consist of—

1st. A large reservoir, deeper than the proper brine-pits, which is dug between them and the sea. This reservoir communicates with the sea by means of a channel provided with a sluice. On the sea-shore, these reservoirs may be filled at high water, though the tides are rather inconvenient than advantageous to brine-pits.

2dly. The brine-pits, properly so called, which are divided into a number of compartments by means of little banks. All these compartments have a communication with each other, but so that the water frequently has a long circuit to make, from one set to another. Sometimes it must flow 400 or 500 yards, before it reaches the extremity of this sort of labyrinth. The various divisions have a number of singular names, by which they are technically distinguished. They should be exposed to the north, north-east, or northwest winds.

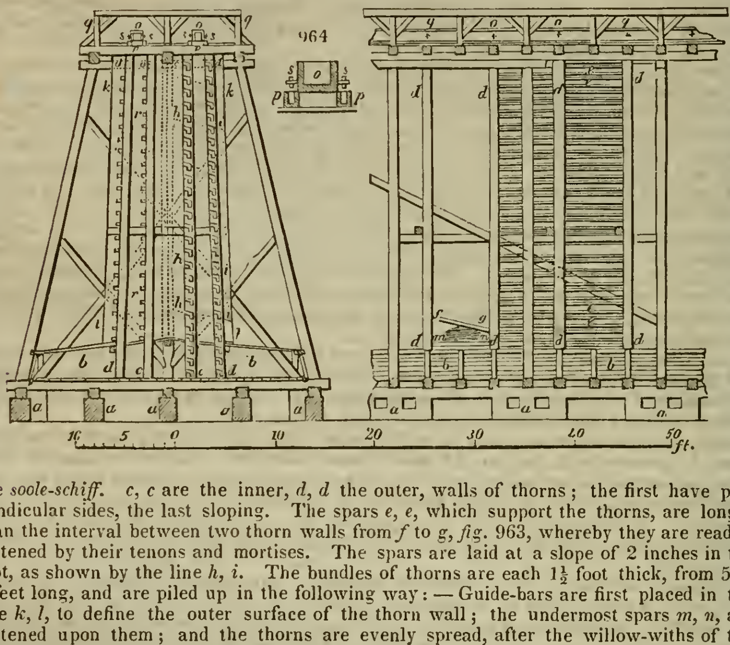
The water of the sea is let into these reservoirs in the month of March, where it is exposed on a vast surface to evaporation. The first reservoir is intended to detain the water till its impurities have subsided, and from it the other reservoirs are supplied, as their water evaporates. The salt is considered to be on the point of crystallizing when the water begins to grow red. Soon after this, a pellicle forms on the surface, which breaks, and falls to the bottom. Sometimes the salt is allowed to subside in the first compartment; at others, the strong brine is made to pass on to the others, where a larger surface is exposed to the air. In either case the salt is drawn out, and left upon the borders to drain and dry.

The salt thus obtained partakes of the color of the bottom on which it is formed; and is hence white, red, or gray.

Sea water contains, in 1000 parts, 25 of chloride of sodium, 5·3 sulphate of magnesia, 3·5 chloride of magnesium, 0·2 carbonate of lime and magnesia, 0·1 sulphate of lime, besides $\frac{1}{2000}$ of sulphate and muriate of potash. It also contains iodide of sodium, and bromide of magnesium. Its average spec. grav. is from 1·029 to 1·030.

Sea-water and weak brines may be cancentrated either by the addition of rock salt, by spontaneous evaporation in brine-pits (see *suprà*), or by graduation. Houses for the last purpose are extensively employed in France and Germany. The weak brine is pumped into an immense cistern on the top of a tower, and is thence allowed to flow down the surface of bundles of thorns built up in regular walls, between parallel wooden frames. At Salza, near Schönebeck, the graduation-house is 5817 feet long, the thorn walls are from 33 to 52 feet high, in different parts, and present a total surface of 25,000 square feet. Under the thorns, a great brine cistern, made of strong wooden planks, is placed, to receive the perpetual shower of water. Upon the ridge of the graduation-house there is a long spout, perforated on each side with numerous holes, and furnished with spigots or stopcocks for distributing the brine, either over the surface of the thorns, or down through their mass; the latter method affording larger evaporation. The graduation-house should be built lengthwise in the direction of the prevailing wind, with its ends open. An experience of many years at Salza and Dürrenberg has shown, that in the former place graduation can go on 258, and in the latter 207 days, on an average, in the year; the best season being from May till August. At Dürrenberg, 3,596,561 cubic feet of water are evaporated annually. According to the weakness of the brine, it must be the more frequently pumped up, and made to flow down over the thorns in different compartments of the building, called the 1st, 2d, and 3d graduation. A deposite of gypsum incrusts the twigs, which requires them to be renewed at the end of a certain time. *Figs.* 962 and 963 represent the graduation-house of the salt-works at Dürrenberg. *a, a, a,* are low stone pillars for supporting the brine cistern *b*, called

962 963

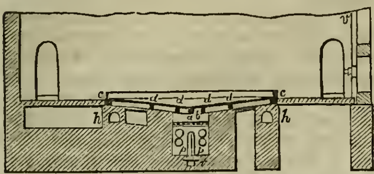


the *soole-schiff*. *c, c* are the inner, *d, d* the outer, walls of thorns; the first have perpendicular sides, the last sloping. The spars *e, e,* which support the thorns, are longer than the interval between two thorn walls from *f* to *g*, *fig.* 963, whereby they are readily fastened by their tenons 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.* 964. 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.

Figs. 965, 966, 967 represent the construction of a salt-pan, its furnace, and the salt store-room of the works at Dürrenberg; *fig.* 967 being the ground plan, *fig.* 966

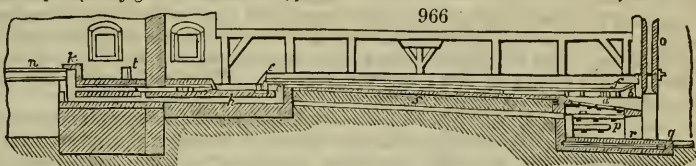
the longitudinal section, and *fig.* 965 the transverse section. *a* is the fire-grate, which slopes upwards to the back part, and is $31\frac{1}{2}$ inches distant from the bottom of the pan. The ratio of the surface of the grate to that of the bottom of the pan, is as 1 to 59·5; that of the air-hole into the ash-pit, as 1 to 306. The bed under the pan is laid with bricks, smoothly plastered over, from *b* to *c*, in *fig.* 966. Upon this bed the pillars *d*, *d*, &c., are built in a radiated direction, being 6 inches broad at the bottom, and tapering to $1\frac{1}{2}$ inch at top. The pan is so laid that its bottom has a fall towards the middle of $2\frac{1}{2}$ inches; see *e*, *f*, *fig.* 966. 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.* 967, 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.

965

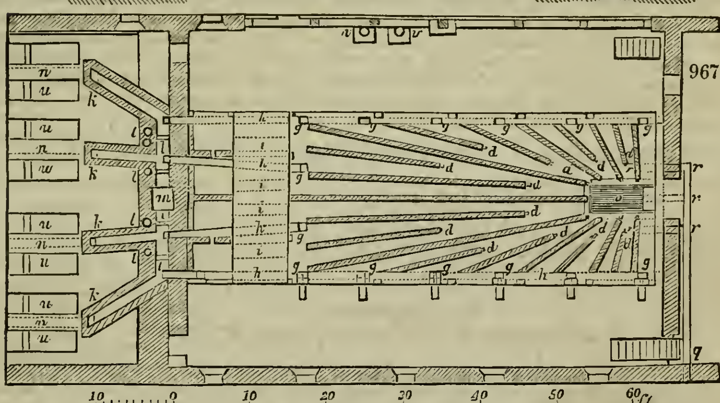


The bottoms of the several flues have a gradual ascent above the level of the fire-grate. A special chimney *o*, rises above the ash-pit, to carry off the smoke, which may chance to regurgitate in certain states of the wind. *p*, *p*, are iron pipes laid upon each side of the ash-pit (see *figs.* 966 and 967), into which cold air is admitted by the flue *q*, *r*

966



967

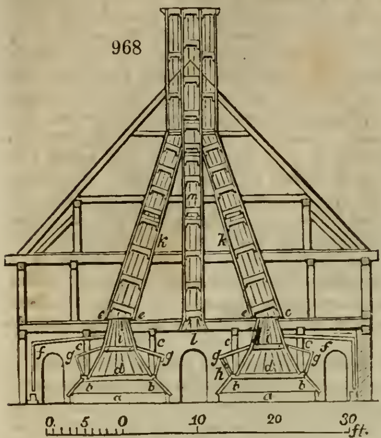


where, becoming heated, it is conducted through iron pipes *s*, and thence escapes at *t*, into the stove-room. Upon both sides of the hot flues in the stove-room, hurdle-frames *u*, *u*, are laid, each of which contains 11 baskets, and every basket, except the undermost, holds 60 pounds of salt, spread 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. 968.

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.

968



In proportion as the brine becomes concentrated by evaporation, more is added from the settling reservoir of the graduation-house, till finally small crystals appear on the surface. No more weak brine is now added, but the charge is worked off, care being taken to remove the scum as it appears. In some places the first pan is called a schlot-plan, in which the concentration is carried only so far as to cause the deposition of the sludge, from which the saline solution is run into another pan, and gently evaporated, to produce the precipitation of the fine salt. This salt should be continually raked towards the cooler and more elevated sides of the pan, and then lifted out with cullender-shovels into large conical baskets, arranged in wooden frames round the border of the pan, so that the drainage may flow back into the boiling liquor. The drained salt is transferred to the hurdles or baskets in the stove-room, which ought to be kept at a temperature of from 120° to 130° Fahr. The salt is then stowed away in the warehouse.

The graduation range should be divided lengthwise into several sections; the first to receive the water of the spring, the lake, or the sea; the second, the water from the first shower-receiver; the third, the water from the second receiver; and so on. The pumps are usually placed in the middle of the building, and lift the brine from the several receivers below into the alternate elevated cisterns. The square wooden spouts of distribution may be conveniently furnished with a slide-board, attached to each of their sides, to serve as a general valve for opening or shutting many trickling orifices at once. The rate of evaporation at Moutiers is exhibited by the following table:—

Number of Showers.	Total Surface of the Fagots.	Specific Gravity of the Brine.	Water evaporated.
		1·010	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 -			1·065
Water assigned at the density of 1·010 - -			1·000

From the above table it appears that no less than 10 falls of the brine have been required to bring the water from the specific gravity 1·010 to 1·140, or 18° Baumé. The evaporation is found to proceed at nearly the same rate with the weaker water, and with the stronger, within the above limits. When it arrives at a density of from 1·140 to 1·16, it is run off into the settling cisterns. M. Berthier calculates, that upon an average, in ordinary weather, at Moutiers, 60 kilogrammes of water (13 gallons, imp.) are evaporated from the fagots, in the course of 24 hours, for every square foot of their surface. Without the aid of currents of air artificially warmed, such an amount of evaporation could not be reckoned upon in this country. In the *schlotting*, or throwing down of the sediment, a little bullock's blood, previously beaten up with some cold brine, promotes the clarification. When the brine acquires, by brisk ebullition, the density of 1·200, it should be run off from the preparation, to the finishing or salting pans.

The mother-water contains a great deal of chloride of magnesium, along with chloride of sodium, and sulphate of magnesia. Since the last two salts mutually decompose each other at a low temperature, and are transformed into sulphate of soda, which crystallizes, and muriate of magnesia, which remains dissolved, the mother-water with this view may be exposed in tanks to the frost during winter, when it affords three successive crystalline deposites, the last being sulphate of soda, nearly pure.

The chloride of magnesium, or bittern, not only deteriorates the salt very much, but occasions a considerable loss of weight. It may, however, be most advantageously got rid of, and converted into chloride of sodium, by the following simple expedient: — Let quicklime be introduced in equivalent quantity to the magnesia present, and it will precipitate this earth, and form chloride of calcium, which will immediately react upon the sulphate of soda in the mother-water, with the production of sulphate of lime and chloride of sodium. The former being sparingly soluble, is easily separated. Lime, moreover, decomposes directly the chloride of magnesium, but with the effect of merely substituting chloride of calcium in its stead. But in general there is abundance of sulphate of soda in brine springs to decompose the chloride of calcium. A still better way of proceeding with sea-water, would be to add to it, in the settling tank, the quantity of lime equivalent to the magnesia, whereby an available deposite of this earth would be obtained, at the same time that the brine would be sweetened. Water thus purified may be safely crystallized by rapid evaporation.

In summer, the saturated boiling brine is crystallized by passing it over vertical ropes; for which purpose 100,000 metres (110,000 yards) are mounted in an apartment 70 metres (77 yards) long. When the salt has formed a crust upon the ropes about 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 5 or 6 days in the pan, is completed in this way in 17 hours; but the mother-waters are more abundant. The salt is, however, remarkably pure.

The boilers constructed at Rosenheim, in Bavaria, evaporate 3½ pounds of water for every pound of wood burned; which is reckoned a favorable result; but some of those described under EVAPORATION, would throw off much more.

" The rock salt mines and principal brine springs are in Cheshire; and the chief part of the Cheshire salt, both fossil and manufactured, is sent by the river Weaver to Liverpool, a very small proportion of it being conveyed elsewhere, by canal or land carriage. There are brine springs in Staffordshire, from which Hull is furnished with white salt; and in Worcestershire, from which Gloucester is supplied. If to the quantity shipped by the Weaver, 100,000 tons of white salt are added annually for internal consumption and exports, exclusive of Liverpool, the total manufacture will be approached very nearly; but as there is now no check from the excise, it is impossible to ascertain it exactly. Fossil salt is used in small quantities at some of the Cheshire manufactories, to strengthen the brine, but is principally exported; some to Ireland, but chiefly to Belgium and Holland."* The average quantity of rock salt sent annually down the river Weaver from the mines in Cheshire, between the years 1803 and 1834 inclusive, was 86,000 tons, of 2,600 lbs. each; the greatest being 125,658, in the year 1823, and the least 47,230, in the year 1813. The average quantity of white salt sent annually down the Weaver from the manufactories in Cheshire during the same period, was 221,351; the greatest being 383,669, in the year 1832, and the least being 120,486, in the year 1811.

M. Clement-Desormes, engineer and chief *actionnaire* of the great salt-works of Dieuze, in France, informs me that 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 10 sous per kilogramme (of 2½ lbs. avoird.), while in this country it is not more than 2 sous (1 penny), its consumption per head will be much greater with us; and, taking into account the immense quantity of salted provisions that are used, it may be reckoned at 22 lbs.; whence our internal consumption will be 240,000 tons, instead of 100,000, as quoted above, from the tables published by the Board of Trade.

In 1836, 9,622,427 bushels, of 56 lbs. = 240,560 tons of salt, value 173,923*l*., were exported from the United Kingdom, of which 1,350,849 bushels went to Russia; 1,235,086 to Belgium; 314,132 to the Western coast of Africa; 1,293,560 to the British North American colonies; 2,870,808 to the United States of America; 53,299 to New South Wales, Van Diemen's Land, and other Australian settlements; 58,735 to the British West Indies; and 90,655 to Guernsey, Jersey, Alderney, and Man.

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 silicious sands seem to be either original crystalline formations, like the sand of Neuilly, in 6-sided prisms, terminated by two 6-sided pyramids, or the *débris* of granitic, schistose, quartzose, or other primitive crystalline rocks, and are abundantly distributed over the globe; as in the immense plains known under the names of downs, deserts, *steppes*, *landes*, &c., which, in Africa, Asia, Europe, and America, are entirely covered with

* Tables of the Revenue, Population, Commerce, &c.. for 1835, p. 122.

loose sterile sand. Valuable metallic ores, those of gold, platinum, tin, copper, iron, titanium, often occur in the form of sand, or mixed with that earthy substance. Pure silicious sands are very valuable for the manufacture of glass, for making mortars, filters, ameliorating dense clay soils, and many other purposes. For moulder's sand, See FOUNDING. Lynn and Ryegate furnish our purest silicious sand.

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 coloring matter is of a resinous nature; and is, therefore, quite soluble in alcohol, essential oils, and alkaline leys; but sparingly in boiling water, and hardly if at all in cold water. The coloring 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 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 sumac. Pelletier did not succeed in repeating this experiment. According to Togler, wool, silk, cotton, and linen, mordanted with salt of tin, and dipped in a cold alcoholic tincture of the wood, or the same tincture mixed with 8 parts of boiling water, become of a superb ponçeau-red color. With alum, they took a scarlet-red; with sulphate of iron, a deep violet, or brown-red. Unluckily, these dyes do not stand exposure to light well.

SANDARACH, is a peculiar resinous substance, the product of the *Thuya articulata*, a small tree of the coniferous family, which grows in the northern parts of Africa, especially round Mount Atlas.

The resin comes to us in pale yellow, transparent, brittle, small tears, of a spherical or cylindrical shape. It has a faint aromatic smell, does not soften, but breaks between the teeth, fuses readily with heat, and has a specific gravity of from 1·05 to 1·09. It contains three different resins; one soluble in spirit of wine, somewhat resembling *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.

SAPAN 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. As all the species of this tree are natives of either the East Indies or the New World, one would imagine that they could not have been used as dye-stuffs in Europe before the beginning of the 16th century. Yet the author of the article "Brazil," in Rees' Cyclopædia, and Mr. Southey, in his History of Brazil, say that *Brazil* wood is mentioned nearly one hundred years before the discoveries of Columbus and Vasco de Gama, by Chaucer, who died in 1400; that it was known many ages before his time; and that it gave the name to the country, instead of the country giving the name to the wood, as I have stated, with Berthollet and other writers on dyeing. The *Cæsalpinia sappan*, being a native of the Coromandel coast, may *possibly* have been transported along with other Malabar merchandise to the Mediterranean marts in the middle ages; but the importation of so lumbering an article in any considerable quantity by that channel, is so improbable, that I am disposed to belive that Brazil wood was not commonly used by the dyers of Europe before the discovery of the New World.

SARD; see LAPIDARY.

SATIN (Eng., Fr., and Germ.), is the name of a silk stuff, first imported from China, which is distinguished 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 checkered work resulting from intermediate decussations, as in common webs. See TEXTILE FABRICS. Satins are woven with the glossy or right side undermost, because the four-fifths of the warp, which are always left there during the action of the healds, serve to support the shuttle in its race. Were they woven in the reverse way, the scanty fifth part of the warp threads could either not support, or would be too much worn by the shuttle.

SATURATION is the term at which any body has taken its full dose or chemical proportion of any other with which it can combine; as water with a salt, or an acid with an alkali in the neutro-saline state.

SCALIOLA 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 colored gypsum, or veins of clay, in a semi-fluid state. The substances employed to color the spots and patches, are the several ochres, boles, *terra di Sienna*, chrome yellow, &c. The surface of the column is turned smooth upon a lathe, polished with stones of different fineness, and finished with some plaster-pap, to give it lustre. Pillars and other flat surfaces are smoothed by a carpenter's plane, with the chisel finely serrated, and afterwards polished with plaster by friction. The glue is the cause of the gloss, but makes the surface apt to be injured by moisture, or even damp air.

SCARLET DYE. (*Teinture en écarlate*, Fr.; *Scharlachfärberei*, Germ.) Scarlet is usually given at two successive operations. The boiler (see *figs.* 364, 365, article DYEING) is made of block tin, but its bottom is formed occasionally of copper.

1. *The bouillon, or the coloring-bath.*—For 100 pounds of cloth, put into the water, when it is little more than lukewarm, 6 pounds of argal, and stir it well. When the water becomes too hot for the hand, throw into it, with agitation, one pound of cochineal in fine powder. An instant afterwards, pour in 5 pounds of the clear mordant G (see TIN MORDANTS), stir the whole thoroughly as soon as the bath begins to boil, introduce the cloth, and wince it briskly for two or three rotations, and then more slowly. At the end of a two-hours' boil, the cloth is to be taken out, allowed to become perfectly cool, and well washed at the river, or winced in a current of pure water. (See an automatic plan of washing described under the article RINSING MACHINE.)

2. *The rougie, or finishing dye.*—The bouillon bath is emptied, and replaced with water for the *rougie*. When it is on the point of boiling, 5½ pounds of cochineal in fine powder are to be thrown in, and mixed with care; when the crust, which forms upon the surface, opens of itself in several places, 14 pounds of solution of tin (as above) are to be added. Should the liquor be likely to boil over the edges of the kettle, it must be refreshed with a little cold water. When the bath has become uniform, the cloth is to be put in, taking care to wince it briskly for two or three turns; then to boil it bodily for an hour, thrusting it under the liquor with a rod whenever it rises to the surface. It is lastly taken out, aired, washed at the river, and dried.

As no person has done more for the improvement of the scarlet dyes than Poërner, I shall here give his processes in detail.

Bouillon, or coloring.—For every pound of cloth or wool, take 14 drachms of cream of tartar. When the bath is boiling, and the tartar all dissolved, pour in successively 14 drachms of solution of tin (*Mordant* F, TIN), and let the whole boil together during a few minutes. Now introduce the cloth, and boil it for 2 hours; then take it out, and let it drain and cool.

Rougie, or dye.—For every pound of woollen stuff, take 2 drachms of cream of tartar. When the bath begins to boil, add 1 ounce of cochineal reduced to fine powder, stir the mixture well with a rod of willow or any white wood, and let it boil for a few minutes. Then pour in, by successive portions, 1 ounce of solution of tin (*Mordant* F), stirring continually with the rod. Lastly, dye as quickly as possible. The color will be a beautiful scarlet.

Second scarlet process of Poërner, the *bouillon* being the same as above given, and always estimated for 1 pound of cloth or wool. *Rougie.*—Take 1 ounce of cochineal in fine powder, and 2 ounces of solution of tin without tartar.

Third scarlet process of Poërner; the *bouillon* being as above. *Rougie* for a pound of cloth.—Take two drachms of cream of tartar, one ounce of cochineal, one ounce of solution of tin, and 2 ounces of sea salt; dye as in process 1. The salt helps the dye to penetrate into the cloth.

TABLES of the COMPOSITION of the BOUILLON and ROUGIE, by different Authors, for 100 pounds of Cloth or Wool.

Composition of the Bouillon.

Names of the Authors.	Starch.		Cream of Tartar.		Cochineal.		Solution of Tin.		Common Salt.	
	lb.	*oz.*	*lb.*	*oz.*	*lb.*	*dr.*	*lb.*	*oz.*	*lb.*	*oz.*
Berthollet - -	0	0	6	0	8	0	5	0	0	0
Hellot - -	0	0	12	8	18	6	12	8	0	0
Scheffer - -	9	6	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
Poërner -	0	0	1	8	6	4	6	4	0	0
	0	0	0	0	6	4	12	8	0	0
	0	0	1	8	6	4	6	4	12	8

M. Lenormand states that he has made experiments of verification upon all the formulæ of the preceding tables, and declares his conviction that the finest tint may be obtained by taking the *bouillon* of Scheffer, and the *rougie* No. 4 of Poërner. The solution which produced the most brilliant red, is that made according to the process of mordant B (TIN.) M. Robiquet has given the following prescription for making a *printing scarlet,* for well-whitened woollen cloth.

Boil a pound of pulverized cochineal in four pints of water down to 2 pints, and pass the decoction through a sieve. Repeat the boiling three times upon the residuum, mix the eight pints of decoction, thicken them properly with two pounds of starch, and boil into a paste. Let it cool down to 104° F., then add four ounces of the subjoined solution of tin, and two ounces of ordinary salt of tin (muriate.) When a ponçeau red is wanted, two ounces of pounded curcuma (turmeric) should be added.

The solution of tin above prescribed, is made by taking—one ounce of nitric acid, of specific gravity 36° B, = 1·33; one ounce of sal ammoniac; four ounces of grain tin. The tin is to be divided into eight portions, and one of them is to be put into the acid mixture every quarter of an hour.

A solution of chlorate of potassa (chloride ?) is said to beautify scarlet cloth in a remarkable manner.

Bancroft proposed to supplant the nitro-muriatic acid, by a mixture of sulphuric and muriatic acids, for dissolving tin; but I do not find that he succeeded in persuading scarlet-dyers to adopt his plans. In fact, the proper base is, in my opinion, a mixture of the protoxyde and peroxyde of tin; and this cannot be obtained by acting upon the metal with the murio-sulphuric acid. He also prescribed the extensive use of the quercitron yellow to change the natural crimson of the cochineal into scarlet, thereby economizing the quantity of this expensive dye-stuff. See LAC DYE.

SCHEELE'S GREEN is a pulverulent arsenite of copper, which may be prepared as follows:—Form, first, an arsenite of potassa, by adding gradually 11 ounces of arsenious acid to 2 pounds of carbonate of potassa, dissolved in 10 pounds of boiling water; next, dissolve 2 pounds of crystallized sulphate of copper in 30 pounds of water; filter each solution, then pour the first progressively into the second, as long as it produces a rich grass-green precipitate. This being thrown upon a filter-cloth, and edulcorated with warm water, will afford 1 pound 6 ounces of this beautiful pigment. It consists of, oxyde of copper 28·51, and of arsenious acid 71·46. This green is applied by an analogous double decomposition to cloth. See CALICO-PRINTING.

SCHWEINFURTH GREEN is a more beautiful and velvety pigment than the preceding, which was discovered in 1814, by 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 color-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 oxyde of copper, in a peculiar state; since when decomposed by sulphuric acid, no acetic odor is exhaled. Its color 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 color, as well as its state of aggregation, and forms a new deposite in the form of a dense granular beautiful green powder. As fine a color 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 color 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 crystallization. Thus the reaction continues during two or three days with the happiest effect. The difference of tint produced by these variations, arises merely from the different sizes of the crystalline particles; for when the several powders are levigated upon a porphyry slab to the same degree, they have the same shade. Schweinfurth green, according to M. Ehrmann's researches, in the 31st *Bulletin de la Société Industrielle de Mulhausen*, consists of, oxyde 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 color. 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 colors are rank poisons. The first was detected a few years ago, as the coloring-matter of some Parisian *bonbons*, by the *conseil de salubrité;* since which the confectioners were prohibited from using it, by the French government.

SCOURING, *or renovating articles of dress.* This art has been much more studied by Frenchmen, who wear the same coats for two or three years, than by Englishmen, who generally cast them off after so many months. The workmen who remove greasy stains from dress, are called, in France, *teinturiers-degraisseurs*, because they are often obliged to combine dyeing with scouring operations. The art of cleansing clothes being founded upon the knowledge of solvents, the practitioner of it should, as we shall presently illustrate by examples, be acquainted with the laws of chemical affinity.

Among the spots which alter the colors fixed upon stuffs, some are caused by a substance which may be described as *simple*, in common language; and others by a substance which results from the combination of two or more bodies, that may act separately or together upon the stuff, and which may therefore be called *compound.*

Simple stains.— Oils and fats are the substances which form the greater part of simple stains. They give a deep shade to the ground of the cloth; they continue to spread for several days; they attract the dust, and retain it so strongly, that it is not removeable by the brush; and they eventually render the stain lighter colored upon a dark ground, and of a disagreeable gray tint upon a pale or light ground.

The general principle of cleansing all spots, consists in applying to them a substance which shall have a stronger affinity for the matter composing them, than this has for the cloth, and which shall render them soluble in some liquid menstruum, such as water, spirits, naptha, oil of turpentine, &c. See Bleaching.

Alkalis would seem to be proper in this point of view, as they are the most powerful solvents of grease; but they act too strongly upon silk and wool, as well as change too powerfully the colors of dyed stuffs, to be safely applicable in removing stains. The best substances for this purpose are—1. Soap. 2. Chalk, fuller's earth, soap-stone or steatite (called in this country French chalk). These should be merely diffused through a little water into a thin paste, spread upon the stain, and allowed to dry. The spot requires now to be merely brushed. 3. Ox-gall and yolk of egg have the property of dissolving fatty bodies without affecting perceptibly the texture or colors of cloth, and may therefore be employed with advantage. The ox-gall should be purified, to prevent its greenish tint from degrading the brilliancy of dyed stuffs, or the purity of whites. Thus prepared (see Gall), it is the most precious of all substances known for removing these kinds of stains. 4. The volatile oil of turpentine will take out only recent stains; for which purpose it ought to be previously purified by distillation over quicklime. Wax, rosin, turpentine, pitch, and all resinous bodies in general, form stains of greater or less adhesion, which may be dissolved out by pure alcohol. The juices of fruits, and the colored juices of all vegetables in general, deposite upon clothes marks in their peculiar hues. Stains of wine, mulberries, black currants, morellos, liquors, and weld, yield only to soaping with the hand, followed by fumigation with sulphurous acid; but the latter process is inadmissible with certain colored stuffs. Iron mould or rust stains may be taken out almost instantaneously with a strong solution of oxalic acid. If the stain is recent, cream of tartar will remove it.

Compound spots. — That mixture of rust of iron and grease called *cambouis* by the French, is an example of this kind, and requires two distinct operations; first, the removal of the grease, and then of the rust, by the means above indicated.

Mud, especially that of cities, is a compound of vegetable remains, and of ferruginous matter in a state of black oxyde. Washing with pure water, followed if necessary with soaping, will take away the vegetable juices; and then the iron may be removed with cream of tartar, which itself must, however, be well washed out. Ink stains, when recent, may be taken out by washing, first with pure water, next with soapy water, and lastly with lemon juice; but if old, they must be treated with oxalic acid. Stains occasioned by smoke, or by sauces browned in a frying-pan, may be supposed to consist of a mixture of pitch, black oxyde of iron, empyreumatic oil, and some saline matters dissolved in pyroligneous acid. In this case several reagents must be employed to remove the stains. Water and soap dissolve perfectly well the vegetable matters, the salts, the pyroligneous acid, and even the empyreumatic oils in a great measure; the essence of turpentine will remove the rest of the oils and all the pitchy matter; then oxalic acid may be used to discharge the iron. Coffee stains require a washing with water, with a careful soaping, at the temperature of 120° F., followed by sulphuration. The two latter processes may be repeated twice or thrice. Chocolate stains may be removed by the same means, and more easily.

As to those stains which change the color of the stuff, they must be corrected by appropriate chemical reagents or dyes. When black or brown cloth is reddened by an acid, the stain is best counteracted by the application of water of ammonia. If delicate silk colors are injured by soapy or alkaline matters, the stains must be treated with colorless vinegar of moderate force. An earthy compound for removing grease spots is made as follows: — Take fuller's earth, free it from all gritty matter by elutriation with water; mix with half a pound of the earth so prepared, half a pound of soda, as much soap, and eight yolks of eggs well beat up with half a pound of purified ox-gall. The whole must be carefully triturated upon a porphyry slab; the soda with the soap in the same manner as colors are ground, mixing in gradually the eggs and the ox-gall previously beat together. Incorporate next the soft earth by slow degrees, till a uniform thick paste be formed, which should be made into balls or cakes of a convenient size, and laid out to dry. A little of this detergent being scraped off with a knife, made into a paste with water, and applied to the stain, will remove it. Purified ox-gall is to be diffused through its own bulk of water, applied to the spots, rubbed well into them with the hands till they disappear, after which the stuff is to be washed with soft water. It is the best substance for removing stains on woollen clothes.

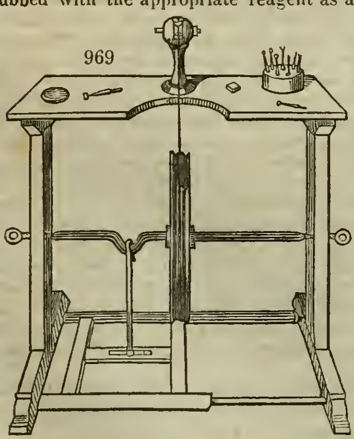
The redistilled oil of turpentine may also be rubbed upon the dry clothes with a sponge or a tuft of cotton till the spot disappear; but it must be immediately afterwards covered with some plastic clay reduced to powder. Without this precaution, a cloud would be formed round the stain, as large as the part moistened with the turpentine.

Oxalic acid may be applied in powder upon the spot previously moistened with water, well rubbed on, and then washed off with pure water.

Sulphurous acid is best generated at the moment of using it. If the clothes be much stained, they should be suspended in an ordinary fumigating chamber. For trifling stains, the sulphur may be burned under the wide end of a small card or paper funnel, whose upper orifice is applied near the cloth.

Manipulations of the scourer. — These consist, first, in washing the clothes in clear soft water, or in soap-water. The cloth must be next stretched on a sloping board, and rubbed with the appropriate reagent as above described, either by a sponge or a small hard brush. The application of a redhot iron a little way above a moistened spot often volatilizes the greasy matter out of it. Stains of pitch, varnish, or oil paint, which have become dry, must first be softened with a little fresh butter or lard, and then treated with the powder of the scouring ball. When the gloss has been taken from silk, it may be restored by applying the filtered mucilage of gum tragacanth; stretching it upon a frame to dry. Ribands are glossed with isinglass. Lemon juice is used to brighten scarlet spots, after they have been cleaned.

969



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.

972

Fig. 969 represents the whole of the sea 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.* 970 a hollow cylinder, for describing circles, and for boring; *fig.* 971 a knobbed tool, or rod terminated by a small ball; *fig.* 972 a stem terminated with a cutting disc, whose edge may be either rounded, square, or sharp; being in the last case called a saw.

Having fixed the tool best adapted to his style of work in the mill, the artist applies to its cutting point, or edge, some diamond-powder, mixed up with olive oil; and turning the wheel, he holds the stone against the tool, so as to produce the wished-for delineation and erosion. A similar apparatus is used for engraving on glass.

In order to give the highest degree of polish to the engraving, tools of boxwood, pewter, or copper, bedaubed with moistened tripoli or rotten-stone, and lastly, a brush, are fastened to the mill. These are worked like the above steel instruments. Modern engravings on precious stones have not in general the same fine polish as the ancient. The article GEMS, in Rees' Cyclopædia, contains a variety of valuable information on this subject, equally interesting to the artist and the scholar.

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 shellac be compounded into sealing-wax, immediately after it has been separated by fusion from the palest qualities of stick or seed lac, it then forms a better and less brittle article, than when the shellac is fused a second time. Hence sealing-wax, rightly prepared in the East Indies, deserves a preference over what can be made in other countries, where the lac is not indigenous. Shellac can be restored in some degree, however, to a plastic and tenacious state by melting it with a very small portion of turpentine. The palest shellac is to be selected for bright-colored sealing-wax, the dark kind being reserved for black.

The following prescription may be followed for making red sealing-wax: — Take 4 ounces of shellac, 1 ounce of Venice turpentine (some say 1½ ounces), and 3 ounces of vermilion. Melt the lac in a copper pan suspended over a clear charcoal fire, then pour the turpentine slowly into it, and soon afterwards add the vermilion, stirring briskly all the time of the mixture with a rod in either hand. In forming the round sticks of sealing-wax, a certain portion of the mass should be weighed while it is ductile, divided into the desired number of pieces, and then rolled out upon a warm marble slab, by means of a smooth wooden block, like that used by apothecaries for rolling a mass of pills. The oval sticks of sealing-wax are cast in moulds, with the above compound in a state of fusion. The marks of the lines of junction of the mould-box may be afterwards removed by holding the sticks over a clear fire, or passing them over a blue gas-flame. Marbled sealing-wax is made by mixing two, three, or more colored 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-colored 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 coloring-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.

SEA WATER, is composed as follows, according to the author of the article *Salines*, in the *Dictionnaire Technologique*: — Chloride of sodium, 2·50; chloride of magnesium, 0·35; sulphate of magnesia, 0·58; carbonates of lime and magnesia, 0·02; sulphate of lime, 0·01; water, 96·54, in 100 parts. See SALT, SEA.

SEGGAR, or SAGGER, is the cylindric case, of fire-clay, in which fine stoneware is enclosed while being baked in the kiln.

SELENIUM, from Σελήνη, the moon, is a metalloid 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 peculiar pyrites, or pyritous sulphur. The extraction of selenium from that deposite is a very complex process.

Selenium, after being fused and slowly cooled, appears of a bluish-gray color, with a glistening surface; but it is reddish brown, and of metallic lustre when quickly cooled.

It is brittle, not very hard, and has little tendency to assume the crystalline state. Selenium is dark-red in powder, and transparent, with a ruby cast, in thin scales. Its specific gravity is 4·30. It softens at the temperature of 176° F., is of a pasty consistence at 212°, becomes liquid at a somewhat higher heat, forming in close vessels dark-yellow vapors, which condense into black drops; but in the air, the fumes have a cinnabar-red color.

This singular substance, apparently intermediate in its constitution between sulphur and metals, has not hitherto been applied to any use in the arts.

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

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 color; the sac containing it being extracted, the juice is to be dried as quickly as possible, because it runs rapidly into putrefaction. Though insoluble in water, it is extremely diffusible through it, and is very slowly deposited. Caustic alkalis dissolve the sepia, and turn it brown; but in proportion as the alkali becomes carbonated by exposure to air, the sepia falls to the bottom of the vessel. Chlorine 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 ley, then adding more ley, 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 color, and a fine grain.

SEPTARIA, called anciently *ludus Helmontii*, (the *quoits* of Van Helmont, from their form,) are lenticular concretions of clay ironstone, intersected by veins of calc-spar, which, when calcined, and ground to powder, form an excellent hydraulic cement. See MORTAR, HYDRAULIC.

SERPENTINE, is a mineral of the magnesian family, of a green color; it is scratched by calcareous spar, is sectile, tough, and therefore easily cut into ornamental forms. It occurs in Unst and Fetlar, in Shetland; at Portsoy, in Banffshire; in Cornwall; and the Isle of Holyhead. The floors of bakers' ovens are advantageously laid with slabs of serpentine.

SHAFT, in mining, signifies a perpendicular or slightly inclined pit.

SHAGREEN. (*Chagrin*, Fr. and Germ.) The true oriental shagreen is essentially different from all modifications of leather and parchment. It approaches the latter somewhat, indeed, in its nature, since it consists of a dried skin, not combined with any tanning or foreign matter whatever. Its distinguishing characteristic is having the grain or hair side covered over with small rough round specks or granulations.

It is prepared from the skins of horses, wild asses, and camels; of strips cut along the chine, from the neck towards the tail, apparently because this stronger and thicker portion of the skin is best adapted to the operations about to be described. These fillets are to be steeped in water till the epidermis becomes loose, and the hairs easily come away by the roots; after which they are to be stretched upon a board, and dressed with the currier's fleshing-knife. They must be kept continually moist, and extended by cords attached to their edges, with the flesh side uppermost upon the board. Each strip now resembles a wet bladder, and is to be stretched in an open square wooden frame by means of strings tied to its edges, till it be as smooth and tense as a drum-head. For this purpose it must be moistened and extended from time to time in the frame.

The grain or hair side of the moist strip of skin must next be sprinkled over with a kind of seeds called *Allabuta*, which are to be forced into its surface either by tramping with the feet, or with a simple press, a piece of felt or other thick stuff being laid upon the seeds. These seeds belong probably to the *Chenapodium album*. They are lenticular, hard, of a shining black color, 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 sometimes been marked with prominent figures in this way. Now shagreen is treated in a similar manner.

The strip of skin is stretched in an inclined plane, with its upper edge attached to hooks, and its under one loaded with weights, in which position it is thinned off with a proper semi-lunar knife, but not so much as to touch the bottom of the seed-pits or depressions. By maceration in water, the skin is then made to swell, and the pits become prominent over the surface which had been shaved. The swelling is completed by steeping the strips in a warm solution of soda, after which they are cleansed by the action of salt brine, and then dyed.

In the East the following processes are pursued. Entirely white shagreen is obtained by imbuing the skin with a solution of alum, covering it with the dough made with Turkey wheat, and after a time washing this away with a solution of alum. The strips are now rubbed with grease or suet, to diminish their rigidity, then worked carefully in hot water, curried with a blunt knife, and afterwards dried. They are died 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.

SHALE, or SLATE CLAY, is an important stratiform member of the coal-measures. See PITCOAL.

SHAMOY LEATHER. See LEATHER.

SHEATHING OF SHIPS. For this purpose many different metals and metallic alloys have been lately proposed. From a train of researches which I made for an eminent copper company, a few years ago, upon various specimens of sheathing which had been exposed upon ships during many voyages, it appeared that copper containing a minute but definite proportion of tin, was by far the most durable.

SHELLAC. See LAC, and SEALING-WAX.

SIENITE is a granular aggregated compound rock, consisting of feldspar and hornblende, sometimes mixed with a little quartz and mica. The hornblende is the characteristic ingredient, and serves to distinguish sienite from granite, with which it has been sometimes confounded; though the feldspar, which is generally red, is the more abundant constituent. The Egyptian sienite, containing but little hornblende, with a good deal of quartz and mica, approaches most nearly to granite. It is equally metalliferous with porphyry; in the island of Cyprus, it is rich in copper; and in Hungary, it contains many valuable gold and silver mines.

Sienite forms a considerable part of the Criffle, a hill in Galloway. It takes its name from the city of Syene, in the Thebaid, near the cataracts of the Nile, where this rock abounds. It is an excellent building-stone, and was imported in large quantities from Egypt by the Romans, for the architectural and statuary decorations of their capital.

SILICA and SILICON. (*Silice, silicium*, Fr.; *Kieselerde, kiesel*, Germ.) Silica was till lately ranked among the earths proper; but since the researches of Davy and Berzelius, it has been transferred to the chemical class of acids. It constitutes the principal portion of most of the hard stones and minerals which compose the crust of the globe; occurring nearly pure in rock crystal, quartz, agate, calcedony, flint, &c. Silica or silicic acid may be obtained perfectly pure, and also in the finest state of comminution, by taking the precipitate formed by passing silicated fluoric gas through water, filtering, washing, and igniting it, to expel the last traces of the fluoride of silicon. The powder thus obtained is so light as to be blown away with the least breath of air. Silica may be more conveniently procured, however, by fusing ground flint with four times its weight of a mixture, in equal parts, of dry carbonate of potassa and carbonate of soda, in a platinum or silver crucible. The alkaline carbonates should be first fused, and the flint powder sprinkled into the liquid, as long as it dissolves with effervescence. The mass is to be then allowed to cool, dissolved in dilute muriatic acid; the solution is to be filtered, and evaporated to dryness; the dry crust is to be pulverized, digested for two hours with a little muriatic acid, to remove any iron and alumina that may be present, next washed with hot water, drained, dried, and ignited.

The above silicate of potassa and soda is the compound called soluble glass, which applied in solution to the surface of wood, calico, paper, &c., renders them unsusceptible of taking fire on the contact of an ignited body.

Silica, as thus prepared, is a white powder, rough to the touch, gritty between the teeth, absolutely insoluble in water, acids, and most liquids. Its specific gravity is 2·66. It cannot be fused by the most intense heat of our furnaces, but at the flame of the oxy-hydrogen blowpipe it melts into a limpid colorless glass. By peculiar chemical methods, an aqueous solution of it may be made artificially, similar to what nature presents us with in many thermal springs, as in those of Reikum and of Geyser in Iceland, and of most mineral waters, in minute quantity. There is no acid except the fluoric which can directly dissolve dry or calcined silica. Silica is composed of 48·04 silicon, and 51·96 oxygen.

SILICATES are compounds of silicic acid (silica), with the bases alumina, lime, magnesia, potassa, soda, &c. They constitute the greater number by far of the hard minerals which incrust the terrestrial globe. Thus cyanite is a subsilicate of alumina; feldspar and leucite, are silicates of alumina and potassa; albite and analcime, are silicates of alumina and soda; stilbite, prehnite, mesolite, labradorite, tourmaline, mica, &c., are silicates of alumina and lime; chrysolite, steatite, serpentine, and meerschaum, are silicates of magnesia; augite and hornblende, are silicates of lime and magnesia, &c.

SILICON, called also silicium, may be obtained by burning potassium in silicated fluoric gas. The product of the combustion is a brown cinder, which, on being thrown into water, disengages hydrogen with violence, and lets fall a dark liver-brown powder, upon which water exercises no action. This matter is silicon mixed with a salt of difficult solution, which is composed of fluorine, potassium, and silicon. This salt may, however, be removed by a great deal of washing. The further details of this curious subject will be given in my forthcoming system of chemistry.

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 and other textile artisans. The threads, as spun by the silkworm, 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 a single.

The specific gravity of silk is 1·300, water being 1·000. It is by far the most tenacious or the strongest of all textile fibres, a thread of it of a certain diameter being nearly three times stronger than a thread of flax, and twice stronger than hemp. Some varieties of silk are perfectly white, but the general color in the native state is a golden yellow.

The production of silk was unknown in Europe till the sixth century, when two monks, who brought some eggs of the silkworm from China or India to Constantinople, were encouraged to breed the insect, and cultivate its cocoons, by the Emperor Justinian. Several silk manufactures were in consequence established in Athens, Thebes, and Corinth, not only for rearing the worm upon mulberry-leaves, but for unwinding its cocoons, for twisting their filaments into stronger threads, and weaving these into robes. The Venetians having then and long afterwards intimate commercial relations with the Greek empire, supplied the whole of western Europe with silk goods, and derived great riches from the trade.

About 1130, Roger II., king of Sicily, set up a silk manufacture at Palermo, and another in Calabria, conducted by artisans whom he had seized and carried off as prisoners of war in his expedition to the Holy Land. From these countries, the silk industry soon spread throughout Italy. It seems to have been introduced into Spain at a very early period, by the Moors, particularly in Murcia, Cordova, and Granada. The last town, indeed, possessed a flourishing silk trade when it was taken by Ferdinand in the 15th century. The French having been supplied with workmen from Milan, commenced, in 1521, the silk manufacture; but it was not till 1564 that they began successfully to produce the silk itself, when Traucat, a working gardener at Nismes, formed the first nursery of white mulberry-trees, and with such success, that in a few years he was enabled to propagate them over many of the southern provinces of France. Prior to this time, some French noblemen, on their return from the conquest of Naples, had introduced a few silkworms with the mulberry into Dauphiny; but the business had not prospered in their hands. The mulberry plantations were greatly encouraged by Henry IV.; and since then they have been the source of most beneficial employment to the French people. James I. was most solicitous to introduce the breeding of silkworms into England, and in a speech from the throne he earnestly recommended his subjects to plant mulberry-trees; but he totally failed in the project. This country does not seem to be well adapted for this species of husbandry, on account of the great prevalence of blighting east winds during the months of April and May, when the worms require a plentiful supply of mulberry-leaves. The manufacture of silk goods, however, made great progress during that king's peaceful and pompous reign. In 1629 it had become so considerable in London, that the silk-throwsters of the city and suburbs were formed into a public corporation. So early as 1661, they employed 40,000 persons. The revocation of the edict of Nantes, in 1685, contributed in a remarkable manner to the increase of the English silk trade, by the influx of a large colony of skilful French weavers, who settled in Spitalfields. The great silk-throwing mill mounted at Derby, in 1719, also served to promote the extension of this branch of manufacture; for soon afterwards, in the year 1730, the English silk goods bore a higher price in Italy than those made by the Italians, according to the testimony of Keysler.

Till the year 1826, however, our silk manufactures in general labored under very grievous fiscal burdens. Foreign organzine, or twisted raw silk, paid an import duty of 14*s*. 7½*d*. per pound; Raw Bengal silk, 4*s*.; and that from other places, 5*s*. 7½*d*. Mr. Huskisson introduced a bill at that time, reducing the duty on organzine to 5*s*., and the duty on other raw silk to 3*d*. per pound. The total prohibition of the import of French manufactured silks, which gave rise to so much contraband trade, was also converted into a duty of 30 per cent. *ad valorem*. During the reign of the prohibitory system, when our silk weavers had no variety of patterns to imitate, and no adequate stimulus to excel, on account of the monopoly which they possessed in the home market, the inferiority of their productions was a subject of constant pride and congratulation among the Lyonnais; and accordingly the English could not stand their competition any where. At that time, the disadvantage on English silk goods, compared to French, was estimated in foreign markets at 40 per cent.; of late years it certainly does not exceed 20, notwithstanding the many peculiar facilities which France enjoys for this her favorite staple.

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 cerements, and comes forth furnished with appropriate wings, antennæ, and feet, for living in its new element, the atmosphere. The male and the female moths couple together at this time, and terminate their union by a speedy death, their whole existence being limited to two months. The cocoons are completely formed in the course of three or four days; the finest being reserved as seed worms. From these cocoons, after an interval of 18 or 20 days, the moth makes its appearance, perforating its tomb by knocking with its head against one end of the cocoon, after softening it with saliva, and thus rendering the filaments more easily torn asunder by its claws. Such moths or aurelias are collected and placed upon a piece of soft cloth, where they couple and lay their eggs.

The eggs, or grains, as they are usually termed, are enveloped in a liquid which causes them to adhere to the piece of cloth or paper on which the female lays them. From this glue they are readily freed, by dipping them in cold water, and wiping them dry. They are best preserved in the *ovum* state at a temperature of about 55° F. If the heat of spring advances rapidly in April, it must not be suffered to act on the eggs, otherwise it might hatch the caterpillars long before the mulberry has sent forth its leaves to nourish them. Another reason for keeping back their incubation is, that they may be hatched together in large broods, and not by small numbers in succession. The eggs are made up into small packets, of an ounce, or somewhat more, which in the south of France are generally attached to the girdles of the women during the day, and placed under their pillows at night. They are, of course, carefully examined from time to time. In large establishments, they are placed in an appropriate stove-room, where they are exposed to a temperature gradually increased till it reaches the 86th degree of Fahrenheit's scale, which term it must not exceed. Aided by this heat, nature completes her mysterious work of incubation in eight or ten days. The teeming eggs are now covered with a sheet of paper pierced with numerous holes, about one twelfth of an inch in diameter. Through these apertures the new-hatched worms creep upwards instinctively, to get at the tender mulberry leaves strewed over the paper.

The nursery where the worms are reared is called by the French a *magnanière;* it ought to be a well-aired chamber, free from damp, excess of cold or heat, rats, and other vermin. It should be ventilated occasionally, to purify the atmosphere from the noisome emanations produced by the excrements of the caterpillars and the decayed leaves. The scaffolding of the wicker-work shelves should be substantial; and they should be from 15 to 18 inches apart. A separate small apartment should be allotted to the sickly worms. Immediately before each moulting, the appetite of the worms begins to flag; it ceases altogether at that period of cutaneous metamorphosis, but revives speedily after the skin is fairly cast, because the internal parts of the animal are thereby allowed freely to develop themselves. At the end of the second age, the worms are half an inch long; and then should be transferred from the small room in which they were first hatched, into the proper apartment where they are to be brought to maturity and set to spin their balls. On occasion of changing their abode, they must be well cleansed from the litter, laid upon beds of fresh leaves, and supplied with an abundance of food every six hours in succession. In shifting their bed, a piece of network being laid over the wicker plates, and covered with leaves, the worms will creep up over them; when they may be transferred in a body upon the net. The litter, as well as the sickly worms, may thus be readily removed, without handling a single healthy one. After the third age, they may be fed with entire leaves; because they are now exceedingly voracious, and must not be subsequently stinted in their diet. The exposure of chloride of lime, spread thin upon plates, to the air of the *magnanière*, has been found useful in counteracting the tendency which sometimes appears of an epidemic disease among the silkworms, from the fetid exhalations of the dead and dying.

When they have ceased to eat, either in the fourth or fifth age, agreeably to the variety of the *bombyx*, and when they display the spinning instinct by crawling up among the twigs of heath, &c., they are not long of 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 one ounce and a quarter; but M. Folzer of Alsace obtained no less than 165 pounds. The silk obtained from a cocoon is from 750 to 1150 feet long. The varnish by which the coils are glued slightly together, is soluble in warm water.

The silk husbandry, as it may be called, is completed in France within six weeks from the end of April, and thus affords the most rapid of agricultural returns, requiring merely the advance of a little capital for the purchase of the leaf. In buying up cocoons, and in the filature, indeed, capital may be often laid out to great advantage. The most hazardous period in the process of breeding the worms, is at the third and fourth moulting; for upon the 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; and on the sixth day of the same age, they acquire their maximum voracity, devouring no less than 223 pounds. From this date their appetite continually decreases, till on the tenth day of this age they consume only fifty-six pounds. The space which they occupy upon the wicker tables, being at their birth only nine feet square, becomes eventually 239 feet. In general, the more food they consume, the more silk will they produce.

A mulberry-tree is valued, in Provence, at from 6*d*. to 10*d*.; it is planted out of the nursery at four years of age; it is begun to be stripped in the fifth year, and affords an increasing crop of leaves till the twentieth. It yields from 1 cwt. to 30 cwts. 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 cwts. of mulberry leaves, which cost upon an average 3 francs per cwt. in a favorable season. One ounce of eggs is calculated, as I have said, to produce from 80 to 100 pounds of cocoons, of the value of 1 fr. 52 centimes per pound, or 125 francs in whole. About 8 pounds of reeled raw silk, worth 18 francs a pound, are obtained from these 100 pounds of cocoons.

There are three denominations of raw silk; viz., organzine, *trame* (shute or tram), and floss. Organzine serves for the warp of the best silk stuffs, and is considerably twisted; 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 vigor, to the centre, where it finishes it, in a state of debility and exhaustion; because it can receive no food from the moment of its beginning to spin by spouting forth its silky substance. The winder is attentive to this progressive attenuation, and introduces the commencement of some cocoons to compensate for the termination of others. The quality of raw silk depends, therefore, very much upon the skill and care bestowed upon its filature. The softest and purest water should be used in the cocoon kettle.

The quality of the raw silk is determined by first winding off 400 ells of it, equal to 475 metres, round a drum one ell in circumference, and then weighing that length. The weight is expressed in grains, 24 of which constitute one denier; 24 deniers constitute one ounce; and 16 ounces make one pound, *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 in France requires, that all the silk tried by the *Condition* must be worked up into fabrics in that country.

In the Journal of the Asiatic Society of Bengal, for January, 1837, there are two very valuable papers upon silkworms; the first, upon those of Assam, by Mr. Thomas Hugon, stationed at Nowgong; the second by Dr. Helfer, upon those which are indigenous to India. Besides the *Bombyx mori*, the Doctor enumerates the following seven species, formerly unknown: — 1. The wild silkworm of the central provinces, a moth not larger than the *Bombyx mori*. 2. The Joree silkworm of Assam, *Bombyx religiosæ*, 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 *Koutkuri mooga*, in Assam. 6. Another *Saturnia*, from the neighborhood of Comercolly. 7. *Saturnia assamensis*, with a cocoon of a yellow-brown color, 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-colored. 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 color, and ranks next in value to the Mazankoory. There are generally five breeds of mooga worms in the year; 1. in January and February; 2. in May and June; 3. in June and July; 4. in August and September; 5. in October and November; the first and last being the most valuable.

The Assamese select for breeding, such cocoons only as have been begun to be formed in the largest number on the same day, usually the second or third after the commencement; those which contain males being distinguishable by a more pointed end. They are put in a closed basket suspended from the roof; the moths, as they come forth, having room to move about, after a day, the females (known only by their large body) are taken out, and tied to small wisps of thatching-straw, selected always from over the hearth, its darkened color 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 neighborhood 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.

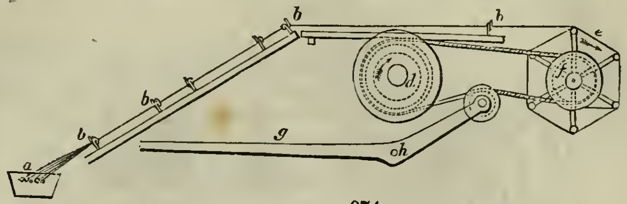
The cocoon of the *Koutkuri mooga* is of the size of a fowl's egg. It is a wild species, and affords filaments much valued for fishing-lines. See Silkworm Gut.

8. The *Arrindy*, or *Eria* worm, and moth, is reared over a great part of Hindostan, 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 that are laid the first three days, amounting to about 200, alone are kept; they are tied up in a cloth, and suspended to the roof till a few begin to hatch. These eggs are white, and of the size of turnip-seed. When a few of the worms are hatched, the cloths are put on small bamboo platters hung up in the house, in which they are fed with tender leaves. After the second moulting, they are removed to bunches of leaves suspended above the ground, beneath which a mat is laid to receive them when they fall. When they cease to feed, they are thrown into baskets full of dry leaves, among which they form their cocoons, two or three being often found joined together. Upon this injudicious practice I have already animadverted.

9. The *Saturnia trifenestrata* has a yellow cocoon of a remarkably silky lustre. It lives on the soom-tree in Assam, but seems not to be much used.

The mechanism of the silk filature, as lately improved in France, is very ingenious. *Figs.* 973 and 974 exhibit it in plan and longitudinal view. *a* is an oblong copper basin containing water heated by a stove or by steam. It is usually divided by transverse partitions into several compartments, containing 20 cocoons, of which there are 5 in one group, as shown in the figure. *b*, *b*, are wires with hooks or eyelets at their ends, through which the filaments run, apart, and are kept from ravelling. *c*, *c*, the points where the filaments cross and rub each other, on purpose to clean their surfaces. *d*, is a spiral groove, working upon a pin point, to give the traverse motion alternately to right and left, whereby the thread is spread evenly over the surface of the reel *e*. *f*, *f*, are the pulleys, which by means of cords transmit the rotatory movement of the cylinder *d*, to the reel *e*. *g*, is a friction lever or tumbler, for lightening or slackening the endless cord, in the act of starting or stopping the winding operation. Every apartment of a large filature contains usually a series of such reels as the above, all driven by one prime mover; each of which, however, may by means of the tumbling lever be stopped at

973



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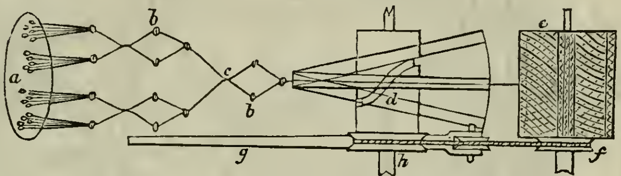


pleasure. The reeler is careful to remove any slight adhesions, by the application of a brush in the progress of her work.

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 is 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.

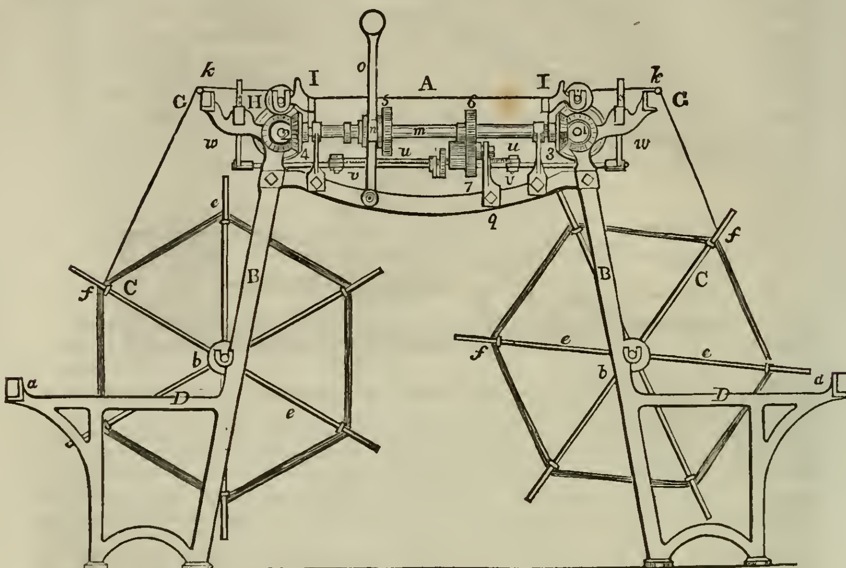
The raw silk, as imported into this country in hanks from the filatures, requires to be regularly wound upon bobbins, doubled, twisted, and reeled in our silk-mills. These processes are called *throwing* silk, and their proprietors are called silk *throwsters;* terms probably derived from the appearance of swinging or tossing which the silk threads exhibit during their rapid movements among the machinery of the mills.

A representation of a French mill for throwing silk, is given in the *Dictionnaire Technologique*, under the article *Moulinage de Soie*. But it is a most awkward, operose, and defective piece of machinery, quite unworthy of being presented to my readers. It was in Manchester that throwing-mills received the grand improvement upon the ancient Italian plan, which had been originally introduced into this country by Sir Thomas Lombe, and erected at Derby. That improvement is chiefly due to the eminent factory engineers, Messrs. Fairbairn and Lillie, who transferred to silk the elegant mechanism of the throstle, so well known in the cotton trade. Still, throughout the silk districts of France, the throwing mills are generally small, not many of them turning off more than 1000 pounds of organzine per annum, and not involving 5000*l*. of capital. The average price of throwing organzine in that country, where the throwster is not answerable for loss, is 7 francs; of throwing trame, from 4 fr. to 5 fr. (per kilogramme ?) Where the throwster is accountable for loss, the price is from 10 fr. to 11 fr. for organzine, and from 6 to 7 for trame. In Italy, throwing adds 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.

SILK-THROWING MILL.

The first process to which the silk is subjected, is winding the skeins, as imported, off upon bobbins. The mechanism which effects this winding off and on, is technically called the *engine*, or swift. The bobbins to which the silk is transferred, are wooden cylinders, of such thickness as may not injure the silk by sudden flexure, and which may also receive a great length of thread without having their diameter materially increased, or their surface velocity changed. *Fig.* 975 is an end view of the silk throwing machine, or *engine*, in which the two large hexagonal reels, called swifts, are

975



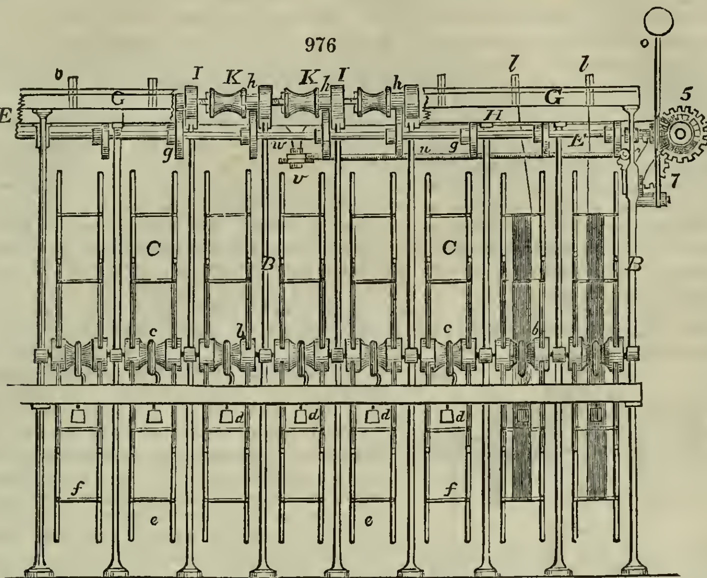
seen in section, as well as the table between them, to which the bobbins and impelling mechanism are attached. The skeins are put upon these reels, from which the silk is gradually unwound by the traction of the revolving bobbins. One principal object of attention, is to distribute the thread over the length of the bobbin-cylinder in a spiral or oblique direction, so that the end of the slender semi-transparent thread may be readily found when it breaks. As the bobbins revolve with uniform velocity, they would soon wind on too fast, were their diameters so small at first as to become greatly thicker when they are filled. They are therefore made large, are not covered thick, but are frequently changed. The motion is communicated to that end of the engine shown in the figure.

The wooden table A, shown here in cross section, is sometimes of great length, extending 20 feet, or more, according to the size of the apartment. Upon this the skeins are laid out. It is supported by the two strong slanting legs B, B, to which the bearings of the light reel c are made fast. These reels are called *swifts*, apparently by the same etymological casuistry as *lucus à non lucendo;* for they turn with reluctant and irregular slowness; yet they do their work much quicker than any of the old apparatus, and in this respect may deserve their name. At every eighth or tenth leg there is a projecting horizontal piece D, which carries at its end another horizontal bar *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.* 976, 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. 796 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.* 975 and 976, the structure of the swifts will be fully understood. From the wooden shaft *b*, six slender wooden (or iron) spokes *e*, *e*, proceed, at equal angles to each other; which are bound together by a cord *f*, near their free ends, upon the transverse line *f* of which cord, the silk thread is wound, in a hexagonal form; due tension being given to the circumferential cords, by sliding them out from the centre. Slender wooden rods are set between each pair of spokes, to stay them, and to keep the cord tight. E is one of the two horizontal shafts, placed upon each side of the *engine*, to which are affixed

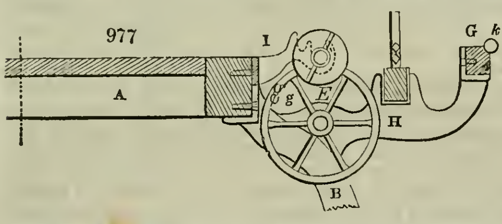
976



a number of light iron pulleys *g*, *g* (shown on a double scale in *fig*. 977. (These serve, by friction, to drive the bobbins which rest upon their peripheries.

To the table A, *fig*. 975, 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*. 981) 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*. 981), by which the bobbins K, K, are made fast to their respective spindles. 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.

977



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

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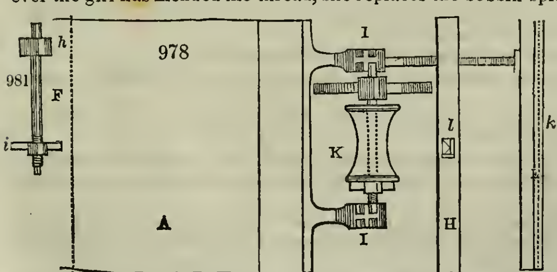
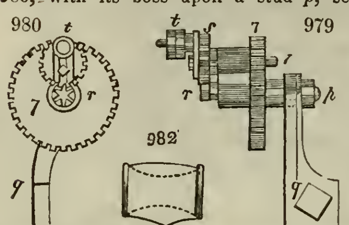
981



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*. 975, there are attached to the shafts E (*fig*. 976), 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*. 975. *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*. 975 and 976), 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*. 979 and 980, with its boss upon a stud *p*, secured to the bracket *q*. In an eccentric hole of the same boss, another stud *r*, revolves, upon which the little wheel *s*, is fixed. This wheel *s*, is in gear with a pinion cut upon the end of the fixed stud *p*; and upon it is screwed the little crank *t*, whose collar is connected by two rods *u* (*figs*. 975 and 976), 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*. 980, having moved the bar H through the whole extent of its traverse. The bobbins, when filled, have the appearance represented in *fig*. 982; 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. 983 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. 984 is a front view of a considerable portion of the machine.

Fig. 985 shows part of a cross section, to explain minutely the mode of winding upon a single bobbin.

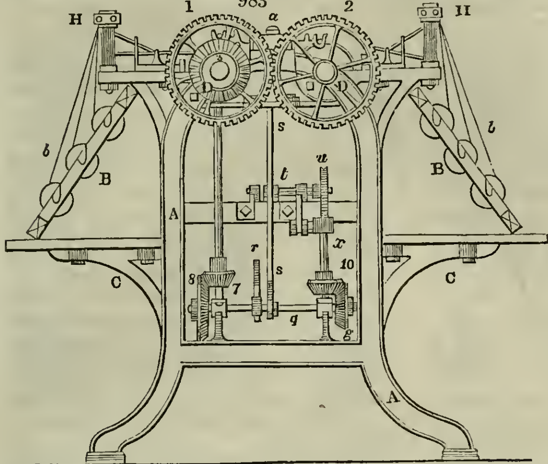
Fig. 986 is the plan of the parts shown in *fig*. 985; these two figures being drawn to double the scale of *figs*. 983 and 984.

A, A, *figs*. 983 and 984, 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*. 985 and 986.

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 moveable pulleys, called *stars*, *c*, *c*, (*figs*. 985, 986,) 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.* 986, 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.* 987.

983



The spindles with their bobbins revolve in two slot-bearings F, F, *fig.* 986, 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*, *g*, are attached), for

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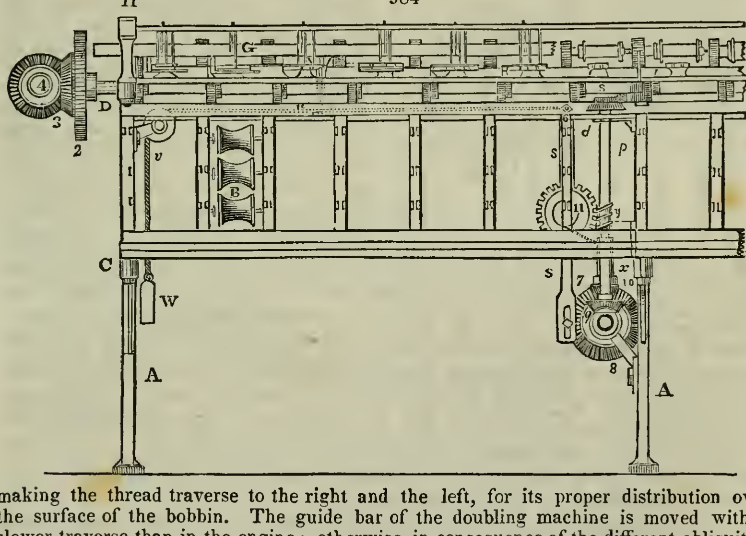

making the thread traverse to the right and the left, for its proper distribution over the surface of the bobbin. The guide bar of the doubling machine is moved with a slower traverse than in the engine; otherwise, in consequence of the different obliquities of the paths, the single threads would be 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′*, *fig.* 986. 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*. 986 and 987), 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, 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.

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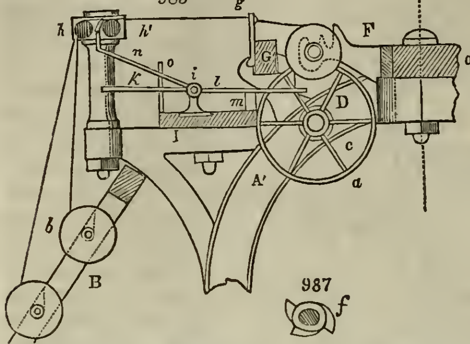

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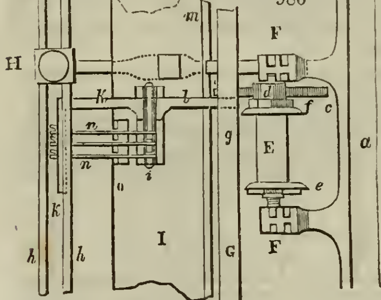
986



The motions are given to the doubling machine in a very simple way. Upon the end of the framing, represented in *fig*. 983, 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*. 984), 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*. 984, 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*. 983. The other end of the lever *s*, is connected by two rods (shown by dotted lines in *fig*. 984) to a brass piece which joins the arms *u* (*fig*. 984), 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 level *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, neccessarily 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*. 983 and 984), which drives the wheel 10 upon the shaft *x*; on whose upper end, the worm *y* works in the wheel 11, made fast to the said eccentric shaft *t*; round which the lever *s* swings or oscillates, causing the guide bars to traverse.

The spinning silk-mill.—The machine which twists the silk threads, either in their single or doubled state, is called the spinning mill. When the raw singles are first twisted in one direction, next doubled, and then twisted together in the opposite direction, an exceedingly wiry, compact thread, is produced, called *organzine*. In the spinning mill, either the singles or the doubled silk, while being unwound from one set of bobbins, and wound upon another set, is subjected to a regular twisting operation; in which process the thread is conducted as usual through guides, and coiled diagonally upon the bobbins by a proper mechanism.

Fig. 988 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.

988

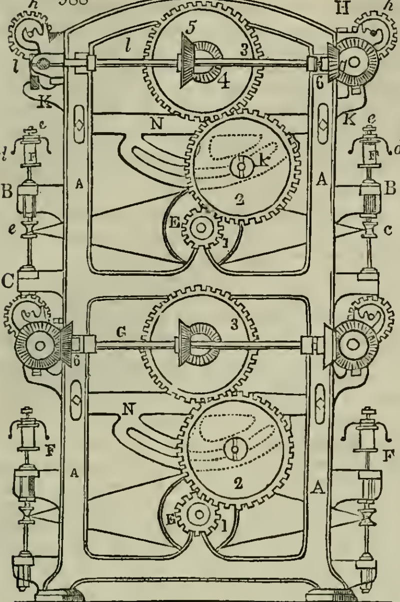


Fig. 989, is a front view, where, as in the former figure, the two working lines are shown.

Fig. 990, is a cross section of a part of the machine, to illustrate the construction and play of the working parts; *figs.* 996, 997, are other views of *fig.* 990.

Fig. 991, shows a single part of the machine, by which the bobbins are made to revolve.

Figs. 992, and 993, show a different mode of giving the traverse to the guide bars, than that represented in *fig.* 990.

Figs. 994, and 995, show the shape of the full bobbins, produced by the action of these two different traverse motions.

The upper part of the machine being exactly the same as the under part, it will be sufficient to explain the construction and operation of one of them.

A, A, are the end upright frames or standards, between which are two or three intermediate standards, according to the length of the machine. They are all connected at their sides by beams B and C, which extend the whole length of the machines. D, D, are the spindles, whose top bearings *a*, *a*, are made fast to the beams B, and their bottoms turn in hard brass steps, fixed to the bar C. These two bars together are

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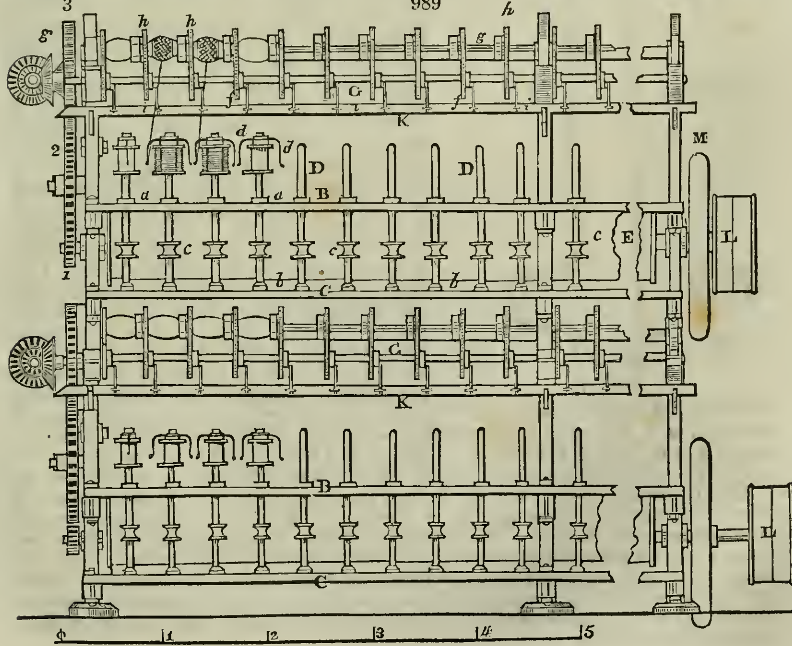

called, by the workmen, the spindle box. The standards A, A, are bound with cross bars N, N.

c, *c*, are the wharves or whorls, turned by a band from the horizontal tin cylinder in the lines of E, E, *fig.* 988, lying in the middle line between the two parallel rows of spindles D, D. F, F, are the bobbins containing the untwisted doubled silk, which are simply pressed down upon the taper end of the spindles. *d*, *d*, are little fliers, 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.* 990. *e*, *e*, are pieces of wood pressed upon the tops of the spindles, to prevent the fliers 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.* 989, 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.* 986.

Upon these little cast-iron shafts or spindles *g*, *fig.* 991, 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 fliers *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.

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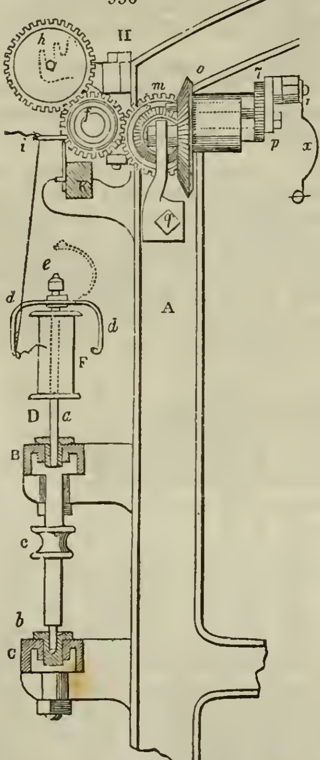

Upon the shaft of the tin cylinder or drum, exterior to the frame, the usual fast and loose pulleys, or riggers, L, L′, are mounted, for driving the whole machine. These riggers are often called steam-pulleys by the workmen, from their being connected by bands with the steam-driven shaft of the factory. 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 equalize the motion. Upon the other ends of these shafts, namely, at the end of the spinning-mill, represented in *fig.* 988, 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 moveable 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 the 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.* 988, 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.

The traverse motion of the guide is given here in a similar way to that of the engine, (*fig.* 975.) Near one of the middle or cross-frames of the machine (see *fig.* 990) 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.* 979 and 980, and which is here marked with the same letters.

To the crank-knob *r*, *fig.* 990, 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.* 992 and 993 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. In *fig.* 993 the elliptical wheels are shown in front, to illustrate their mode of operating upon each other. *Fig.* 994 is a block filled by the motion of the eccentric, *fig.* 990; and *fig.* 995 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.* 995. The conical ends of the block (*fig.* 994) 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.

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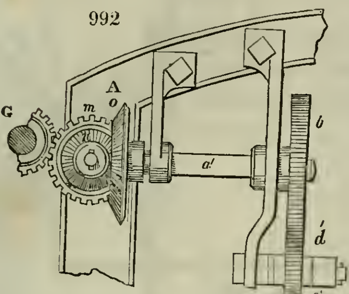

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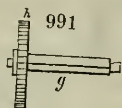

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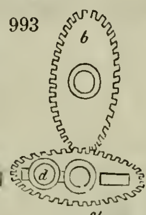

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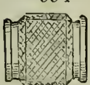

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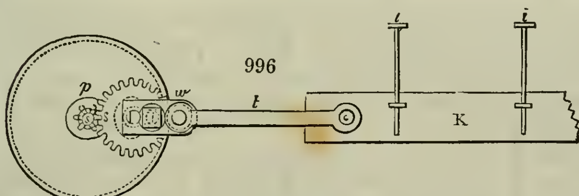

Figs. 996, 997 are two different views of the differential mechanism described under *fig.* 990.

The bent wire *x*, *fig.* 990, is called the guider iron. It is attached at one end to the pivot of the sun-and-planet wheel-work *t*, *s*, o, and at the other to the guide bar *f*, *f*, *fig.* 989. 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.* 994.

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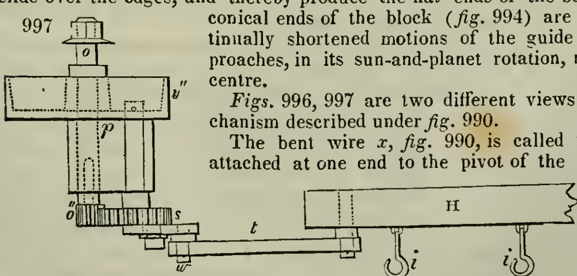

THE SILK AUTOMATIC REEL.

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*. 994.

Fig. 998 is a front view of the reel; little more than one half of it being shown. *Fig*. 999 is an end view. Here the steam pulleys are omitted, for fear of obstructing the

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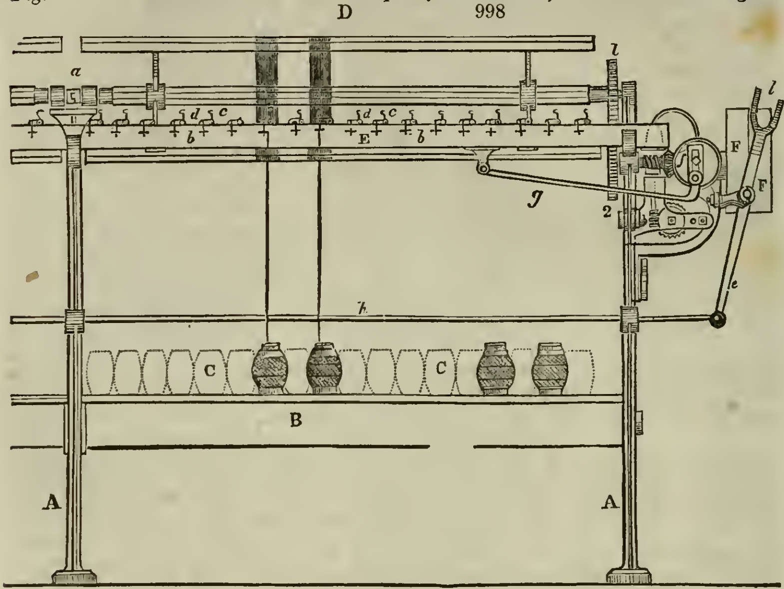

view of the more essential parts. A, A, are the two end framings, connected by mahogany stretchers, which form the table B, for receiving the bobbins C, C, which are sometimes weighted at top with a lump of lead, to prevent their tumbling. D is the reel, consisting of four long laths of wood, which are 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 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*. 999, which works in a wheel 5, attached to the short upright shaft *h* (*fig*. 998). At the end of *h*, there is another worm, which works in a wheel 6; at whose circumference there is a stud *i*, which strikes once at every revolution against an arm attached to a bell, seen to the left of 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.

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.

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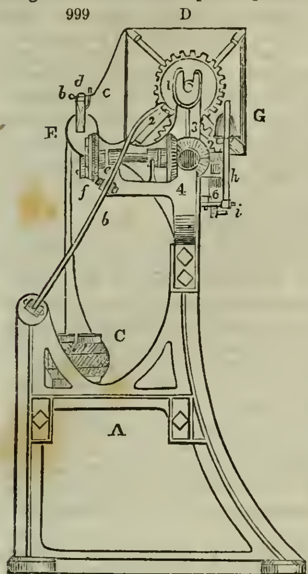

The wages of the workpeople in the silk-throwing mills of Italy are about one half of their wages in Manchester; but this difference is much more than counterbalanced by the protecting duty of 2*s.* 10*d.* a pound upon thrown silk, and the superior machinery of our mills. In 1832, there was a power equal 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 colors 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.

An Estimate of the Annual Quantities of Silk produced or exported from the several Countries in the World, exhibiting also the Countries to which exported.

Countries whence exported.	Quantities.		Countries to which exported.	Quantities.
Italy exports	34,000 bales of 225 small lbs.			Bales.
France produces	10,500 . .	73⅛ kils., or	England	28,000
India and Bengal export	9,500 . .	128½ Vienna lbs.	France	22,000
Persia	7,500 . .	162 lbs. English	Prussia	7,600
China	4,000 . .		Russia	6,400
Asia Minor	3,500 . .		Austria and Germany	5,000
Levant, Turkey, and Archipelago export	3,500 . .		Switzerland	5,000
Spain exports	1,500 . .			
	. .		Total	74,000
Total	74,000 bales.			

Note.—These estimates exclude the silk manufactured in Italy.

The declared value of the silk manufactures exported from the United Kingdom in 1836, was 917,822*l.*; and in 1837, only 494,569. The deficit in the last year was owing to the commercial crisis in the United States; which country took, the preceding year, our silk goods to the value of 524,301*l.*

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 color, 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.* 1000, *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*, a board with wooden pegs, for the same purpose.

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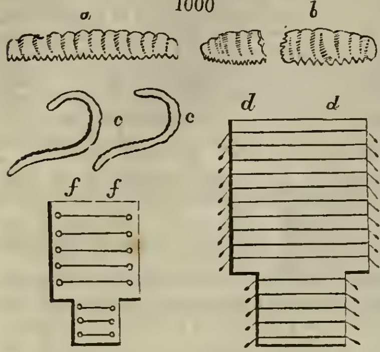

SILVER (*Argent*, Fr.; *Silber*, Germ.) was formerly called a *perfect* metal, because heat alone revived its oxyde, and because it could pass unchanged through fiery trials, which apparently destroyed most other metals. The distinctions, perfect, imperfect, and noble, are now justly rejected. The bodies of this class are all equal in metallic nature, each being endowed merely with different relations to other forms of matter, which serve to characterize it, and to give it a peculiar value.

When pure and planished, silver is the brightest of the metals. Its specific gravity in the ingot is 10·47; but, when condensed under the hammer or in the coining press, it becomes 10·6. It melts at a bright red heat, a temperature estimated by some as equal to 1280° Fahr., and by others to 22° Wedgewood. It is exceedingly malleable and ductile; affording leaves not more than $\frac{1}{100000}$ of an inch thick, and wire far finer than a human hair.

By Sickingen's experiments, its tenacity is, to that of gold and platinum, as the numbers 19, 15, and $26\frac{1}{4}$; so that it has an intermediate strength between these two metals. Pure atmospheric air does not affect silver, but that of houses impregnated with sulphureted hydrogen, soon tarnishes it with a film of brown sulphuret. It is distinguished chemically from gold and platinum by its ready solubility in nitric acid, and from almost all other metals, by its saline solutions affording a curdy precipitate with a most minute quantity of sea salt, or any soluble chloride.

Silver occurs under many forms in nature :—

1. *Native silver* possesses the greater part of the above properties; yet, on account of its being more or less alloyed with other metals, it differs a little in malleability, lustre, density, &c. It sometimes occurs crystallized in wedge-form octahedrons, in cubes, and cubo-octahedrons. At other times it is found in dendritic shapes, or arborescences, resulting from minute crystals implanted upon each other. But more usually it presents itself in small grains without determinable form, or in amorphous masses of various magnitude.

The *gangues* (mineral matrices) of native silver are so numerous, that it may be said to occur in all kinds of rocks. At one time it appears as if filtered into their fissures, at another as having vegetated on their surface, and at a third, as if impasted in their substance. Such varieties are met with principally in the mines of Peru.

The native metal is found in almost all the silver mines now worked; but especially in that of Kongsberg in Norway, in carbonate and fluate of lime, &c.; at Schlangenberg in Siberia, in a sulphate of barytes; at Allémont, in a ferruginous clay, &c. In the article MINES, I have mentioned several large masses of native silver that have been discovered in various localities.

The metals most usually associated with silver in the native alloy are gold, copper, arsenic, and iron. At Andreasberg and Guadalcanal it is alloyed with about 5 per cent. of arsenic. The auriferous native silver is the rarest; it has a brass-yellow color.

2. *Antimonial silver.*—This rare ore is yellowish-blue; destitute of malleability; even very brittle; spec. grav. 9·5. It melts before the blowpipe, and affords white fumes of oxyde of antimony; being readily distinguished from arsenical iron, and arsenical cobalt, by its lamellar fracture. It consists of from 76 to 84 of silver, and from 24 to 16 of antimony.

3. *Mixed antimonial silver.*—At the blowpipe it emits a strong garlic smell. Its constituents are, silver 16, iron 44, arsenic 35, antimony 4. It occurs at Andreasberg.

4. *Sulphuret of silver.*—This is an opaque substance, of a dark-gray or leaden hue; slightly malleable, and easily cut with a knife, when it betrays a metallic lustre. The silver is easily separated by the blowpipe. It consists of, 13 of sulphur to 89 of silver,

* Nobb's Art of Trolling.

by experiment; 13 to 87 are the theoretic proportions. Its spec. grav. is 6·9. It occurs crystallized in most silver mines, but especially in those of Freyberg, Joachimsthal in Bohemia, Schemnitzin, Hungary, and Mexico.

5. *Red sulphuret of silver; silver glance.*—Its spec. grav. is 5·7. It contains from 84 to 86 of silver.

6. *Sulphureted 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 sulphuret of silver,* the red silver of many mineralogists, is an ore remarkable for its lustre, color, and the variety of its forms. It is friable, easily scraped by the knife, and affords a powder of a lively crimson red. Its color in mass is brilliant red, dark red, or even metallic reddish-black. It crystallizes in a variety of forms. Its constituents are,—silver from 56 to 62; antimony from 16 to 20; sulphur from 11 to 14; and oxygen from 8 to 10. The antimony being in the state of a purple oxyde in this ore, is reckoned to be its coloring principle. It is found in almost all silver mines; but principally in those of Freyberg, Sainte-Marie-aux-Mines, and Gua-dalcanal.

8. *Black sulphuret of silver,* is blackish, brittle, cellular, affording globules of silver at the blowpipe. It is found only in certain mines, at Allémont, Freyberg; more abundantly in the silver mines of Peru and Mexico. The Spaniards call it *negrillo.*

9. *Chloride of silver, or horn silver.*—In consequence of its semi-transparent aspect, its yellowish or greenish color, and such softness that it may be cut with the nail, this ore has been compared to horn, and may be easily recognised. It melts at the flame of a candle, and may be reduced when heated along with iron or black flux, which are distinctive characters. It is seldom crystallized; but occurs chiefly in irregular forms, sometimes covering the native silver as with a thick crust, as in Peru and Mexico. Its density is only 4·74.

Chloride of silver sometimes contains 60 or 70 per cent. of clay; and is then called butter-milk ore, by the German miners. The blowpipe causes globules of silver to sweat out of it. This ore is rather rare. It occurs in the mines of Potosi, of Annaberg, Freyberg, Allémont, Schlangenberg, in Siberia, &c.

10. *Carbonate of silver,* a species little known, has been found hitherto only in the mine of S. Wenceslas, near Wolfache.

TABLE of the Quantities of SILVER brought into the Market every year, on an average, from 1790 to 1802.

Old Continent.	Lbs. Avoird.	New Continent.	Lbs. Avoird.
ASIA.			
Siberia - - -	38,500	Central America - -	1,320,000
EUROPE.			
Hungary - -	44,000	South America - -	605,000
Austrian States - -	11,000		
Hartz and Hessia -	11,000		
Saxony - - -	22,000		
Norway - - -	22,000		
Sweden - - - } France - - - } Spain - - - }	11,000		
Total of the Old Continent	159,500	Total of the New Continent	1,925,000

Thus the New Continent furnished twelve times more silver than the old. For more detailed statistics of silver, see the end of the article.

The following is Mr. Ward's description of the treatment of silver ores in Mexico:—

"After returning from San Augustin," says he, "I passed the whole of the after noon at the *hacienda* (metallurgic works) of Salgado, in which the ores of the Valenciana mine are reduced. The *hacienda,* of which a representation is given below, *fig.* 1001, contains forty-two crushing-mills, called *arrastres,* and thirty-six stampers. The ore, on being extracted from the mine, is placed in the hands of the *pepenadores,* men and women, who break all the larger pieces with hammers, and after rejecting those in which no metallic particles are contained, divide the rest into three classes" (inferior, middling, and rich). "These are submitted to the action of the *morteros* (stamps), one of which, of eight stampers, is capable of reducing to powder ten cargas of ore (each of 350 lbs.) in twenty-four hours. This powder not being thought sufficiently fine for the quicksilver to act upon with proper effect, it is transferred from the *morteros* to the *arrastres* (crushing-mills, see wood-cut), in which water is used. Each of these reduces to a fine impalpable metalliferous mud, six quintals (600 lbs.) of powder in

24 hours. At Guanajuato, where water-power cannot be obtained, the *arrastres* are worked by mules (see *fig*. 1001), which are kept constantly in motion at a slow pace, and are changed every 6 hours. The grinding-stones, as well as the sides and bottom of the mill itself, are composed of granite; four blocks of which revolve in each crushing-mill, attached to cross-bars of wood. This part of the operation is thought of great importance, for it is upon the perfection of the grinding that the saving of the quicksilver is supposed in a great measure to depend, in the subsequent amalgamation. The grinding is performed usually in a covered shed or gallery, which in a large *hacienda*, like Salgado, from the number of *arrastres* at work at the same time, is necessarily of considerable extent."

1001 *The Gallera of the Hacienda of Salgado.*

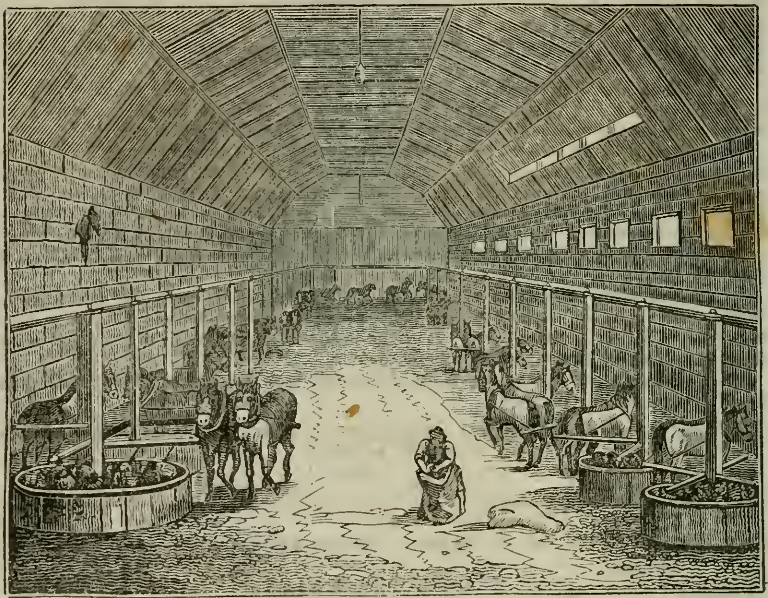

Fig. 1002, represents the rude grinding apparatus used at the *lavaderos*, or gold washings, in Chile. The streamlet of water conveyed to the hut of the gold washer, is received upon a large rude stone, whose flat surface has been hollowed out into a shallow basin, and in the same manner into 3 or 4 others in succession; the auriferous particles are thus allowed to deposite themselves in these receptacles, while the lighter earthy atoms, still suspended, are carried off by the running water. The gold thus collected is mixed with a quantity of ferruginous black sand and stony matter, which requires the process of trituration, effected by the very rude and simple *trapiche* shown in the figure; consisting of two stones, the under one being about three feet in diameter, and slightly concave. The upper stone is a large spherical boulder of syenitic granite, about two feet in diameter, having on its upper part two iron plugs fixed oppositely, to which is secured, by lashings of hide, a transverse horizontal pole of *canela* (cinnamon) *wood*, about 10 feet long; two men seated on the extremities of this lever, work it up and down alternately, so as to give to the stone a rolling motion, which is sufficient to crush and grind the materials placed beneath it. The washings thus ground, are subjected to the action of running water, upon inclined planes formed of skins, by which process the silicious particles are carried off, while a portion of the ferruginous matter, mixed with the heavier grains of gold, is extracted by a loadstone; it is again washed, till nothing but pure gold-dust remain. The whole process is managed with much dexterity; and if there were much gold to be separated, it

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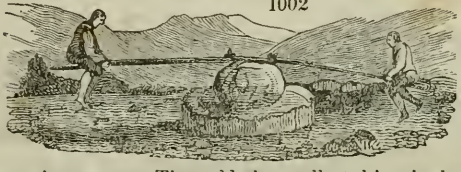
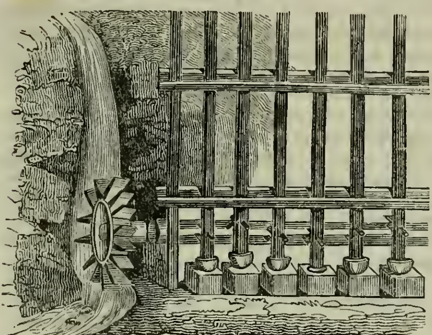


would afford very profitable employment; but generally the small quantity collected is sufficient only to afford subsistence to a few miserable families.

The *trapiche, ingenio,* or mill, for grinding the ores of silver, is a very simple piece of mechanism. A place is chosen where a small current of water, whose section will present a surface of six inches diameter, can be brought to a spot where it can fall perpendicularly ten or twelve feet; at this place a well is built of this depth, about 6 feet in diameter; in its centre is fixed an upright shaft, upon a central brass pin; it is confined above by a wooden collar. A little above its foot, the shaft has a small wheel affixed to it, round which are fixed a number of radiating spokes, shaped at the end somewhat like cups, and forming altogether a horizontal wheel, four feet in diameter. Upon the slanting edges of the cups, the water is made to strike with the force it has acquired in falling down a nearly perpendicular trough, scooped out of the solid trunk of a tree. This impression makes the wheel turn with a quick rotatory motion. The upright axis rises about 6 feet above the top of the well, at about half which height is inserted a small horizontal arm, four feet long, which serves as an axle to a ponderous mill-stone of granite, of from four to six feet diameter, which is made to roll on its edge in a circular trough, sometimes made of the same material, and sometimes of hard wood.

The weight of this quickly rolling stone effects the pulverization of the ore. In some cases, it is taken out in the dry state, and sifted; but more generally the separation of the finely ground particles is accomplished by the action of running water. For this purpose a small stream is made to trickle into the circular trough, by which the pounded ore is worked up into a muddy consistence, and the finer particles flow off with the excess of water, through a notch cut in the margin of the trough. This fine matter is received in little pools, where the pounded ore is left to settle; and the clear water being run off, the powder is removed from the bottom, and carried to the place of amalgamation.

1003



The *ingenios*, or stamping-mills, are driven by a small breast water-wheel, of five feet diameter, and one foot broad. *Fig.* 1003 will give a sufficient idea of their construction. The long horizontal shaft, fixed on the axis of the wheel, is furnished with 5 or 6 cams placed at different situations round the shaft, so as to act in succession on the projecting teeth of the upright rods or pestles. Each of these weighs 200 pounds, and works in a corresponding oblong mortar of stone or wood.

The *patio*, or amalgamation floor, *fig*. 1004, is a large flat space, open to the sky, 312 feet in length, by 236 in breadth, and securely surrounded by strong walls. It is paved with large unhewn blocks of porphyry, and is capable of containing 24 *tortas*, or flat circular collections of *lama*, of about 50 feet diameter, and 7 inches deep, when the patio is not filled, (but of somewhat smaller dimensions when nearly so,) ranged in 4 rows, and numbered from the left-hand corner. At one end a small space is generally set apart for the assays, which are made each on one monton.

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The following description of Mexican amalgamation is given by Captain Lyon.

A torta of Zacatecas contains 60 montons of 20 quintals each, and is thus formed: — In the first instance, a square space, of the requisite size for a torta, is marked out, and enclosed by a number of rough planks, which are propped in their places on the patio floor by large stones, and dried horse-dung and dust are piled round their edges to prevent the escape of the lama. A heap of saltierra (salt mixed with earthy impurities) is then piled in the centre, in the proportion of 2 fanegas (each = 1·6 English bushels) and a half to the monton, = 150 for the torta. After this, the lama, or ore ground into a fine paste, is poured in. When the last or 60th monton is delivered, the saltierra is shovelled down and well mixed with the lama, by treading it with horses, and turning it with shovels; after which the preparation is left at rest for the remainder of the day. On the following day comes the *el incorporo*. After about one hour's treading by horses, the magistral or roasted and pulverized copper ore is mixed with the lama, (the *repaso* or treading-mill still continuing,) in summer in the proportion of 15 cargas of 12 arrobas (25 lbs. each) to the torta, if the ore be of 6 marcs to the monton, and in winter in only half the quantity. For it is a singular fact, that in summer the mixture cools, and requires more warmth; while in winter it acquires of itself additional heat. With poorer ores, as for instance those of 4 marcs to the monton, 12 cargas are applied in summer, and 6 in winter. From November to February, lime is also occasionally used to cool the lama, in the proportion of about a peck per monton.

The *repaso*, or treading out, is continued by six horses, which are guided by one man, who stands in the lama, and directs them all by holding all their long halters. This operation is much more effectual in a morning than an evening, and occupies about five or six hours. When the magistral is well mixed, the quicksilver is applied by being sprinkled through pieces of coarse cloth doubled up like a bag, so that it spurts out in very minute particles. The second treading of the horses then follows; after which the whole mixture is turned over by six men with wooden shovels, who perform the operation in an hour. The torta is then smoothed and left at rest for one entire day, to allow the incorporation to take place. It undergoes the turning by shovels and treading by horses every other day, until the amalgamator ascertains that the first admixture of quicksilver is found to be all taken up by the silver; and this he does by vanning or washing a small quantity of the torta in a little bowl. A new supply is then added, and when this has done its duty, another is applied to catch any stray particles of silver. On the same day, after a good repaso, the torta is removed on hand-barrows by the laborers, to the *lavaderos*, in order that it may receive its final cleansing. The general method of proportioning the quicksilver to the tortas, is by allowing that every marco of silver which is promised by trial of the ores as the probable produce of a monton, will require in the whole process 4 lbs.

In metals of five to six marcs and a half per monton (of the average richness of Zacatecas), 16 lbs. of quicksilver were incorporated for every monton, = 900 lbs. for the torta. On the day of the second addition, the proportion is 5 lbs. the monton; and when the torta is ready to receive the last dose of quicksilver, it is applied at the rate of 7 lbs. the monton, = 420 lbs.; making a total of 1620 lbs. of quicksilver. With poorer ores, less quicksilver and less magistral are required.

The usual time for the completion of the process of amalgamation, is from 12 to 15 days in the summer, and 20 to 25 in the winter. This is less than a third of the time taken at some other mines in Mexico. This rapidity is owing to the tortas being spread very flat, and receiving thereby the stronger influence of the sun. In the Mexican mines, only one monton is commonly mixed at a time; and the lama is then piled in a small conical heap or monton.

Lavadero, or washing vat.—Here the prepared tortas are washed, in order to carry off the earthy matters, and favor the deposition of the amalgam at the bottom. Each vat is about 8 feet deep, and 9 in diameter; and solidly built in masonry.

A large horizontal wheel, worked by mules, drives a vertical one, which turns a horizontal wheel fitted round a perpendicular wooden shaft, revolving upon an iron pivot at the bottom of the vat. To the lower end of this shaft, four cross-beams are fitted, from which long wooden teeth rise to the height of 5 feet. Their motion through the water being rapid, keeps all the lighter particles afloat, while the heavier sink to the bottom. The large wheel is worked by four mules, two at each extremity of the cross-beam. Water is supplied from an elevated tank. It requires 12 hours' work of one tub to wash a torta. Eight porters are employed in carrying the prepared *lama* of the torta in hand-barrows to the vats. The earthy matter receives a second washing.

The amalgam is carried in bowls into the *azogueria*, where it is subjected to straining through the strong canvass bottom of a leather bag. The hard mass left in the bag is moulded into wedge-shaped masses of 30 lbs., which are arranged in the burning-house, (*fig.* 1005), 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 vapors.

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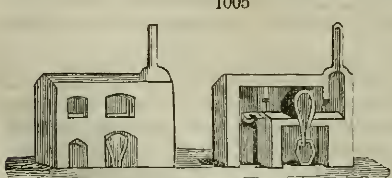

A large bell-shaped cover, called *capellina*, is now hoisted up, and carefully lowered over the *pina*, by means of pulleys. A strong lute of ashes, saltierra, and lama is applied to its lower edge, and made to fit very closely to the plate on which the base stands. A wall of fire-bricks is then built loosely round the capellina, and this space is filled with burning charcoal, which is thrice replenished, to keep it burning all night. After the heat has been applied 20 hours, the bricks and ashes are removed, the luting broken, and the capellina hoisted up. The burned silver is then found in a hard mass, which is broken up, weighed, and carried to the casting-house, to be formed into bars of about 1080 ounces each. The loss of silver in burning is about 5 ounces to each bar (*barra*), and the loss of quicksilver, from $2\frac{1}{2}$ upon the good metals, to 9 upon the coarse.

Molina told Mr. Miers, that the produce of the galena ores of Uspaltata did not average more than 2 marcs per *caxon* of 5000 lbs., which is an excessively poor ore. The argentiferous galena ores of Cumberland afford 11 marcs per caxon; while the average produce of the Potosi silver ores is only 5 or 6 marcs in the same quantity. These comparisons afford the clearest evidence that the English mode of smelting can never be brought into com petition with the process of amalgamation as practised in America.

Humboldt, Gay Lussac, Boussingault, Karsten, and several other chemists of note, have offered solutions of the amalgamation enigma of Mexico and Peru. The following seems to be the most probable *rationale* of the successive steps of the process:—

The addition of the *magistral* (powder of the roasted copper pyrites), is not for the purpose of disengaging muriatic acid from the sea salt (*saltierra*), as has been supposed, since nothing of the kind actually takes place; but, by reciprocal or compound affinity, is 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 oxyde of silver, but always a great abundance of oxyde of iron, the acid would carry off both partly, but leave the chloride of silver in a freer state. A magistral, such as sulphate of iron, which is not in a condition to generate the chlorides, will not suit the present purpose; only such metallic sulphates are useful as are ready to be transformed into chlorides by the *saltierra*. This is peculiarly the case with sulphate of copper. Its deuto-chloride gives up chlorine to the silver, becomes in consequence a protochloride, while the chloride of silver, thus formed, is revived, and amalgamated with the quicksilver present, by electro-chemical agency which is excited by the saline menstruum; just as the voltaic pile of copper and silver is rendered active by a solution of sea salt. A portion of chloride of mercury will be simultaneously formed, to be decomposed in its turn by the sulphate of silver resulting from the mutual action of the acidified pyrites, and the silver or its oxyde in the ore. An addition of quicklime counteracts the injurious effect of too much magistral, by decomposing the resulting sulphate of copper. Quicksilver being an excellent conductor of heat, when introduced in too great quantities, is apt to cool the mass too much, and thereby enfeebles the operation of the deuto-chloride of copper upon the silver.

There is a method of extracting silver from its ores by what is called *imbibition*. This is exceedingly simple, consisting in depriving, as far as possible, the silver of its gangue, then melting it with about its own weight of lead. The alloy thus procured, contains from 30 to 35 *per cent.* of silver, which is separated by cupellation on the great scale, as described under ores of *lead*. In this way the silver is obtained at Kongsberg in Norway.

The amalgamation works at Halsbrücke, near Freyberg, for the treatment of silver ores by mercury, have been justly admired as a model of arrangement, convenience, and regularity; and I shall conclude this subject with a sketch of their general distribution.

Fig. 1006 presents a vertical section of this great *usine* or *hüttenwerk*, subdivided into

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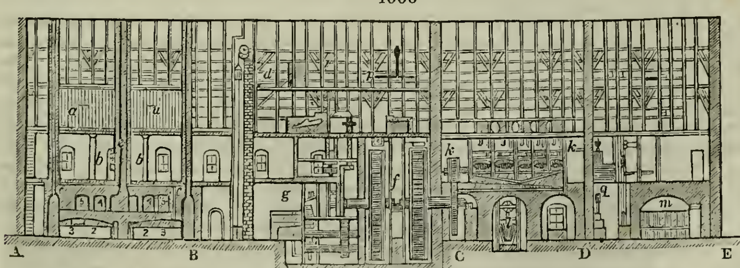


four main departments. The first, A, B, is devoted to the preparation and roasting of the matters intended for amalgamation. The second, B, C, is occupied with two successive siftings and the milling. The third, C, D, includes the amalgamation apartment above, and the wash-house of the residuum below. And in the fourth, D, E, the distilling apparatus is placed, where the amalgam is finally delivered.

Thus, from one extremity of this building to the other, the workshops follow in the order of the processes; and the whole, over a length of 180 feet, seems to be a natural laboratory, through which the materials pass, as it were of themselves, from their crude to their refined condition; so skilfully economized and methodical are the labors 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 up with salt; *c, c*, are the roasting furnaces; in each of which we see, 1, the fireplace; 2, 3, the reverberatory hearth, divided into two portions, one a little higher than the other, and more distant from the fireplace, called the *drier*. The materials to be calcined fall into it, through a chimney 6. The other part 2, of the hearth, is the calcining area. Above the furnace are chambers of sublimation 4, 5, for condensing some volatile matters which escape by the opening 7. *e* is the main chimney.

2. In the division 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 work, 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.

4. 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 a way 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, sulphurets of arsenic, of copper, iron, lead (nickel, cobalt), zinc, with several earthy minerals. It is essential that the ores to be amalgamated shall contain a certain proportion of sulphur, in order that they may decompose enough of sea salt in the roasting to disengage as much chlorine as to convert all the silver present into a chloride. With this view, ores poor in sulphur are mixed with those that are richer, to make up a determinate average. The ore-post is laid upon the *bed-floor*, in a rectangular heap, about 17 ells long, and 4½ ells broad (13 yards and 3⅔); and upon that layer the requisite quantity of salt is let down from the floor above, through a wooden tunnel; 40 cwts. of salt being allotted to 400 cwts. of ore. The heap being made up with alternate strata to the desired magnitude, must be then well mixed, and formed into small bings, called *roast-posts*, weighing each from 3½ to 4½ cwts. The annual consumption of salt at Halsbrücke is 6000 cwts.; it is supplied by the Prussian salt-works.

Roasting of the Amalgamation Ores.— The furnaces appropriated to the roasting of the ore-posts are of the reverberatory class, provided with soot chambers. They are built up alongside of the *bed-floor*, and connected with it by a brick tunnel. The prepared ground ore (*erzmehl*) is spread out upon the hearth, and dried with incessant turning over; then the fire is raised so as to kindle the sulphur, and keep the ore redhot for one or two hours; during which time, dense white-gray vapors of arsenic, antimony, and water, are exhaled. The desulphuration next begins, with the appearance of a blue flame. This continues for three hours, during which the ignition is kept up; and the mass is diligently turned over, in order to present new surfaces, and to prevent any caking. Whenever sulphurous acid ceases to be formed, the finishing calcination is to be commenced with increased firing; the object being now to decompose the sea salt by means of the metallic sulphates that have been generated, to convert them into chlorides, with the simultaneous production of sulphate of soda. The stirring is to be continued till the proofs taken from the hearth no longer betray the smell of sulphurous, but only of muriatic acid gas. This roasting stage lasts commonly three quarters of an hour, 13 or 14 furnaces are worked at the same time at Halsbrücke; and each turns out in a week 5 tons upon an average. Out of the *nicht* chambers or soot vaults of the furnaces, from 96 to 100 cwts. of ore-dust are obtained, containing 32 marcs (16 lbs.) of silver. This dust is to be treated like unroasted ore. The fuel of the first fire is pitcoal; of the finishing one, fir-wood. Of the former 115½ cubic feet, and of the latter, 294¼, 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 color. 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.* 1006. The casks are 2 feet 10 inches long, 2 feet 8 inches wide, inside measure, and are provided with iron ends. The staves are 3½ 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 canvass 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 ¾ to ⅞ of a cwt. of pieces of iron, 1½ inch square, and ⅜ thick, are added. When these pieces get dissolved, they are replaced by others from time to time. The casks being two thirds full, are set to revolve for 1½ or 2 hours, till the ore-powder and water become a uniform pap; when 5 cwts. of quicksilver are poured into each of them. The casks being again made tight, are put in gear with the driving machinery, and kept constantly revolving for 14 or 16 hours, at the rate of 20 or 22 turns in the minute. During this time they are twice stopped and opened, in order to see whether the pap be of the proper consistence; for if too thick, the globules of quicksilver do not readily combine with the particles of ore; and if too thin, they fall and rest at the bottom. In the first case, some water must be added; in the second, some ore. During the rotation, the temperature rises, so that even in winter it sometimes stands so high as 104° F.

The chemical changes which occur in the casks are the following:—The metallic chlorides present in the roasted ore are decomposed by the iron, whence results muriate of iron, whilst the deutochloride of copper is reduced partly to protochloride, and partly to metallic copper, which throw down metallic silver. The mercury dissolves the silver, copper, lead, antimony, into a complex amalgam. If the iron is not present in sufficient quantity, or if it has not been worked with the ore long enough to convert the copper deutochloride into a protochloride, previously to the addition of the mercury, more or less of the last metal will be wasted by its conversion into protochloride (calomel.) The water holds in solution sulphate of soda, undecomposed sea salt, with chlorides of iron, manganese, &c.

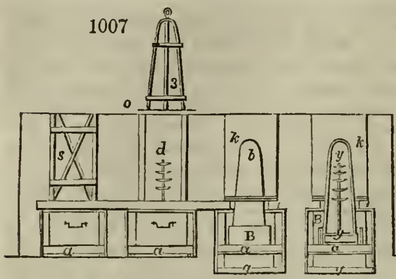
As soon as the revivification is complete, the casks must be filled with water, set to revolve slowly (about 6 or 8 times in the minute), whereby in the course of an hour, or an hour and a half at most, a great part of the amalgam will have collected at the bottom; and in consequence of the dilution, the portion of horn silver held in solution by the sea salt will fall down and be decomposed. Into the small plug in the centre of the bung, a small tube with a stopcock is now to be inserted, to discharge the amalgam into its appropriate chamber. The cock must be stopped whenever the brown muddy residuum begins to flow. The main bung being then opened, the remaining contents of the casks are emptied into the *wash-tun*, while the pieces of iron are kept back. The residuary ore is found to be stripped of its silver 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, 1½ hour for diluting, 1 hour for emptying. In 14 days, 3200 cwts. of ore are amalgamated. For working 100 cwts. of ore, 14½ lbs. of iron, and 2 lbs. 12½ ounces of mercury are required; whence, for every pound of silver obtained, 0·95 of an ounce of mercury are consumed.

Trials have been made to conduct the amalgamation process in iron casks, heated to 150° or 160° Fahrenheit, over a fire; but, though the de-silvering was more complete, the loss by mercury was so much greater as to more than counterbalance that advantage.

Treatment of the Amalgam.—It is first received in a moist canvass bag, through which the thin uncombined quicksilver spontaneously passes. The bag is then tied up and subjected to pressure. Out of 20 casks, from 3 to 3½ cwts. of solid amalgam are thus procured, which usually consist of 1 part of an alloy, containing silver of 12 or 13 *loths* (in 16), and 6 parts of quicksilver. The foreign metals in that alloy are, copper, lead, gold, antimony, cobalt, nickel, bismuth, zinc, arsenic, and iron. The filtered quicksilver contains moreover 2 to 3 loths of silver in the cwt.

Fig. 1007 represents the apparatus for distilling the amalgam in the Halsbrücke works; marked *m* in *fig.* 1006. *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, whereby they are fitted upon the stem of the candelabra, 3 inches apart, each plate being successively smaller than the one below it. 3 indicates a cast-iron bell, furnished with a wrought-iron frame and hook, for raising it by means of a pulley and cord. *s* is a sheet-iron door for closing the stove, whenever the bell has been set in its place.

1007



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 fire-place, 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 volatilizes, 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.

The solid amalgam which is distilled in the above apparatus, would be distilled more profitably out of iron trays set in the mercurial retorts described and figured in pages 815, 816.

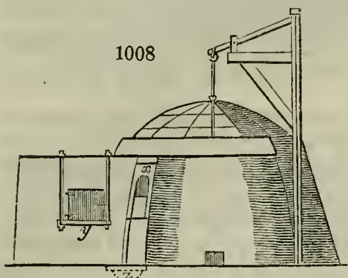
From 3 cwts. of amalgam, distilled under the bell, from 95 to 100 marcs ($\frac{1}{2}$ lbs.) of *teller* silver (dish silver) are procured, containing from 10 to 13$\frac{1}{2}$ parts of fine silver out of 16; one fifth part of the metal being copper. The *teller* silver is refined in quantities of 160 or 170 marcs, in black-lead crucibles filled within two inches of their brims, and submitted to brisk ignition. The molten mass exhales some vapors, 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 vapors 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 quite 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.

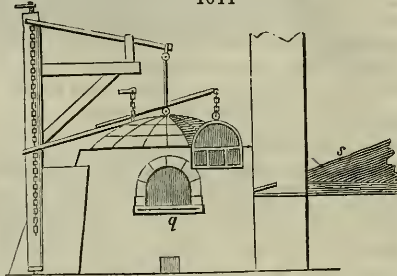
The earthy residuum of the amalgamation casks being submitted to a second amalgamation, affords out of 100 cwts. about 2 lbs. of coarse silver. This is first fused along with three or four per cent. of a mixture of potashes and calcined quicksalz (impure sulphate of soda), and then refined. The supernatant 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 deposite contains from $\frac{1}{4}$ 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 argentiferous or *rich lead* is treated in Germany by the cupellation furnace represented in *figs.* 1008, 1009, 1010, and 1011. These figures exhibit the cupellation furnace of the principal smelting works in the Hartz, where the following parts must be distinguished; (*fig.* 1010); 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, moveable 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 at a time; *s*, *fig.*

1008

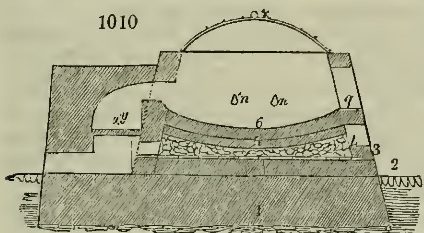


1011



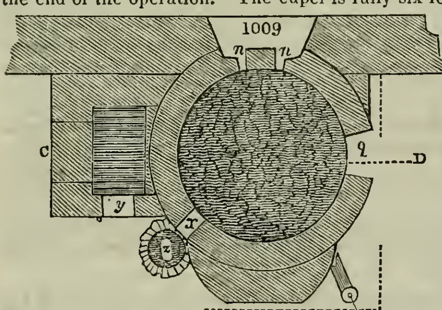
1011, two bellows, like those of a smith's forge; *y*, door of the fireplace, through which billets of wood are thrown on the grate; *x*, small aperture or door, for giving issue to the frothy scum of the cupellation, and the litharge; *z*, basin of safety, usually covered with a stone slab, over which the litharge falls; in case of accident the basin is laid open to admit the *rich lead.*

1010



The following is the mode of conducting the cupellation. Before putting the lead into the furnace, a floor is made in it of ashes beat carefully down (see 6, *fig.* 1010); 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 six feet in diameter.

1009



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 moveable dome of iron plate has been lined with loam, 84 quintals (cwts.) 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 moveable lid is now luted on the furnace, and heat is slowly applied in the fireplace, by burning fagots of fir-wood, which is gradually raised. Section 1010 is in the line C, D, of 1009.

At the end of three hours, the whole lead being melted, the instant is watched for when no more ebullition can be perceived on the surface of the bath or melted metal; then, but not sooner, the bellows are set a playing on the surface at the rate of 4 or 5 strokes per minute, to favor the oxydizement.

In five hours, reckoned from the commencement of the process, the fire is smartly raised; when a grayish froth (*abstrich*) is made to issue from the small aperture *x* of the furnace. This is found to be a brittle mixture of oxydized 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 moveable valves suspended before the tuyères n, n, (*fig.* 1010), the workman can direct the blast as he will over the surface of the metal. The wind should be made to cause a slight curl on the liquid, so as to produce circular undulations, and gradually propel a portion of the litharge generated towards the edges of the cupel, and allow this to retain its shape till the end of the operation. The stream of air should drive the greater part of the litharge towards the small opening x, where the workman deepens the outlet for it, in proportion as the level of the metal bath descends, and the bottom of the floor rises by the apposition of the litharge formed. Litharge is thus obtained during about 12 hours; after which period the cake of silver begins to take shape in the centre of the cupel.

Towards the end of the operation, when no more than four additional quintals of litharge can be looked for, and when it forms solely in the neighborhood of the silver cake in the middle of the floor, great care must be taken to set apart the latter portions, because they contain silver. About this period, the fire is increased, and the workman places before the little opening x a brick, to serve as a mound to the efflux of litharge. The use of this brick is,—1. to hinder the escape of the silver in case of any accident; for example, should an explosion take place in the furnace; 2. to reserve a magazine of litharge, should that still circulating round the silver cake be suddenly absorbed by the cupel, for in this dilemma the litharge must be raked back on the silver; 3. to prevent the escape of the water that must be thrown on the silver at the end of the process.

When the argentiferous litharge, collected in the above small magazine, is to be removed, it is let out in the form of a jet, by the dexterous use of the iron hook.

Lastly, after 20 hours, the silver cake is seen to be well formed, and nearly circular. The moment for stopping the fire and the bellows is indicated by the sudden disappearance of the colored particles of oxyde of lead, which, in the latter moments of oxydation, undulate with extreme rapidity over the slightly convex surface of the silver bath, moving from the centre to the circumference. The phenomenon of their total disappearance is called the *lightning*, or fulguration. Whenever this occurs, the plate of silver being perfectly clean, there is introduced into the furnace, by the door 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 18 or 20 hours' working. The promptitude of the operation depends on the degree of purity of the leads employed, and on the address of the operator, with whom also lies the economy of fuel. A good workman completes the cupellation of 84 quintals with 300 billets, each equivalent to a cubic foot and eight tenths of wood (Hartz measure); others consume 400 billets, or more. In general, the cupellation of 100 quintals of lead, executed at the rate of 84 quintal charges, occasions a consumption of 790 cubic feet of resinous wood billets.

The products of the charge are as 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 *pounds Cologne are equal to* 103 *pounds avoirdupois; and the above quintal contains* 116 *Cologne pounds.*

The loss of lead inevitable by this operation, is estimated at 4 parts in 100. It has been diminished as much as possible in the Frankenscharn works of the Hartz, by leading the smoke into long flues, where the lead fumes are condensed into a metallic soot. The silver cake receives a final purification at the Mint, in a cupel on a smaller scale.

From numerous experiments in the great way, it has been found that not more than 100 quintals of lead can be profitably cupelled at one operation, however large the furnace, and however powerful and multiplied the bellows and tuyères may be; for the loss on either the lead or the silver, or on both, would be increased. In one attempt, no less than 500 quintals were acted on, in a furnace with two fireplaces, and four escapes for the litharge; but the silver remained disseminated through the lead, and the *lightning* could not be brought on. The chief object in view was economy of fuel.

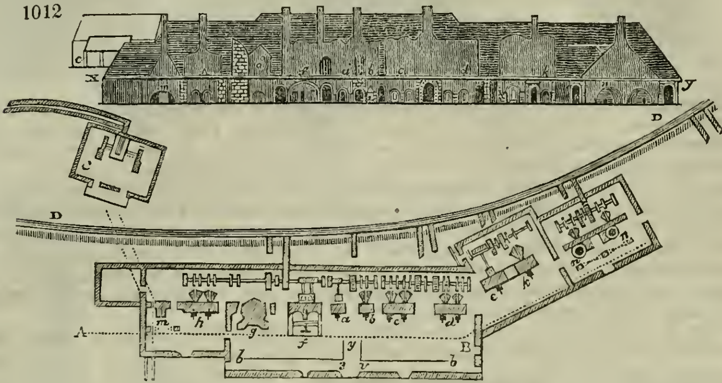
Reduction of the Litharge.—This is executed in a slag-hearth, with the aid of wood charcoal.

Such is the train of operations by which the cupriferous galena *schlich*, or ground ore is reduced, in the district of Clausthal, into lead, copper, and silver. The works of Frankenscharn have a front fully 400 feet long.

Fig. 1011, exhibits the plan and elevation of these smelting-works, near Clausthal, in the Hartz, for lead ores containing copper and silver, where about 84,000 cwts. of *schlich*

Silver-smelting Works of Frankenscharn, near Clausthal.

1012



(each of 123 Cologne pounds) are treated every year. This quantity is the produce of thirty distinct mines, as also of nearly as many stamp and preparation works. All these different *schlichs*, which belong to so many different joint-stock companies, are confounded and worked up together in the same series of metallurgic operations; the resulting mixture being considered as one and the same ore belonging to a single undertaking; but in virtue of the order which prevails in this royal establishment, the rights of each of the companies, and consequently of each shareholder, are equitably regulated. A vigorous control is exercised between the mines and the stamps, as also between the stamps and the smelting-houses; while the cost of the metallurgic operations is placed under the officers of the crown, and distributed, upon just principles, among the several mines, according to the quantities of metal furnished by each.

From these arrangements, the following important advantages flow:—

1. The poor ores may be smelted with profit, without putting the companies to any risk or expense in the erection of new works; 2, by the mixture of many different ores, the smelting and metallic product become more easy and abundant; 3, the train of the operations is conducted with all the lights and resources of science; and 4, the amount of metal brought into the market is not subject to such fluctuations as might prove injurious to their sale.

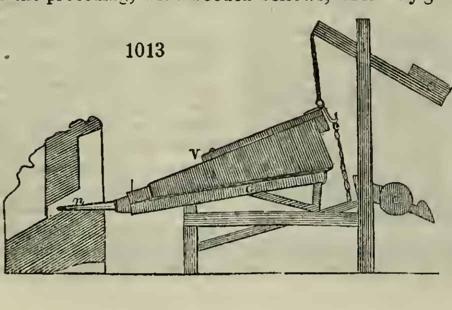
The following is the series of operations;—

1. The fusion of the schlich (sludge); 2, the roasting of the mattes under a shed, and their treatment by four successive re-meltings; 3, the treatment of the resulting black copper; 4, the liquation; 5, the re-liquation (*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.

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 the melting furnace, with a cylinder bellows behind it; *b*, *c*, *d*, furnaces similar to the preceding, with wooden bellows, such as *fig.* 1013; *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*, *p*, cupellation furnaces.

1013



x, *y*, a floor which separates the principal smelting-house into two stories; the materials destined for charging the furnaces being deposited in beds upon the upper floor, to which they are carried by means of two inclined planes, terraced in front of the range of buildings.

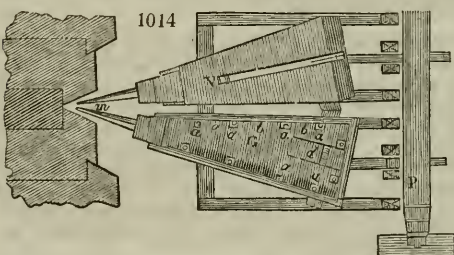
Here 89,600 quintals of schlich are annually smelted, which furnish—

Marketable lead, - - - - - -	20,907 quintals.
Marketable litharge, containing 90 per cent. of lead, -	7,555
Silver, about - - - - - -	67
Copper, (finally purified in the works of Altenau,) -	35
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 moveable 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. 1014, 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.* 1013, raises it again.

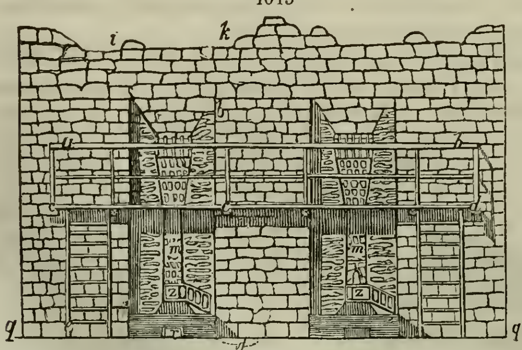
1014



Figs. 1015, 1016, 1017, 1018, represent the moderately high (*demihauts*, or *half-blast*) furnaces employed in the works of the lower Hartz, near Goslar, for smelting the silvery lead ores extracted from the mine of Rammelsberg. See its section in *fig.* 737.

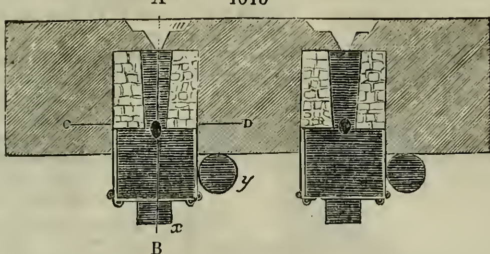
Fig. 1015, is the front elevation of the twin furnaces, built in one body of masonry; *fig.* 1016, is a plan taken at the level of the tuyères, in the line V, *l*, 6, of *fig.* 1017; *figs.* 1017 and 1018, exhibit two vertical sections; the former in the line A, B, the latter in the line C, D, of *fig.* 1016. In these four figures the following objects may be distinguished.

1015



a, *b*, *c*, *d*, a balcony or platform which leads to the place of charging, *n;* *e*, *f*, wooden stairs, by which the charging workmen mount from the ground *p*, *q*, of the works, to the platform; *g*, *h*, brick-work of the furnaces; *i*, *k*, wall of the smelting-works, against which they are supported; *l*, upper basin of reception, hollowed out of the *brasque*, (or ground charcoal bed,) 6; *m*, arch of the tuyère V, by which each furnace receives the blast of two bellows; *n*, place of charging, which takes place through the upper orifice *n*, *o*, of the basin *n*, *o*, v, *t*, of the furnace; *t*, a slab of clay, placed in such a way that, during the treatment of the lead, a little metallic zinc may run together in a sloping gutter, seen in *fig*. 1001, formed of slates cemented together with clay.

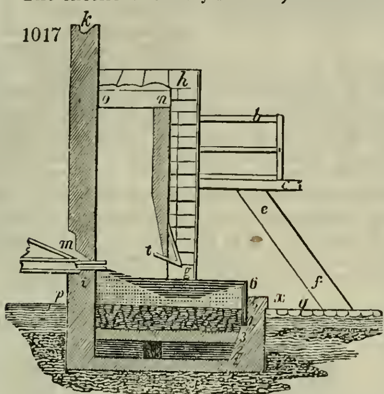
1016



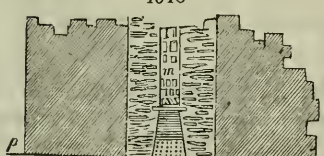
In *figs*. 1015 and 1017, 1, *z*, is the brick-work of the foundations; *m*, conduits (called evaporatory) for the exhalation of the moisture; 4, a layer of slags, rammed above; 5, a bed of clay, rammed above the slags; 6, a brasque, composed of one part of clay, and two parts of ground charcoal, which forms the sole of the furnace.

The excellent refinery furnace, or *treibheerd*, of Frederickshütte, near Tarnowitz, in Upper Silesia, is represented in *figs*. 1019 and 1020. *a*, is the bottom, made of slag or cinders; *b*, the foundation of fire-bricks; *c*, the body of the hearth proper, composed of a mixture of 7 parts of dolomite, and 1 of fire-clay, in bulk; *d*, the grate of the air furnace; *e*, the fire-bridge; *f*, the dome or cap, made of iron plate strengthened with bars, and lined with clay-lute, to protect the metal from burning; *g*, the door of the fireplace; *h*, the ash-pit; *i*, the tap-hole; *k*, *k*, the flue, which is divided by partitions into several channels; *l*, the chimney; *m*, a damper-plate for regulating the draught; *n*, a back valve, for admitting air to cool the furnace, and brushes to sweep the flues; *o*, *tuyère* of copper, which by means of an iron wedge may be sloped more or less towards the hearth; *p*, the *schnepper*, a round piece of sheet iron, hung before the *eye* of the *tuyère*, to break and spread the blast; *q*, the outlet for the glassy litharge.

1017



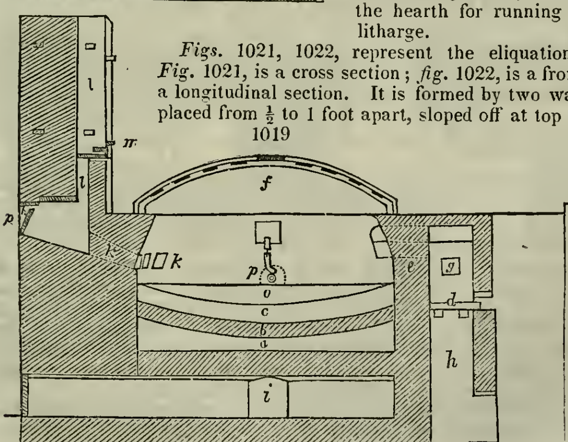
1018



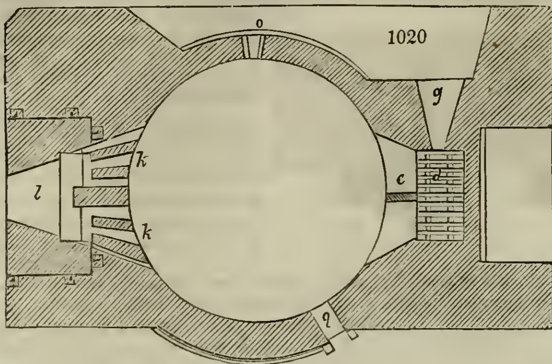
Lime-marl has been found to answer well for making the body of the hearth-sole, as it absorbs the vitrified litharge freely, without combining with it. A basin-shaped hollow is formed in the centre, for receiving the silver at the end of the process; and a gutter is made across the hearth for running off the *glätte* or fluid litharge.

Figs. 1021, 1022, represent the eliquation hearth of Neustadt. *Fig*. 1021, is a cross section; *fig*. 1022, is a front view; and *fig*. 1023, 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, three inches thick, and 18 inches broad, called *saigers-charten*, or refining plates, *b*, *b*, inclined three inches towards each other in the middle, so as to leave at the lowest point a slit two and a half inches wide between them, through which the lead, as it sweats out by the heat, is allowed to fall into

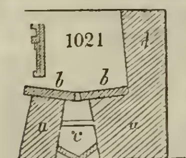
1019



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

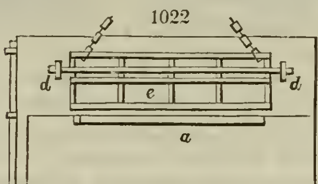


a crucible or pot. Upon one of the long sides, and each of the shorter ones, of the hearth, the walls *d*, *d*, are raised two feet high, and upon these the liquation lumps rest; upon the other long side, where there is no wall, there is an opening for admitting these lumps into the hearth. The openings are then shut with a sheet or cast iron plate *e*, which, by means of a chain, pulley, and counterweight, may be easily raised and lowered. *f*, is a passage for increasing the draught of air.

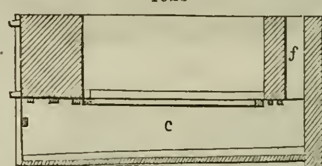


Figs. 1023 and 1026, represent the refining furnaces of Fredeiickshütte by Tarnowitz; *a*, is the fire door; *b*, the grate; *c*, the door for introducing the silver; *d*, the moveable test, resting upon a couple of iron rods *e*, *e*, which are let at their ends into the brick-work. They lie lower than 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.

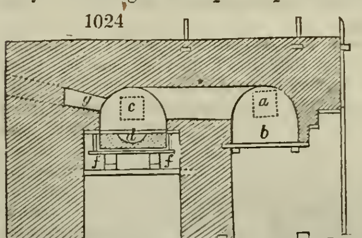
At these smelting-houses, from 150 to 160 cwts. of very pure *workable lead* (lead con-

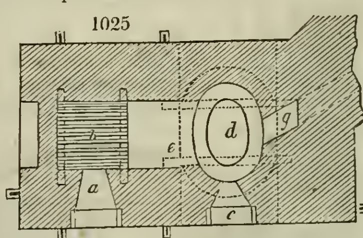


1023



taining merely a little silver) are put into the furnace at once, and from 10 to 14 cwts. run off in vitrified oxyde; the remainder is then refined with some pure lead, when an alloy containing from 14½ to 15½ loths of blicksilber per cwt. is obtained.

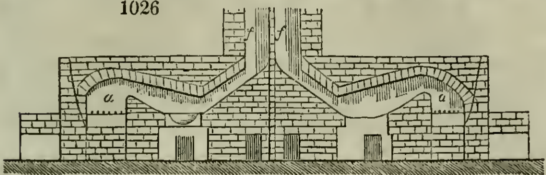




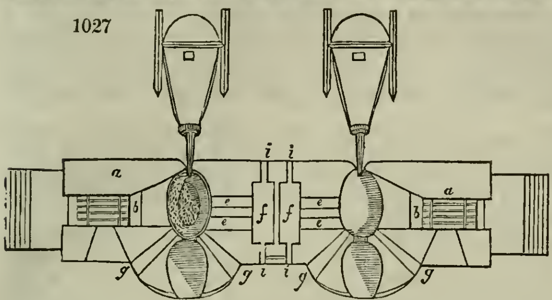
English refining furnaces.—The refining of lead is well performed in some works in the neighborhood of Alston-moor, in reverberatory furnaces, *figs.* 1026 and 1027, whose fireplace is 22 inches square, and is separated from the sole by a fire-bridge, 14 inches in breadth. The flame, after having passed over the surface of the lead in the cupel, enters two flues *e*, *e*, on the opposite side of the furnace, which terminate in a chimney *i*, *i*, *i*, *i*, 40 feet high. At the bottom of the chimney are openings *f*, *f*, for taking out the metallic dust deposited within. These openings are shut during the process.

The cupel or test, which constitutes, in fact, the sole of the hearth in which the operation takes place, is moveable. It consists of a vertical elliptical ring of iron, A, B, C, D, *figs.* 1028 and 1029, $3\frac{3}{4}$ inches high, the greatest diameter of the ellipse being 4 feet, and the smallest 2 . Four iron bars (A, D, *m*, *m'*, B, C, *n*, *n'*) are fixed across its bottom, which are also $3\frac{3}{4}$ inches broad, and an inch thick. The first of these bars is placed 9 inches from the end of the elliptic ring nearest the fireplace, and the three others are equally distributed between this bar and the back end.

1026

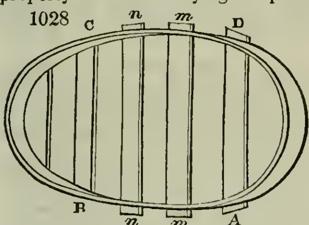


1027

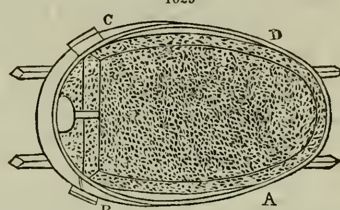


In forming the cupel, several layers of a mixture of moistened bone ashes, and fern ashes, in very fine powder, are put into the *test-frame.* The bone ash constitutes from $\frac{1}{8}$ to $\frac{1}{16}$ of the bulk of the mixture, according to the purity of the fern ashes employed, estimated by the proportion of potash they contain, which has the property of semi-vitrifying the powder of burnt bones, of thus removing its friability, and

1028



1029



rendering it more durable. The layers of ashes are strongly beat down, till the frame is entirely filled. The mass thus formed is then hollowed out by means of a little spade, made on purpose, till it is only three quarters of an inch thick above the iron bars near the centre of the bottom. A flange, 2 inches broad, is made at the upper part, and $2\frac{1}{2}$ inches at the lower part, except on the front or *breast*, which is 5 inches thick. In this anterior part, there is hollowed out an opening of an inch and a quarter broad, and 6 inches long, with which the outlet or *gateway* of the litharge communicates.

The cupel thus prepared is placed in the refining furnace. It rests in an iron ring built into the brickwork. The arched roof of the furnace is 12 inches above the cupel near the fire-bridge, and 9 inches near the flue at the other end.

The tuyère is placed in the back of the furnace, opposite to the side at which the litharge is allowed to overflow.

Openings *g*, *g*, are left at the sides of each cupel, either for running off or for introducing melted lead.

Refining of lead to extract its silver.—This operation, which the lead of Derbyshire cannot be submitted to with advantage, is performed in a certain number of the smelting-houses at Alston-moor, and always upon leads reduced in the Scotch furnace.

The cupel furnace above described must be slowly heated, in order to dry the cupel without causing it to crack, which would infallibly be produced by sudden evaporation of the moisture in it. When it has been thus slowly brought to the verge of a red heat, it is almost completely filled with lead previously melted in an iron pot. The cupel may be charged with about 5 cwts. At the temperature at which the lead is introduced, it is immediately covered with a gray pellicle of oxyde; but when the heat of the furnace has been progressively raised to the proper pitch, it becomes whitish-red, and has its surface covered over with litharge. Now is the time to set in action the blowing-machine, the blast of which, impelled in the direction of the great axis of the cupel, drives the litharge towards the *breast* of the cupel, and makes it flow out by the *way* prepared for it, through which it falls upon a cast-iron plate, on a level with the floor of the apartment, and is dispersed into tears. It is carried in this state to the furnace of reduction, and revived. As by the effect of the continual oxydization which it undergoes, the surface of the metal necessarily falls below the level of the gateway of the litharge, melted lead must be added anew by ladling it into the furnace from the iron boiler, as occasion may require. The operation is carried on in this manner till 84 cwts. or 4 Newcastle *fodders* of lead have been introduced, which takes from 16 to 18 hours, if the tuyère has been properly set. The whole quantity of silver which this mass of lead contains, is left in combination with about 1 cwt. of lead, which, under the name of rich lead, is taken out of the cupel.

When a sufficient number of these pieces of rich lead have been procured, so that by their respective quality, as determined by assaying, they contain in whole from 1000 to 2000 ounces of silver, they are re-melted to extract their silver, in the same furnace, but in a cupel which differs from the former in having at its bottom a depression capable of receiving at the end of the process the cake of silver. In this case a portion of the bottom remains uncovered, on which the scoriæ may be pushed aside with a little rake, from the edges of the silver.

The experiments of MM. Lucas and Gay Lussac have proved that fine silver, exposed to the air in a state of fusion, absorbs oxygen gas, and gives it out again in the act of consolidation. The quantity of oxygen thus absorbed may amount to twenty-two times the volume of the silver. The following phenomena are observed when the mass of metal is considerable; for example, from 40 to 50 pounds.

The solidification commences at the edges, and advances towards the centre. The liquid silver, at the moment of its passage to the solid state, experiences a slight agitation, and then becomes motionless. The surface, after remaining thus tranquil for a little, gets all at once irregularly perturbed, fissures appear in one or several lines, from which flow, in different directions, streams of very fluid silver, which increase the original agitation. The first stage does not yet clearly manifest the presence of gas, and seems to arise from some intestine motion of the particles in their tendency to group, on entering upon the process of crystallization, and thus causing the rupture of the envelop or external crust, and the ejection of some liquid portions.

After remaining some time tranquil, the metal presents a fresh appearance, precisely analogous to volcanic phenomena. As the crystallization continues, the oxygen gas is given out with violence at one or more points, carrying with it melted silver from the interior of the surface, producing a series of cones, generally surmounted by a small crater, vomiting out streams of the metal, which may be seen boiling violently within them.

These cones gradually increase in height by the accumulation of metal thrown up, and that which becomes consolidated on their sloping sides. The thin crust of metal on which they rest, consequently experiences violent impulses, being alternately raised and depressed by such violent agitation, that were it not for the tenacity and elasticity of the metal, there would evidently arise dislocation, fissures, and other analogous accidents. At length several of the craters permanently close, while others continue to allow the gas a passage. The more difficult this is, the more the craters become elevated, and the more their funnels contract by the adhesion or coagulation of a portion of the metal. The projection of globules of silver now becomes more violent; the latter being carried to great distances, even beyond the furnace, and accompanied by a series of explosions, repeated at short intervals. It is generally the last of these little volcanoes that attains the greatest altitude, and exhibits the foregoing phenomena with the greatest energy. It is, moreover, observable, that these cones do not all arise at the same time, some having spent their force, when others commence forming at other points. Some reach the height of an inch, forming bases of two or three inches in diameter. The time occupied by this exhibition is at least from half to three quarters of an hour.

During the formation of these cones, by the evolution of gas, portions of silver are shot forth, which assume, on induration, a form somewhat cylindrical, and often very fantastic, notwithstanding the incompatibility which appears to exist between the fluidity of the silver and these elongated figures. Their appearance is momentary, and without any symptoms of gas, although it is impossible to decide whether they may not arise from its influence; they seem, in fact, to resemble the phenomena of the first volcanic period.

Till very recently, the only operations employed for separating silver from lead in the English smelting-works, were the following:—

1. Cupellation, in which the lead was converted into a vitreous oxyde, which was floated off from the surface of the silver.
2. Reduction of that oxyde, commonly called litharge.
3. Smelting the bottoms of the cupels, to extract the lead which had soaked into them, in a glassy state.

Cupellation and its two complementary operations were, in many respects, objectionable processes; from the injurious effects of the lead vapors upon the health of the workmen; from the very considerable loss of metallic lead, amounting to 7 per cent. at least; and, lastly, from the immense consumption of fuel, as well as from the vast amount of manual labor incurred in such complicated operations. Hence, unless the lead were tolerably rich in silver, it would not bear the expense of cupellation.

The patent process lately introduced by Mr. Pattinson, of Newcastle, is not at all prejudicial to the health of workmen; it does not occasion more than 2 per cent. of loss of lead, and in other respects it is so economical, that it is now profitably applied in Northumberland to alloys too poor in silver to be treated by cupellation. This process is founded upon the following phenomena.

After melting completely an alloy of lead and silver, if we allow it to cool very slowly, continually stirring it meanwhile with a rake, we shall observe at a certain period a continually increasing number of imperfect little crystals, which may be taken out with a drainer, exactly as we may remove the crystals of sea salt deposited during the concentration of brine, or those of sulphate of soda, as its agitated solution cools. On submitting to analysis the metallic crystals thus separated, and also the liquid metal deprived of them, we find the former to be lead almost alone, but the latter to be rich in silver, when compared with the original alloy. The more of the crystalline particles are drained from the metallic bath, the richer does the *mother* liquid become in silver. In practice, the poor lead is raised by this means to the standard of the ordinary lead of the litharge works; and the better lead is made ten times richer. This very valuable alloy is then submitted to cupellation; but as it contains only a tenth part of the quantity of lead subjected to crystallization, the loss in the cupel will be obviously reduced to one tenth of what it was by the former process; that is, seven tenths of a per cent., instead of seven.

These nine tenths of the lead separated by the drainer, are immediately sent into the market, without other loss than the trifling one, of about one half per cent., involved in reviving a little dross skimmed off the surface of the melted metal at the beginning of the operation. Hence the total waste of lead in this method does not exceed two per cent. And as only a small quantity of lead requires to be cupelled, this may be done with the utmost slowness and circumspection; whereby loss of the precious metal, and injury to the health of the work-people, are equally avoided.

The crystallization refinery of Mr. Pattinson is an extremely simple smelting-house. It contains 3 hemispherical cast-iron pans, 41 inches in diameter, and $\frac{1}{4}$ of an inch thick. The 3 pans are built in one straight line, the broad flange at their edge being supported upon brick-work. Each pan has a discharge pipe, proceeding laterally from one side of its bottom, by which the melted metal may be run out when a plug is withdrawn, and each is heated by a small separate fire.

Three tons of the argentiferous lead constitute one charge of each pan; and as soon as it is melted, the fire is withdrawn; the flue, grate-door, and ash-pit, are immediately closed, and made air-tight with bricks and clay-lute. The agitation is now commenced, with a round bar of iron, terminated with a chisel-point, the workman being instructed merely to keep moving that simple rake constantly in the pan, but more especially towards the edges, where the solidification is apt to begin. He must be careful to take out the crystals, progressively as they appear, with an iron drainer, heated a little higher than the temperature of the metal bath. The liquid metal lifted in the drainer, flows readily back through its perforations, and may be at any rate effectually detached by giving the ladle two or three jogs. The solid portion remains in the form of a spongy, semi-crystalline, semi-pasty mass.

The proportion of crystals separated at each melting, depends upon the original quality of the alloy. If it be poor, it is usually divided in the proportion of two thirds of poor crystals, and one third of rich liquid metal; but this proportion is reversed if the alloy contain a good deal of silver.

Let us exemplify, by the common case of a lead containing 10 ounces of silver per ton. Operating upon 3 tons of this alloy, or 60 cwts., containing 30 oz. of silver, there will be obtained in the first operation—

(*a*) 40 cwts. at $4\frac{1}{4}$ ounces of silver per ton; in whole 9 oz. }
(*b*) 20 cwts. at 21 — — 21 } 30 oz.

Each of these alloys, (*a*) and (*b*), will be joined to alloys of like quality obtained in the treatment of one or several other portions of three tons of the primitive alloy. Again, three tons of each of these rich alloys are subjected to the crystallization process, and thus in succession. Thus poorer and poorer lead is got on the one hand, and richer and richer alloys on the other. Sometimes the *mother* metal is parted from a great body of poor crystals, by opening the discharge-pipe, and running off the liquid, while the workman keeps stirring, to facilitate the separation of the two.

25 fodders, 15 cwts., 49 lbs. = 540 cwts., 49 lbs. of alloy, holding 5 oz. of silver per fodder, in the whole 130 oz., afforded, after three successive crystallizations,—

	oz.
440 cwts. of poor lead, holding ½ oz. of silver per fodder; in all	10½
15 cwts. 49 — holding the original quantity, nearly -	3½
84 cwts. of lead for the cupel, holding 29 oz. - - -	116
Total - - - - - - - - - -	130

1 cwt. of loss, principally in the reduction of dross.

The expenses of the new method altogether, including 3*s.* per fodder of patent dues, are about one third of the old; being 17*l.* 13*s.* and 54*l.* 16*s.* respectively, upon 84 cwts. of lead, at 29 oz. per fodder.

In the conditions above stated, the treatment of argentiferous lead occasions the following expenses:—

FOR ONE FODDER.	£	*s.*	*d.*
By the new process - - - - - - - -	0	13	7
By the old process - - - - - - - -	2	2	2

Admitting that the treatment of silver holding lead is economically possible only when the profit is equal to one tenth of the gross expenses of the process, we may easily calculate, with the preceding data, that it is sufficient for the lead to have the following contents in silver:—

With the new process, 3 ounces per fodder; or, - - 0·000078
With the old process, $8\frac{4}{70}$ ounces per fodder; or, - - 0·000218

To conclude, the refining by crystallization reduces the cost of the parting of lead and silver, in the proportion of three to one; and allows of extracting silver from a lead which contains only about three oz. per ton. In England, the new method produces at present very advantageous results, especially in reference to the great masses to which it may be applied. In 1828, the quantity of lead annually extracted from the mines in the United Kingdom had been progressively raised to 47,000 tons. Reduced almost to one half of this amount in 1832, by the competition of the mines of la Sierra de Gador, the English production began again to increase in 1833. In 1835, 35,000 tons of lead were obtained, one half of which only having a mean content of eight and a half ounces of silver per ton, was subjected to cupellation, and produced 14,000 oz. of that precious metal. The details of this production are—

Silver extracted from 17,500 tons of lead, holding upon the average eight and a half ounces per ton, - - - - - - - -	140,000 oz.
Silver extracted from silver ores, properly so called, in Cornwall, -	36,000
	176,000

In 1837, the production of lead amounted probably to 40,000 tons; upon which the introduction of the new method would have the effect not only of reducing considerably the cost of parting the 20,000 tons of lead containing 8 oz. of silver per ton, but of permitting the extraction of 4 or 5 oz. of silver, which may be supposed to exist upon an average in the greater portion of the remaining 20,000 tons. Otherwise, this mass of the precious metal would have had no value, or have been unproductive.

There are two oxydes of silver; called argentic oxyde, and suroxyde, by Berzelius. 1. The first is obtained by adding solution of caustic potassa, or lime-water, to a solution of nitrate of silver. The precipitate has a brownish-gray color, 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 oxyde is an energetic base; being slightly soluble in pure water, reacting like the alkalis upon reddened litmus paper, and displacing, from their combinations with the alkalis, a portion of the acids, with which it forms insoluble compounds. It is insoluble in the caustic leys of potassa or soda. By combination with caustic ammonia, it forms *fulminating silver.* This formidable substance may be prepared by precipitating the nitrate of silver with lime-water, washing the oxyde upon a filter, and spreading it upon gray paper, to make it nearly dry. Upon the oxyde, still moist, water of ammonia is to be poured, and allowed to remain for several hours. The powder which becomes black, is to be freed from the supernatant liquor by decantation, divided into small portions while moist, and set aside to dry upon bits of porous paper. Fulminating silver may be made more expeditiously by dissolving the nitrate in water of pure ammonia, and precipitating by the addition of caustic potassa ley in slight excess. If fulminating silver be pressed with a hard body in its moist state, it detonates with unparalleled violence; nay, when touched even with a feather, in its dry state, it frequently explodes. As many persons have been seriously wounded, and some have been killed, by these explosions, the utmost precautions should be taken, especially by young chemists, in its preparation. This violent phenomenon is caused by the sudden production of water and nitrogen, at the instant when the metallic oxyde is reduced. The quiescent and divellent affinities seem to be so nicely balanced in this curious compound, that the slightest disturbance is sufficient to incite the hydrogen of the ammonia to snatch the oxygen from the silver. The oxyde of silver dissolves in glassy fluxes, and renders them yellow. It consists, according to Berzelius, of 93·11 parts of silver, and 6·89 of oxygen. 2. The suroxyde of silver is obtained by passing a voltaic current through a weak solution of the nitrate; it being deposited, of course, at the positive or oxygenating pole. It is said to crystallize in needles of a metallic lustre, interlacing one another, which are one third of an inch long. When thrown into muriatic acid, it causes the disengagement of chlorine, and the formation of chloride of silver; into water of ammonia, it occasions such a rapid production of nitrogen gas, with a hissing sound, as to convert the whole liquid into froth. If a little of it, mixed with phosphorus, be struck with a hammer, a loud detonation ensues. With heat it decrepitates, and becomes metallic silver.

Sulphuret of silver, which exists native, may be readily prepared by fusing the constituents together; and it forms spontaneously upon the surface of silver exposed to the air of inhabited places, or plunged into eggs, especially rotten ones. The tarnish may be easily removed, by rubbing the metal with a solution of *cameleon mineral*, prepared by calcining peroxyde of manganese with nitre. Sulphuret of silver is a powerful sulphobase; since though it be heated to redness in close vessels, it retains the volatile sulphides, whose combinations with the alkalis are decomposed at that temperature. It consists of 87·04 of silver, and 12·96 of oxygen.

A small quantity of tin, alloyed with silver, destroys its ductility. The best method of separating these two metals, is to laminate the alloy into thin plates, and distil them along with corrosive sublimate. The bichloride of tin comes over in vapors, and condenses in the receiver. Silver and lead, when combined, are separated by heat alone in the process of cupellation, as described in the article Assay, and in the reduction of silver ores. See *suprà*.

An alloy, containing from one twelfth to one tenth of copper, constitutes the silver coin of most nations; being a harder and more durable metal under friction than pure silver. When this alloy is boiled with a solution of cream of tartar and sea-salt, or scrubbed with water of ammonia, the superficial particles of copper are removed, and a surface of fine silver is left.

Chloride of silver is obtained by adding muriatic acid, or any soluble muriate, to a solution of nitrate of silver. A curdy precipitate falls, quite insoluble in water, which being dried and heated to dull redness, fuses into a semi-transparent gray mass, called, from its appearance, *horn-silver*. Chloride of silver dissolves readily in water of ammonia, and crystallizes in proportion as the ammonia evaporates. It is not decomposed by a red heat, even when mixed with calcined charcoal; but when hydrogen or steam is passed over the fused chloride, muriatic acid exhales, and silver remains. When fused along with potassa, (or its carbonate,) the silver is also revived; while oxygen (or also carbonic acid) gas is liberated, and chloride of potassium is formed. Alkaline solutions do not decompose chloride of silver. When this compound is exposed to light, it suffers a partial decomposition, muriatic acid being disengaged. See Assay by the *humid method*.

The best way of reducing the chloride of silver, says Mohr, is to mix it with one third of its weight of colophony, (black rosin,) and to heat the mixture moderately in a crucible till the flame ceases to have a greenish-blue color; then suddenly to increase the fire, so as to melt the metal into an ingot.

The subchloride may be directly formed, by pouring a solution of deuto-chloride of copper or iron upon silver leaf. The metal is speedily changed into black spangles, which, being immediately washed and dried, constitute subchloride of silver. If the contact of the solutions be prolonged, chloride would be formed.

The bromide, cyanide, fluoride, and iodide of silver, have not been applied to any use in the arts. Sulphate of silver may be prepared by boiling sulphuric acid upon the metal. See Refining of Gold and Silver. It dissolves in 88 parts of boiling water, but the greater part of the salt crystallizes in small needles, as the solution cools. It consists of 118 parts of oxyde, combined with 40 parts of dry acid. Solutions of the hyposulphite of potassa, soda, and lime, which are bitter salts, dissolve chloride of silver, a tasteless substance, into liquids possessed of the most palling sweetness, but not at all of any metallic taste.

The iodide of silver is remarkable, like some other metallic compounds, for changing its color alternately with heat and cold. If a sheet of white paper be washed over with a solution of nitrate of silver, and afterwards with a somewhat dilute solution of hydriodate of potash, it will immediately assume the pale yellow tint of the cold silver iodide. On placing the paper before the fire, it will change color from a pale primrose to a gaudy brilliant yellow, like the sun-flower; and on being cooled, it will again resume the primrose hue. These alternations may be repeated indefinitely, like those with the salts of cobalt, provided too great a heat be not applied. The pressure of a finger upon the hot yellow paper makes a white spot, by cooling it quickly.

Fulminate of silver is prepared in the same way as FULMINATE *of Mercury*, which see.

On the 10th of February, 1798, the Lords of the Privy Council appointed the Hon. Charles Cavendish, F. R. S., and Charles Hatchett, Esq., F. R. S., to make investigations upon the wear of gold coin by friction. Their admirable experiments were begun in the latter end of 1798, and completed in April, 1801, having been instituted and conducted with every mechanical aid, as devised by these most eminent chemical philosophers, and provided at no small expense, by the government. The following are the important conclusions of their official report :—*

"Gold made standard by a mixture of equal parts of silver and copper, is not so soft as gold alloyed only with silver; neither is it so pale; for it appears to be less removed from the color of fine gold, than either the former or the following metal.

"Gold, when alloyed with silver and copper, when annealed, does not become black, but brown; and this color is more easily removed by the blanching liquor, or solution of alum, than when the whole of the alloy consists of copper. It may also be rolled and stamped with great facility; and, under many circumstances, it appears to suffer less by friction than gold alloyed by silver or copper alone.

"If copper alone forms the alloy, it must be dissolved and separated from the surface of each piece of coin, in the process of annealing and blanching.

"Upon a comparison of the different qualities of the three kinds of standard gold, it appears (strictly speaking) that gold made standard by silver and copper is rather to be preferred for coin."

It will, undoubtedly, seem not a little strange to the uninitiated, that this report, and its important deductions, should have been of late years entirely set at naught, without any scientific reason or research, apparently for the purpose of giving a certain official in our Mint a good job, in sweating out all the silver from our sovereigns, and replacing it, in the new coinage, with copper, taking on an average 3*d.* worth of silver out of each ounce of our excellent gold coin, and charging the country 6½*d.* for its extraction, besides the very considerable expense in providing fine copper to replace the silver. The pretence set up for this extraordinary degradation of the gold, was, that our coin might peradventure be exported, in order to be de-silvered abroad, a danger which could have been most readily averted, by leaving out as much gold in every sovereign as was equivalent to the silver introduced, and thus preserving its intrinsic value in precious metal. When the film of fine gold which covers each of our present pieces has been rubbed off from the prominent parts, these must appear of a very different and deeper color than the flat part or ground of the coin. "The reason, therefore, is sufficiently apparent, says Mr. Hatchett, why gold which is alloyed with silver only, cannot be liable to this blemish ;" and with one half of silver alloy, it must be much less liable to it, than with copper alone. Why did the political economists in the recent Committee of the House of Commons on the Mint, blink this question of public economy and expediency ?

Gold, as imported from America, Asia, and Africa, contains on an average nearly the right proportion of silver for making the best coin; and were it alloyed to our national standard, of 22 parts of gold, 1 of silver, and 1 of copper, as defined by Messrs. Cavendish and Hatchett, then by simply adding the deficient quantities of one or two of these metals, by the rule of alligation, the very considerable expense would be saved to the nation, and sulphureous nuisance to the Tower Hamlets, now foolishly incurred in de-silvering and cuprifying sovereigns at the Royal Mint.

It was long imagined in Europe, that the average metallic contents of the silver ores of Mexico and Peru, were considerably greater than those of Saxony and Hungary. Much poorer ores, however, are worked among the Cordilleras than in any part of Europe. The mean product of the whole silver ores that are annually reduced in Mexico, amounts only to from 0·18 to 0·25 of a per cent.; that is, from 3 to 4 ounces in 100 lbs.; the true average being, perhaps, not more than 2½. It is by their greater profusion of ores, not their superior richness, that the mines of South America surpass those of Europe.

GOLD and SILVER produced in Forty Years, from 1790 to 1830.

	Gold.	Silver.
Mexico,	£6,436,453	£139,818,032
Chile,	2,768,488	1,822,924
Buenos Ayres,	4,024,895	27,182,673
Russia,	3,703,743	1,502,981

* It is inserted in the Philosophical Transactions for 1803.

Returns of the Dollars coined at the different Mints in Mexico.

	1829.	1830.	1831.	1834.
Mexico - -	1,280,000	1,090,000	1,386,000	952,000
Guanajuato - -	2,406,000	2,560,000	2,603,000	2,703,000
Zacatecas - -	4,505,000	5,190,000	4,965,000	5,527,000
Guadalaxara - -	596,000	592,000	590,000	715,000
Durango - -	659,000	453,000	358,000	1,215,000
San Luis - -	1,613,000	1,320,000	1,497,000	928,000
Ilalpan - -	728,000	90,000	323,000	—
Total - -	11,787,000	11,295,000	11,722,000	12,040,000

The returns for 1832 and 1833 are wanting.

Peru.—Returns of Gold and Silver coined at the Mints of Lima and Casco.

	Gold.	Silver.	Total, in Dollars.
1830	180,000	2,015,000	2,195,000
1831	92,000	2,384,000	2,476,000
1832	94,000	3,210,000	3,284,000
1833	150,000	2,990,000	3,140,000
1834	110,000	3,150,000	3,260,000

Returns of Silver in Bars produced at the different Smelting-works in Peru.

	Lima.	Truxillo.	Pasco.	Ayacucho	Puno.	Arequipa.	Total, in Dollars.
1830	270,000	190,000	780,000	120,000	250,000	150,000	1,760,000
1831	270,000	60,000	1,110,000	70,000	310,000	110,000	1,930,000
1832	290,000	100,000	1,800,000	70,000	345,000	25,000	2,640,000
1833	222,000	70,000	2,130,000	50,000	25,000	65,000	2,562,000

Returns of Silver in Dollars exported from the Provinces of Chili.

	Coquimbo.	Huasco.	Copiano.
1831	785,000	115,000	670,000
1832	316,000	—	36,000
1833	490,000	100,000	585,000
	1,591,000	215,000	1,291,000

Santiago—Mint Coinage.

Gold.	Silver.	Total.
1832, 174,000; 1833, 392,500	1832, 42,000; 1833, 92,000	700,500

The production of Silver in the kingdom of Saxony amounted to—

59,231 marcs and 8 loths, in the year 1825
55,023 — — — 1826
60,034 — — — 1827
61,361 — — — 1828
65,176 — and 10 loths — 1830
65,886 — — — 1832

The mine of Himmelfürst alone produces annually 10,000 marcs.

The quantity of Silver produced in the Prussian States was—

22,135 marcs	in 1825		20,612 marcs	in 1829
20,071	— 1826		20,887	— 1830
18,631	— 1827	mmmmmm	19,031	— 1831
21,731	— 1828		22,083	— 1832

The whole annual production of Europe, and Asiatic Russia, has been rated by Humboldt at 292,000 marcs, by other authorities at 310,000 marcs; while at the beginning of the present century, that of the Spanish colonies in America was 3,349,160 marcs, or nearly twelve times as much. The sum total is 3,704,160 marcs, of 3609 grains troy each; which is nearly 1,900,000 lbs. avoirdupois; that is, little less than 9000 tons.

The English Mint silver contains 222 pennyweights of fine silver, and 18 of copper, in the troy pound of 240 pennyweights: or 92·5 in 100 parts. 1 pound troy = 5760 grains, contains 65·8 shillings, each weighing 87·55 grains. The French silver coin contains one tenth of copper, and a franc weighs 5 grammes = 77·222 grains troy. The Prussian dollar (*thaler*) is the standard coin; 10½ *thaler* weigh 1 marc; hence, 1 *thaler* weighs 343·7 grains troy, and contains 257·9 grains of fine silver; being 75 per cent. of silver, and 25 of alloy. The Austrian coin contains $\frac{13}{288}$ of alloy, according to Wasserberg; which is only 4½ per cent.

SILVER LEAF is made in precisely the same way as *gold leaf*, to which article I must therefore refer the reader.

SILVERING is the art of covering the surfaces of bodies with a thin film of silver. When silver leaf is to be applied, the methods prescribed for gold leaf are suitable. Among the metals, copper or brass are those on which the silverer most commonly operates. Iron is seldom silvered; but the processes for both metals are essentially the same.

The principal steps of this operation are the following:—

1. The *smoothing down* the sharp edges, and polishing the surface of the copper; called *émorfiler* by the French artists.

2. The *annealing;* or making the piece to be silvered red-hot, and then plunging it in very dilute nitric acid, till it be bright and clean.

3. *Pumicing;* or clearing up the surface with pumice-stone and water.

4. The *warming*, to such a degree merely as, when it touches water, it may make a slight hissing sound; in which state it is dipped in the very weak aquafortis, whereby it acquires minute insensible asperities, sufficient to retain the silver leaves that are to be applied.

5. The *hatching*. When these small asperities are inadequate for giving due solidity to the silvering, the plane surfaces must be hatched all over with a graving tool; but the chased surfaces need not be touched.

6. The *blueing* consists in heating the piece till its copper or brass color 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, one of washed whiting, and one and a half of sea salt. After clearing the surface of the brass, it is to be rubbed with a bit of soft leather, or cork moistened with water, and dipped in the above powder. After the silvering, it should be thoroughly washed with water, dried, and immediately varnished. Some use a mixture of 1 part of the silver precipitate with 10 of cream of tartar, and this mixture also answers very well.

Others give a coating of silver by applying with friction, in the moistened state, a mixture of 1 part of silver-powder precipitated by copper, 2 parts of cream of tartar, and as much common salt. The piece must be immediately washed in tepid water very faintly alkalized, then in slightly warm pure water, and finally wiped dry before the fire. See PLATED MANUFACTURE.

The inferior kinds of plated buttons get their silver coating in the following way:—

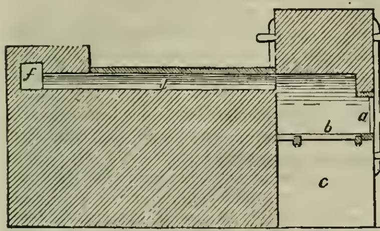
2 ounces of chloride of silver are mixed up with 1 ounce of corrosive sublimate, 3 pounds of common salt, and 3 pounds of sulphate of zinc, with water, into a paste. The buttons being cleaned, are smeared over with that mixture, and exposed to a moderate degree of heat, which is eventually raised nearly 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.

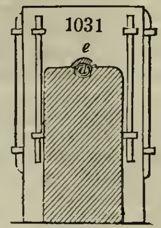
Leather is silvered by applying a coat of parchment size, or spirit varnish, to the surface, and then the silver leaf, with pressure.

SIMILOR is a golden-colored variety of brass.

SINGEING OF WEBS. The old furnace for singeing cotton goods is represented in longitudinal section, *fig.* 1030, and in a transverse one in *fig.* 1031. *a* is the fire-door; *b* the grate; *c*, the ash-pit; *d*, a flue 6 inches broad, and 2½ high, over which a hollow semi-cylindrical mass of cast iron *e*, is laid, one inch thick at the sides, and 2½ thick at the top curvature. The flame passes along the fire-flue *d*, into a side opening *f*, in the chimney. The goods are swept swiftly over this ignited piece of iron, with considerable friction, by means of a wooden roller, and a swing frame for raising them at any moment out of contact.

1030



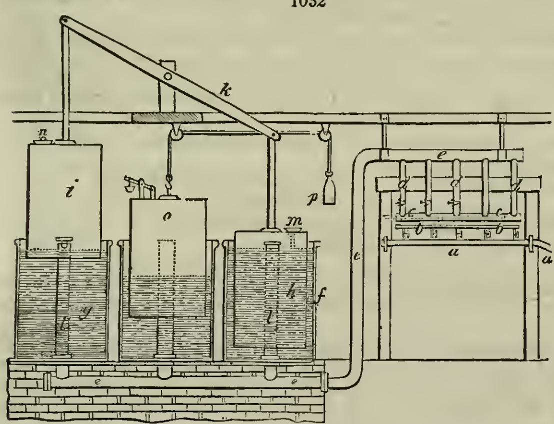


In some shops, semi-cylinders of copper, three quarters of an inch thick, have been substituted for those of iron, in singeing goods prior to bleaching them. The former last three months, and do 1500 pieces with one ton of coal; while the latter, which are an inch and a half thick, wear out in a week, and do no more than from 500 to 600 pieces with the same weight of fuel.

In the early part of the year 1818, Mr. Samuel Hall enrolled the specification of a patent for removing the downy fibres of the cotton thread from the interstices of bobbinet lace, or muslins, which he effected by singeing the lace with the flame of a gas-burner. The second patent granted to Mr. Hall, in April, 1823, is for an improvement in the above process; viz., causing a strong current of air to draw the flame of the gas through the interstices of the lace, as it passes over the burner, by means of an aperture in a tube placed immediately above the row of gas-jets, which tube communicates with an air-pump or exhauster.

Fig. 1032 shows the construction of the apparatus complete, and manner in which it operates; *a*, *a*, is a gas-pipe, supplied by an ordinary gasometer; from this pipe, several small ones extend upwards to the long burner *b*, *b*. This burner is a horizontal tube, perforated with many small holes on the upper side, through which, as jets, the gas passes; and when it is ignited, the bobbinet lace, or other material intended to be singed, is extended and drawn rapidly over the flame, by means of rollers, which are not shown in the figure.

1032



The simple burning of the gas, even with a draught chimney, as in the former specification, is found not to be at all times efficacious; the patentee, therefore, now introduces a hollow tube *c*, *c*, with a slit or opening, immediately over the row of burners; and this tube, by means of the pipes *d*, *d*, *d*, communicates with the pipe *e*, *e*, *e*, which leads to the exhausting apparatus.

This exhausting apparatus consists of two tanks, *f* and *g*, nearly filled with water, and two inverted boxes or vessels, *h* and *i*, which are suspended by rods to the vibrating beam *k*; each of the boxes is furnished with a valve opening upwards; *l*, *l*, are pipes extending from the horizontal part of the pipe *e*, up into the boxes or vessels *h* and *i*, which pipes have valves at their tops, also opening upward. When the vessel *h* descends, the water in the tank forces out the air contained within the vessel at the valve *m*; but when that vessel rises again, the valve *m* being closed, the air is drawn from the pipe *e*, through the pipe *l*. The same takes place in the vessel *i*, from which the air in its descent is expelled through the valve *n*, and, in its ascent, draws the air through the pipe *l*, from the pipe *c*. By these means, a partial exhaustion is effected in the pipe *e*, *e*, and the tube *c*, *c*; to supply which, the air rushes with considerable force through the long opening of the tube *c*, *c*, and carries with it the flame of the gas-burners. The bobbinet lace, or other goods, being now drawn over the flame between the burner *b*, *b*, and the exhausted tube *c*, *c*, by means of rollers, as above said, the flame of the gas is forced through the interstices of the fabric, and all the fine filaments and loose fibres of the thread are burnt off, without damaging the substance of the goods.

To adjust the draught from the gas-burners, there are stopcocks introduced into several of the pipes *d*; and to regulate the action of the exhausting apparatus, an air vessel *o*, is suspended by a cord or chain passing over pulleys, and balanced by a weight *p*. There is also a scraper introduced into the tube *c*, which is made, by any convenient contrivance, to revolve and slide backwards and forwards, for the purpose of removing any light matter that may arise from the goods singed, and which would otherwise obstruct the air passage. Two of these draught tubes *c*, may be adapted and united to the exhausting apparatus, when a double row of burners is employed, and the inclination of the flame may be directed upwards, downwards, or sideways, according to the position of the slit in the draft tube, by which means any description of goods may, if required, be singed on both sides at one operation.

The greater part of the bobbinet lace made in England, is sent to Mr. Hall's works, at Basford, near Nottingham, to be singed; and at a reduction of price truly wonderful. He receives now only one farthing for what he originally was paid one shilling.

SKIN (*Peau*, Fr.; *Haut*, Germ.), the external membrane of animal bodies, consists of three layers: 1. the epidermis, scarf-skin, (*Oberhaut*, Germ.); 2. the vascular organ, or papillary body, which performs the secretions; and 3. the true skin, (*Lederhaut*, Germ.), of which leather is made. The skin proper, or dermoid substance, is a tissue of innumerable very delicate fibres, crossing each other in every possible direction, with small orifices between them, which are larger on its internal than on its external surface. The conical channels thus produced are not straight, but oblique, and filled with cellular membrane; they receive vessels and nerves which pass out through the skin (*cutis vera*), and are distributed upon the secretory organ. The fibrous texture of the skin is composed of the same animal matter as the serous membranes, the cartilages, and the cellular tissue; the whole possessing the property of dissolving in boiling water, and being, thereby, converted into glue. See Glue, Leather, and Tan.

SLAG (*Laitier*, Fr.; *Schlacke*, Germ.), is the vitreous mass which covers the fused metals 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 oxydes of iron and other metals; being analogous in composition, and having the same crystalline form as the mineral, *pyroxene*. See Copper and Iron.

SLATES (*Ardoises*, Fr.; *Schiefern*, Germ.) The substances belonging to this class may be distributed into the following species:—

1. Mica-slate, occasionally used for covering houses.
2. Clay-slate, the proper 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-slate.*—This is a mountain rock of vast continuity and extent, of a schistose texture, composed of the minerals mica and quartz, the mica being generally predominant.

2. *Clay-slate.*—This substance is closely connected with mica; so that uninterrupted transitions may be found between these two rocks in many mountain chains. It is a simple schistose mass, of a bluish-gray or grayish-black color, of various shades, and a shining, somewhat pearly internal lustre on the faces, but of a dead color in the cross fracture.

Clay-slate is extensively distributed in Great Britain. It skirts the Highlands of Scotland, from Lochlomond by Callender, Comrie, and Dunkeld; resting on, and gradually passing into mica-slate throughout the whole of that territory. Roofing-slate occurs, on the western side of England, in the counties of Cornwall and Devon; in various parts of North Wales and Anglesea; in the north-east parts of Yorkshire, near Ingleton, and in Swaledale; as also in the counties of Cumberland and Westmoreland. It is likewise met with in the county of Wicklow and other mountainous districts of Ireland.

All the best beds of roofing-slate improve in quality as they lie deeper under the sur face; near to which, indeed, they have little value.

A good roofing-slate should split readily into thin even laminæ; it should not be absorbent of water either on its face or endwise, a property evinced by its not increasing perceptibly in weight after immersion in water; and it should be sound, compact, and not apt to disintegrate in the air. The slate raised at Eisdale, on the west coast of Argyllshire, is very durable.

Cleaving and dressing of the slates.—The splitter begins by dividing the block, cut lengthwise, to a proper size, which he rests on end, and steadies between his knees. He uses a mallet and a chisel, which he introduces into the stone in a direction parallel to the *folia*. By this means he reduces it into several manageable pieces, and he gives to each the requisite length, by cutting cross grooves on the flat face, and then striking the slab with the chisel. It is afterwards split into thinner sections, by finer chisels dexterously applied to the edges. The slate is then dressed to the proper shape, by being laid on a block of wood, and having its projecting parts at the ends and sides cut off with a species of hatchet or chopping-knife. It deserves to be noticed, that blocks of slate may lose their property of divisibility into thin laminæ. This happens from long exposure to the air, after they have been quarried. The workmen say, then, that they have lost their waters. For this reason, the number of splitters ought to be always proportioned to the number of block-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.* Color, cream-yellow, in alternate stripes; massive; composition impalpable; principal fracture, slaty, thin, and straight; cross fracture, fine earthy; feels fine, but meager; adheres little, if at all, to the tongue; is very soft, passing into friable; specific gravity in the dry state, 0·6; when imbued with moisture, 1·9. It is supposed to have been formed from the ashes of burnt coal. It is found at Planitz, near Zwickau, and at Kutschlin near Bilin in Bohemia.

5. *Drawing-slate*, or *black chalk;* has a grayish-black color; 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 color, is easily broken or exfoliated, has a shining streak, adheres strongly to the tongue, and absorbs water rapidly, with the emission of air-bubbles and a crackling sound.

7. *Bituminous shale*, is a species of soft, sectile slate-clay, much impregnated with bitumen, which occurs in the coal-measures.

8. *Slate-clay*, has a gray or grayish-yellow color; is massive, with a dull glimmering lustre from spangles of mica interspersed. Its slaty fracture approaches at times to earthy; fragments, tabular; soft, sectile, and very frangible; specific gravity, 2·6. It adheres to the tongue, and crumbles down when immersed for some time in water. It is found as an alternating bed in the coal-measures. (See the sections of the strata under PITCOAL.) When breathed upon, it emits a strong argillaceous odor. 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.

SMALL WARES, is the name given in this country to textile articles of the tape kind, narrow bindings of cotton, linen, silk, or woollen fabric; plaited sash cord, braid, &c. Tapes are woven upon a loom like that for weaving ribands, which is now generally driven by mechanical power. Messrs. Worthington and Mulliner obtained a patent, in June, 1825, for improvements in such a loom, which have answered the purposes of their large factory in Manchester very well; and in May, 1831, Mr. Whitehead, of the same town, patented certain improvements in the manufacture of small wares. The objects of the latter patent are, the regular taking up of the tape or cloth, as it is woven, a greater facility of varying the vibration of the lay, together with the saving of room required for a range of looms to stand in.* See BRAIDING MACHINE.

SMALT, see AZURE and COBALT.

Imported for home consumption in 1834, 162,232 lbs.; in 1835, 96,649; in 1836, 79,531; duty, 4*d.* per lb.

SMELTING, is the operation by which the ores of iron, copper, lead, &c., are reduced to the metallic state. See METALLURGY, ORES, and the respective metals.

SOAP (*Savon*, Fr.; *Seife*, Germ.), is a chemical compound, of saponified fats or oils with potash or soda, prepared for the purposes of washing linen, &c. Fatty

* Newton's London Journal, vol. xiii. p 192; and vol. i. combined series, p. 212.

matters, when subjected to the action of alkaline leys, undergo a remarkable change, being converted into three different acids, called stearic, margaric, and oleic; and it is these acids, in fact, which combine with the bases, in definite proportions, to form compounds analogous to the neutro-saline. Some chemical writers describe under the title soap, every compound which may result from the union of fats with the various earths and metallic oxydes—a latitude of nomenclature which common language cannot recognise, and which would perplex the manufacturer.

Soaps are distinguished into two great classes, according to their consistence; the hard and the soft; the former being produced by the action of soda upon fats, the latter by that of potash. The nature of the fats contributes also somewhat to the consistence of soaps; thus tallow, which contains much stearine and margarine, forms with potash a more consistent soap than liquid oils will do, which consist chiefly of oleine. The drying oils, such as those of linseed and poppy, produce the softest soaps.

1. *Of the manufacture of hard soap.*—The fat of this soap, in the northern countries of Europe, is usually tallow, and in the southern, coarse olive oil. Different species of grease are saponified by soda, with different degrees of facility; among oils, the olive, sweet almond, rapeseed, and castor oil; and among solid fats, tallow, bone grease, and butter, are most easily saponified. According to the practice of the United Kingdom, six or seven days are required to complete the formation of a pan of hard soap, and a day or two more for settling the impurities, if it contains rosin. From 12 to 13 cwts. of tallow are estimated to produce one ton of good soap. Some years ago, in many manufactories the tallow used to be saponified with potash leys, 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 leys, 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 soda-ash used by the soap-boiler, contains in general about 36 per cent. of real soda, in the state of dry carbonate, mixed with muriate of soda, and more or less undecomposed sulphate. I have met lately with soda-ash, made from sulphate of soda, in which the materials had been so ill worked, and so imperfectly decomposed, as to contain 16 per cent. of sulphate, a circumstance equally disgraceful, as it was ruinous to the soda manufacturer. The barillas from Spain and Teneriffe contain from 18 to 24 per cent. of real soda. The alkali in both states is employed in England; barilla being supposed by many to yield a finer white or curd soap, on account of its freedom from sulphur.

The crude soda of either kind being ground, is to be stratified with lime in cylindrical cast-iron vats, from 6 to 7 feet wide, and from 4 to 5 feet deep; the lowest layer consisting, of course, of unslaked or shell quicklime. The vats have a false bottom, perforated with holes, and a lateral tubulure under it, closed commonly with a wooden plug, similar to the *épine* of the French soap pans, by which the leys trickle off clear and caustic, after infiltration through the beds of lime. The quantity of lime must be proportional to the carbonic acid in the soda.

Upon 1 ton of tallow put into the soap pan, about 200 gallons of soda ley, of specific gravity 1·040, being poured, heat is applied, and after a very gentle ebullition of about 4 hours, the fat will be found to be completely saponified, by the test of the spatula, trowel, or pallet knife; for the fluid ley will be seen to separate at once upon the steel blade, from the soapy paste. Such leys, if composed of pure caustic soda, would contain 4 per cent. of alkali; but from the presence of neutro-saline matter, they seldom contain so much as 2 per cent.; in fact, a gallon may be estimated to contain not more than 2 ounces; so that 200 gallons contain 25 pounds of real soda. The fire being withdrawn from the soap pan, the mass is allowed to cool during one hour, or a little more, after which the spent leys, which are not at all alkaline, are run off by a spigot below, or pumped off above, by a pump set into the pan. A second similar charge of ley is now introduced into the pan, and a similar boiling process is renewed. Three such boils may be given in the course of one day's work, by an active soap-maker. Next day the same routine is resumed with somewhat stronger leys, and so progressively, till, towards the sixth day, the ley may have the density of 1·160, and will be found to contain 6 per cent. of real soda.* Were the ley a solution of pure caustic soda, it would contain at this density no less than $14\frac{2}{3}$ per cent. of alkali. The neutro-saline matter present in the spent ley is essential to the proper granulation and separation of the saponaceous compound; for otherwise the watery menstruum would dilute and even liquefy the soap. Supposing $12\frac{1}{2}$ cwts. of tallow to yield upon an average 20 cwts. of hard soap, then 20 cwts. of tallow will produce 32 cwts.; and as its average contents in soda are 6 per cent., these 32 cwts. should require 1·52 cwts. of real soda for their production. If barilla at 20 per cent. be the alkali employed, then 7·6 cwts. of barilla must be consumed in the said process.

* According to my own experiments upon the soda ley used in the London soap-works.

If the alkali be soda-ash of 40 per cent., half the weight will of course suffice. I have reason to believe that there is great waste of alkali incurred in many soap-works, as 6 cwts. of soda-ash, of at least 30 per cent., are often expended in making 1 ton of soap, being 50 per cent. more than really enters into the composition of the soap.

The barillas always contain a small proportion of potash, to which their peculiar value, in making a less brittle or more plastic hard soap than the factitious sodas, may with great probability be ascribed. Chemistry affords many analogies, especially in mineral waters, where salts, apparently incompatible, co-exist in dilute solutions. We may thus conceive how a small quantity of stearate or oleate of potash may resist the decomposing action of the soda salts. The same modification of the consistence of hard soap may, however, be always more conveniently produced by a proper admixture of oleine with stearine.

Soda which contains sulphurets is preferred for making the mottled or marbled soap, whereas the desulphureted 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 ley of crude soda, through the rose spout of a watering-can. The dense sulphureted 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 leys. The alkali seizes the acid of the sulphate, and sets the protoxyde 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 oxyde combines also with the stearine to form a metallic soap. When the oxyde 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 ley; 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 ley, 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 colored ley impregnates the soapy particles in various forms and degrees, whence a varied marbling results.

Three pounds of olive oil afford five pounds of marbled Marseilles soap of good quality, and only four pounds four ounces of white soap; showing that more water is retained by the former than the latter. Oils of grains, as linseed and rapeseed, do not afford so solid a soda soap as oil of olives; but tallow affords a still harder soap with soda. Some of the best Windsor soap made in London contains one part of olive oil (gallipoli) for every nine parts of tallow. Much of the English hard soap is made with kitchen and bone fat, of a very coarse quality; the washing of the numerous successive leys, however, purifies the foul fats, and deprives them of their offensive smell in a great degree. It is common now at Marseilles to mix ten per cent. of the oil of grains with olive oil; for which purpose a large proportion of the oils extracted from seeds in the mills of the *Department du Nord* is sent to Marseilles; but five per cent. of poppy-seed oil, mixed with tallow, renders the soap made with the mixture stringy and unfit for washing; because the two species of fat refuse to amalgamate.

The affinity between the stearine of tallow and the alkali, is so great that a soap may be speedily made from them in the cold. If we melt tallow at the lowest possible temperature, and let it cool to the fixing point, then add to it half its weight of caustic ley, at 36° B., agitating meanwhile incessantly with a pallet knife, we shall perceive, at the end of some hours of contact, the mixture suddenly acquire a very solid consistence, and at the same moment assume a marked elevation of temperature, proving the phenomenon to be due to chemical attraction. In some trials of this kind, the thermometer has risen from 54° to 140° F.

According to recent experiments made in Marseilles, 100 pounds of olive oil take, for their conversion into soap, 54 pounds of crude soda, of 36 per cent. alkaline strength. One part of lime is employed for rendering three parts of the soda caustic. The richer the oil is in stearine, the more dilute should be the ley used in the saponification; and *vice versâ* when it abounds in oleine. For oil of the former kind, the first leys added have a density of from 8° to 9° B.; but for the latter kind, the density is from 10° to 11°. When four parts of olive oil are mixed with one part of poppy, rape, or linseed oil, as is now the general practice at Marseilles, then for such a mixture the first leys have usually a specific gravity of from 20° to 25°, the second from 10° to 15°, and the third from 4° to 5°, constituting a great difference from the practice in Great Britain, where the weaker leys are generally employed at the commencement. The chief reason for this practice is, however, to be found in the more complete causticity of the weak than of the strong leys, according to the slovenly way in which most of our soap-boilers prepare them. Indeed, one very extensive manufacturer of soap in London assured me that the leys should not be caustic; an extraordinary assertion, upon which no comment need be made. In common cases, I would recommend the first combination of the ingredients to be made with somewhat weak, but perfectly caustic ley, and when the saponification is fairly established, to introduce the stronger ley.

In a Marseilles soap-house, there are four ley-vats in each set: No. 1 is the *fresh vat*, into which the fresh alkali and lime are introduced; No. 2 is called the *avançaire*, being one step in advance; No. 3 is the small *avançaire*, being two steps in advance, and therefore containing *weaker* liquor; No. 4 is called the *water* vat, because it receives the water directly.

Into No. 3 the moderately exhausted or somewhat spent leys are thrown. From No. 3 the ley is run or pumped into No. 2, to be strengthened; and in like manner from No. 3 into No. 1. Upon the lime paste in No. 4, which has been taken from No. 3, water is poured; the ley thus obtained is poured upon the paste of No. 3, which has been taken from No. 2. No. 3 is twice lixiviated; and No. 2, once. Thereceiver under No. 1 has four compartments; into No. 1 of which the first and strongest ley is run; into No. 2 the second ley; into No. 3 the third ley; and into No. 4 the fourth ley, which is so weak as to be used for lixiviation, instead of water; (*pour d'avances*).

The lime of vat No. 4, when exhausted, is emptied out of the window near to which it stands; in which case the water is poured upon the contents of No. 3; and upon No. 2 the somewhat spent leys.

No. 1 is now the *avançaire* of No. 4; because this has become, in its turn, the *fresh* vat, into which the fresh soda and quicklime are put. The ley discharged from No. 3 comes, in this case, upon No. 2; and after being run through it, is thrown upon No. 1.

144 pounds of oil yield at Marseilles, upon an average, not more than from 240 to 244 pounds of soap; or 100 pounds yield about 168; so that in making 100 pounds of soap, at this rate nearly 60 pounds of oil are consumed.

OF YELLOW OR ROSIN SOAP.

Rosin, although very soluble in alkaline menstrua, is not however susceptible, like fats, of being transformed into an acid, and will not of course saponify, or form a proper soap by itself. The more caustic the alkali, the less consistence has the resinous compound which is made with it. Hence fat of some kind, in considerable proportion, must be used along with the rosin, the *minimum* being equal parts; and then the soap is far from being good. As alkaline matter cannot be neutralized by rosin, it preserves its peculiar acrimony in a soap poor in fat, and is ready to act too powerfully upon woollen and all other animal fibres to which it is applied. It is said that rancid tallow serves to mask the strong odor 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 leys. 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 ley, 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 ley; and when the paste is found, on cooling a sample of it, to acquire a solid consistence, and when diffused in a little water, not to leave a resinous varnish on the skin, we may consider the soap to be finished. We next proceed to draw off the superfluous leys, and to purify the paste. For this purpose, a quantity of leys at 80° B. being poured in, the mass is heated, worked well with a rake, then allowed to settle, and drained of its leys. A second service of leys, at 4° B., is now introduced, and finally one at 2°; after each of which, there is the usual agitation and period of repose. The pan being now skimmed, and the scum removed for another operation, the soap is laded off by hand-pails into its frame-moulds. A little palm oil is usually employed in the manufacture of yellow soap, in order to correct the flavor of the rosin, and brighten the color. This soap, when well made, ought to be of a fine wax-yellow hue, be transparent upon the edges of the bars, dissolve readily in water, and afford, even with hard pump-water, an excellent lather.

The frame-moulds for hard soap are composed of strong wooden bars, made into the form of a parallelogram, which are piled over each other, and bound together by screwed iron rods, that pass down through them. A square well is thus formed, which in large soap factories is sometimes 10 feet deep, and capable of containing a couple of tons of soap.

Mr. Sheridan some time since obtained a patent for combining silicate of soda with hard soap, by triturating them together in the hot and pasty state with a crutch in an iron pan. In this way from 10 to 30 per cent. of the silicate may be introduced. Such soap possesses very powerful detergent qualities, but it is apt to feel hard and be somewhat gritty in use. The silicated soda is prepared by boiling ground flints in a strong caustic ley, 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 frusta of cones are called curbs; the third, or undermost, is the pan, to which alone the heat is applied, and which, if it gets cracked in the course of boiling, may easily be lifted up within the conical pieces, by attaching chains or cords for raising it, without disturbing the masonry, in which the curbs are firmly set. The surface of the hemispherical pan at the bottom, is in general about one tenth part of the surface of the conical sides.

The white ordinary tallow soap of the London manufacturers, called curd soap, consists, by my experiments, of—fat, 52; soda, 6; water, 42; = 100. Nine tenths of the fat, at least, is tallow.

I have examined several other soaps, and have found their composition somewhat different.

The foreign Castile soap of the apothecary has a specific gravity of 1·0705, and consists of—

Soda - - - -	9
Oily fat - - - -	76·5
Water and coloring-matter	14·5
	100·0

English imitation of Castile soap, spec. grav. 0·9669, consists of—

Soda - - - -	10·5
Pasty consistenced fat - -	75·2
Water, with a little coloring-matter - - -	14·3
	100·0

A perfumer's white soap was found to consist of—

Soda - - - -	9
Fatty matter - - -	75
Water - - - -	16
	100

Glasgow white soap—

Soda - - - -	6·4
Tallow - - - -	60·0
Water - - - -	33·6
	100·0

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
	100·0

M. D'Arcet states the analysis of Marseilles soap at—

Soda - - -	6
Oil - - -	60
Water - - -	34
	100

SOFT SOAP.

The principal difference between soaps with base of soda, and soaps with base of potash, depends upon their mode of combination with water. The former absorb a large quantity of it, and become solid; they are chemical hydrates. The others experience a much feebler cohesive attraction; but they retain much more water in a state of mere mixture.

Three parts of fat afford, in general, fully five parts of soda soap, well dried in the open air; but three parts of fat or oil will afford from six to seven parts of potash soap of moderate consistence. This feebler cohesive force renders it apt to deliquesce, especially if there be a small excess of the alkali. It is, therefore, impossible to separate it from the leys; 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 leys of muriate of potash. Those of muriate or sulphate of soda change the potash into a soda soap, by double decomposition. From its superior

* By my own experiments upon the liquid silicate made at Mr. Gibbs' excellent soap factory.

† My own experiments. See Fats, Oils, and Stearine.

solubility, more alkaline reaction, and lower price, potash soap is preferred for many purposes, and especially for scouring woollen yarns and stuffs.

Soft soaps are usually made in this country with whale, seal, olive, and linseed oils, and a certain quantity of tallow; on the continent, with the oils of hempseed, sesame, rapeseed, linseed, poppy-seed, and colza; or with mixtures of several of these oils. When tallow is added, as in Great Britain, the object is to produce white and somewhat solid grains of stearic soap in the transparent mass, called figging, because the soap then resembles the granular texture of a fig.

The potash leys should be made perfectly caustic, and of at least two different strengths; the weakest being of specific gravity 1·05; and the strongest, 1·20, or even 1·25. Being made from the potashes of commerce, which contain seldom more than 60 per cent., and often less, of real alkali, the leys 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 ley is introduced; the fire being kept up so as to bring the mixture to a boiling state. Then some more oil and ley are added alternately, till the whole quantity of oil destined for the pan is introduced. The ebullition is kept up in the gentlest manner possible, and some stronger ley is occasionally added, till the workman judges the saponification to be perfect. The boiling becomes progressively less tumultuous, the frothy mass subsides, the paste grows transparent, and it gradually thickens. The operation is considered to be finished when the paste ceases to affect the tongue with an acrid pungency, when all milkiness and opacity disappear, and when a little of the soap placed to cool upon a glass plate, assumes the proper consistency.

A peculiar phenomenon may be remarked in the cooling, which affords a good criterion of the quality of the soap. When there is formed around the little patch, an opaque zone, a fraction of an inch broad, this is supposed to indicate complete saponification, and is called the *strength;* when it is absent, the soap is said to want its *strength.* When this zone soon vanishes after being distinctly seen, the soap is said to have *false* strength. When it occurs in the best form, the soap is perfect, and may be secured in 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 leys at 15° B.; and the product is 460 pounds of well-boiled soap.

If hempseed oil have not been employed, the soap will have a yellow color, instead of the green, so much in request on the continent. This tint is then given by the addition of a little indigo. This dye-stuff is reduced to fine powder, and boiled for some hours in a considerable quantity of water, till the stick with which the water is stirred presents, on withdrawing it, a gilded pellicle over its whole surface. The indigo paste diffused through the liquid, is now ready to be incorporated with the soap in the pan, before it stiffens by cooling.

M. Thenard states the composition of soft soap at—potash 9·5, + oil 44·0, + water 46·5, = 100.

Good soft soap of London manufacture, yielded to me—potash 8·5, + oil and tallow 45, + water 46·5.

Belgian soft or green soap afforded me—potash 7, + oil 36, + water 57, = 100.

Scotch soft soap, being analyzed, gave me—potash 8, + oil and tallow 47, + water 45.

Another well-made soap—potash 9, + oil and fat 34, + water 57.

A rapeseed-oil soft soap, from Scotland, consisted of—potash 10, + oil 51·66, + water 38·33.

An olive-oil (gallipoli) soft soap, from ditto, contained—potash with a good deal of carbonic acid 10, oil 48, water 42, = 100.

A semi-hard soap, from Verviers, for fulling woollen cloth, called *savon 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 cwts. of tallow, are put into the soap-pan, with 250 gallons of ley 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 caldron. Should it soon subside into a doughy-looking paste, we may infer that the ley has been too strong. Its proper appearance is that of a thin glue. We should now introduce about 42 gallons of a stronger ley, equivalent to 8700 gr. of potash per gallon; and after a short interval, an additional 42 gallons; and thus suc-

cessively 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 leys—1500 pounds of American potashes, and 500 to 600 pounds of quicklime.

The ley 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 ley run off from the first, is transferred into the second; that of the second into the third; and so on to the fifth.

In conducting the *empatage* of the soap, they put into the pan, on the eve of the boiling-day, 6 *aimes* (1 ohm, = 30 gallons imperial) of oil of colza, in summer, but a mixture of that oil with linseed oil in winter, along with 2 aimes of potash ley 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, ley of 16° or 17° must be introduced successively, in quantities of $\frac{1}{4}$ of an aime after another, till from 2 to 4 aimes be used. The boil is finished by pouring some ley of 20° B., so that the whole quantity may amount to $9\frac{1}{2}$ aimes.

It is considered that the operation will be successful, if from the time of kindling the fire till the finish of the boil, only five hours elapse. In order to prevent the soap from boiling over, a wheel is kept revolving in the pan. The operative considers the soap to be finished, when it can no longer be drawn out into threads between the finger and thumb. He determines if it contains an excess of alkali, by taking a sample out during the boil, which he puts into a tin dish; where if it gets covered with a skin, he pours fresh oil into the pan, and continues the boil till the soap be perfect. No wonder the Belgian soap is bad, amid such groping in the dark, without one ray of science!

SOFT TOILET SOAPS.

The soft fancy toilet soaps are divisible into two classes: 1. good *potash soap*, colored and scented in various ways, forms the basis of the Naples and other ordinary soft soaps of the perfumer; 2. *pearl soap*, (*savon nacré*,) which differs from the other both in physical aspect and in mode of preparation.

Ordinary soft Toilet Soap.—Its manufacture being conducted on the principles already laid down, presents no difficulty to a man of ordinary skill and experience; the only point to be strictly attended to, is the degree of evaporation, so as to obtain soap always of uniform consistence. The fat generally preferred is good hog's lard; of which thirty pounds are to be mixed with forty-five pounds of a caustic ley marking 17° on Baumé's scale; the temperature is to be gradually raised to ebullition, but the boil must not be kept up too long or too briskly, till after the *empatage* or saponification is completed, and the whole of the ley intimately combined with the fatty particles; after this, the evaporation of the water may be pushed pretty quickly, by a steady boil, till copious vapors cease to rise. This criterion is observed when the paste has become too stiff to be stirred freely. The soap should have a dazzling snowy whiteness, provided the lard has been well refined, by being previously triturated in a mortar, melted by a steam heat, and then strained. The lard soap so prepared, is semi-solid, and preserves always the same appearance. If the paste is not sufficiently boiled, however, it will show the circumstance very soon; for in a few days the soap will become gluey and stringy, like a tenacious mass of birdlime. This defect may not only be easily avoided, but easily remedied, by subjecting the paste to an adequate evaporation. Such soaps are in great request for shaving, and are most convenient in use, especially for travellers. Hence their sale has become very considerable.

Pearl soft Soap.—It is only a few years since the process for making this elegant soap became known in France. It differs little from the preceding, and owes its beautiful aspect merely to minute manipulations, about to be described. Weigh out 20 pounds of purified hog's lard on the one hand, and 10 pounds of potash ley at 36° B. on the other. Put the lard into a porcelain capsule, gently heated upon a sand-bath, stirring constantly with a wooden spatula; and when it is half melted, and has a milky appearance, pour into it only one half of the ley, still stirring, and keeping up the same temperature, with as little variation as possible. While the saponification advances gradually, we shall perceive, after an hour, some fat floating on the surface, like a film of oil, and at the same time the soapy granulations falling to the bottom. We must then add the second portion of the ley; whereon the granulations immediately disappear and the paste is formed. After conducting this operation during four hours, the paste becomes so stiff and compact, that it cannot be stirred; and must then be lightly beaten. At this time the capsule must be transferred from the sand-bath into a basin of warm water, and allowed to cool very slowly.

The soap, though completely made, has yet no pearly appearance. This physical property is developed only by pounding it strongly in a marble mortar; whereby all its particles, which seemed previously separated, combine to form a homogeneous paste. The perfume given to it, is always essence of bitter almonds; on which account the soap is called *almond cream, crème d'amandes.*

HARD SOAPS FOR THE TOILET.

The soaps prepared for the perfumer, are distinguished into different species, according to the fat which forms their basis. Thus there is soap of tallow, of hog's lard, of oil of olives, of almonds, and palm oil.

It is from the combination of these different sorts, mingled in various proportions, and perfumed agreeably to the taste of the consumer, that we owe the vast number of toilet soaps sold under so many fantastic names. One sort is rarely scented by itself, as a mixture of several is generally preferred; in which respect every perfumer has his peculiar secret. Some toilet soaps, however, require the employment of one kind more than of another.

Formerly the Windsor soap was made in France, wholly with mutton suet; and it was accordingly of inferior value. Now, by mixing some olive oil or lard with the suet, a very good Windsor soap is produced. I have already stated, that the fat of the London Windsor is, nine parts of good ox tallow, and one of olive oil. A soap made entirely with oil and soda, does not afford so good a lather as when it contains a considerable proportion of tallow.

The soaps made with palm oil are much used; when well made, they are of excellent quality, and ought to enter largely into all the colored sorts. They naturally possess the odor of violets.

The soaps made with oil of almonds are very beautiful, and preserve the agreeable smell of their perfume; but being expensive, are introduced sparingly into the mixtures by most manufacturers.

Some perfumers are in the habit of making what may be called extempore soaps, employing leys at 36° Baumé in their formation. This method, however, ought never to be adopted by any person who prefers quality to beauty of appearance. Such soap is, indeed, admirably white, glistening, contains no more water than is necessary to its constitution, and may therefore be sold the day after it is made. But it has counter-balancing disadvantages. It becomes soon very hard, is difficultly soluble in water, and, if not made with tallow, does not lather well. Hog's lard is very commonly used for making that soap. Twenty kilogrammes of the fat are taken, to ten kilogrammes of soda ley, at 36° B. (specific gravity 1·324); as soon as the former is nearly fluid, five kilogrammes of the ley are introduced, and the mixture is continually agitated during an hour with a wooden spatula. The temperature should never be raised above 150° Fahr. at the commencement of the operation; at the end of one hour, five other kilogrammes of ley are to be added, with careful regulation of the heat. The paste thus formed by the union of the fat and alkali, ought to be perfectly homogeneous, and should increase in consistence every hour, till it becomes firm enough to be poured into the frame; during which transfer, the essential oils destined to scent it, should be introduced. Next day the soap is hard enough; nor does it differ in appearance from ordinary soap, only it requires prompt manipulation to be cut into bars and cakes; for when neglected a day or two, it may become too brittle for that purpose, and too hard to take the impression of the stamps in relief. Such an article gets the name of *little-pan soap*, on account of the small quantity in which it is usually manufactured. Hard soap, made in the common way, is, on the contrary, called *large-pan soap*. This extemporaneous compound is now seldom or never made by respectable manufacturers. In making Windsor soap, the admixture of olive oil is advantageous; because, being richer in oleine than suet, it saponifies less readily than it, and thus favors the formation of a more perfect neutral combination. When the soap cuts, or parts from the ley, when the paste becomes clotty, or, in the language of the operative, when the grain makes its appearance, the fire should be immediately withdrawn, that the impurities may be allowed to subside. This part of the operation lasts twelve hours at least; after which, the soap, still hot, becomes altogether fluid and perfectly neutral.

For every 1000 pounds of the paste, there must be introduced nine pounds of essences, mingled in the following proportions:—six pounds of essence of carui; one and a half ditto lavender, (finest); one and a half ditto rosemary.

The mixture must be well stirred, in order to get completely saturated with the perfumes; and this may be readily done without at all touching or stirring up the subjacent leys; in the course of two hours, the soap may be transferred into the ordinary frames. In twenty-four hours, the mass is usually solidified enough for cutting into bars and cakes, ready to be stamped for sale.

The above method of scenting Windsor soap is practised only in the largest establishments; in the smaller, the soap is pailed out of the soap-pans, into a pan provided with a steam case or jacket, and there mixed with the essential oils, by means of appropriate heat and agitation.

The most fashionable toilet soaps are, the rose, the *bouquet*, the cinnamon, the orange-flower, the musk, and the bitter almond or peach blossom.

Soap à la rose.—This is made of the following ingredients: 30 pounds of olive-oil soap; 20 of good tallow soap.

Toilet soaps must be reduced to thin shavings, by means of a plane, with its under face turned up, so that the bars may be slid along it. These shavings must be put into an untinned copper pan, which is surrounded by a water-bath, or steam. If the soap be old and hard, 5 pounds of water must be added to them; but it is preferable to take fresh-made soaps, which may melt without addition, as soap some time kept does not readily form a homogeneous paste. The fusion is commonly completed in an hour, or thereby, the heat being applied at 212° F., to accelerate the progress, and prevent the dissolution of the constituent water of the soap. For this purpose the interior pan may be covered. Whenever the mass is sufficiently liquefied, 1½ ounces of finely ground vermilion are to be introduced, and thoroughly mixed, after which the heat may be taken off the pan; when the following perfumes may be added with due trituration:—3 ounces of essence of rose; 1 ditto cloves; 1 ditto cinnamon; 2½ ditto bergamot; = 7½.

The scented soap being put into the frames, speedily consolidates. Some recommend to pass the finished fused soap through a tammy cloth, in order to free it from all clots and impurities; a very proper precaution in the act of transferring it to the frame. If the preceding instructions be observed, we obtain a soap perfect in every point of view; possessing a delicious fragrance, equally rich and agreeable, a beautiful roseate hue, and the softest detergent qualities, which keeping cannot impair. Such a soap has, in fact, been known to retain every property in perfection during four or five years. When the essential oils are particularly volatile, they should not be added to the soap till its temperature has fallen to about 140° Fahr.; but in this case a more careful trituration is required. The economy is, however, ill bestowed; for the cakes made of such cooler soap are never so homogeneous and glossy.

Soap au bouquet.—30 pounds of good tallow soap; 4 ounces of essence of bergamot; oil of cloves, sassafras, and thyme, 1 ounce each; neroli, ½ ounce. The color is given with 7 ounces of brown ochre.

Cinnamon Soap.—30 pounds of good tallow soap; 20 ditto of palm-oil soap. Perfumes:—7 ounces of essence of cinnamon; 1¼ ditto sassafras; 1¼ ditto bergamot. Color:—1 pound of yellow ochre.

Orange-flower Soap.—30 pounds of good tallow soap; 20 ditto palm-oil soap. Perfumes:—7½ ounces essence of Portugal; 7½ ditto amber. Color:—9½ ounces, consisting of 8¼ of a yellow-green pigment, and 1¼ of red lead.

Musk Soap.—30 pounds of good tallow soap; 20 ditto palm-oil soap. Perfumes:—Powder of cloves, of pale roses, gilliflower, each 4½ ounces; essence of bergamot, and essence of musk, each 3½ ounces. Color:—4 ounces of brown ochre, or Spanish brown.

Bitter Almond Soap—Is made by compounding, with 50 pounds of the best white soap, 10 ounces of the essence of bitter almonds.

LIGHT SOAPS.

The apparatus employed for making these soaps is a copper pan, heated by a water-bath; in the bottom of the pan there is a step, to receive the lower end of a vertical shaft, to which arms or paddles are attached, for producing constant agitation, by causing them to revolve among the liquefied mass. Into a pan so mounted, 50 pounds of good oil soap of any kind are put (for a tallow soap does not become frothy enough), and melted by proper heat, with the addition of 3 or 4 pounds of water. By the rapid rotation of the machine, an abundant thick lather is produced, beginning first at the bottom, and creeping gradually upwards to the top of the pan, when the operation should be stopped; the soap having by this time doubled its volume. It must now be pailed off into the frame, allowed to cool, and then cut into cakes. Such soap is exceedingly pleasant at the wash-stand, feeling very soft upon the skin, affording a copious thick lather, and dissolving with the greatest ease.

TRANSPARENT SOAPS.

These soaps were for a long time manufactured only in England, where the process was kept a profound secret. They are now made every where.

Equal parts of tallow soap, made perfectly dry, and spirit of wine, are to be put into a copper still, which is plunged in a water-bath, and furnished with its capital and refrigeratory. The heat applied to effect the solution should be as slight as possible, to avoid evaporating too much of the alcohol. The solution being effected, must be suffered to settle; and after a few hours' repose, the clear supernatant liquid is drawn off into tin frames, of the form desired for the cakes of soap. These bars do not acquire their proper degree of transparency till after a few weeks' exposure to dry air. They are now planed, and subjected to the proper mechanical treatment for making cakes of any form. The soap is colored with strong alcoholic solution of archil for the rose tint, and of turmeric for the deep yellow. Transparent soaps, however pleasing to the eye, are always of indifferent quality; they are never so detergent as ordinary soaps, and they eventually acquire a disagreeable smell.

Soap charged with duty in	1834.	1835.	1836.
	lbs.	*lbs.*	*lbs.*
Hard - - - - - -	144,344,043	148,806,207	146,539,210
Soft - - - - - -	10,401,281	12,103,109	13,358,894
Amount of duty at 1½*d.* per lb. on hard soap	£902,150	£930,039	£915,861
do. at 1*d.* soft soap	43,339	50,429	55,662

SOAPSTONE; see STEATITE.

SODA, *Caustic soda* (*Hydrate de soude*, Fr.; *Aetznatron*, Germ.), is an alkaline substance, used in chemical researches, in bleaching, and in the manufacture of soap. It is prepared by boiling a solution of crystallized carbonate of soda in 4 or 5 parts of water, with half its weight of recently slaked and sifted lime. At the end of half an hour, the vessel of iron, porcelain, or preferably silver, may be removed from the fire, and covered carefully, till the calcareous matter has settled into a solid magma at the bottom. The clear supernatant ley may be then decanted into bottles for use in the liquid state, or evaporated, out of contact of air, till it assumes an oily appearance, then poured upon an iron or marble slab, broken into pieces, and put up in vials secured with greased stoppers or corks.

Caustic soda is a white brittle mass, of a fibrous texture, a specific gravity of 1·536, melting at a heat under redness, having a most corrosive taste and action upon animal matters, dissolving readily in both water and alcohol, attracting carbonic acid when exposed to the atmosphere, but hardly any water, and falling thereby into an efflorescent carbonate; it forms soaps with tallow, oils, wax, rosin; dissolves wool, hair, silk, horn, alumina, silica, sulphur, and some metallic sulphurets. It consists of 77·66 soda, and 22·34 water. A solution of caustic soda affords no precipitate with solution of chloride of platinum, or tartaric acid, as a solution of caustic potash never fails to do.

The following TABLE of the quantity of CAUSTIC SODA contained in LEYS of different densities, has been given by Richter:—

Spec. grav.	Soda per cent.	Spec. grav.	Soda per cent.	Spec. grav.	Soda per cent.	Spec. grav.	Soda per cent.
1·00	0·00	1·12	11·10	1·22	20·66	1·32	29·96
1·02	2·07	1·14	12·81	1·24	22·58	1·34	31·67
1·04	4·02	1·16	14·73	1·26	24·47	1·35	32·40
1·06	5·89	1·18	16·73	1·28	26·33	1·36	33·08
1·08	7·69	1·20	18·71	1·30	28·16	1·38	34·41
1·10	9·43						

Soda free from water can be obtained only by the combustion of *sodium*, which see.

SODA, CARBONATE OF (*Kohlensaures natron*, Germ.), is the soda of commerce in various states, either crystallized, in lumps, or in a crude powder called soda-ash. It exists in small quantities in certain mineral waters; as, for example, in those of Seltzer, Seydschutz, Carlsbad, and the volcanic springs of Iceland, especially the Geyser; it frequently occurs as an efflorescence in slender needles upon damp walls, being produced by the action of the lime upon the sea salt present in the mortar. The mineral soda is the sesquicarbonate, to be afterwards described.

Of manufactured soda, the variety most 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 burned in rude furnaces, at a temperature just sufficient to cause the ashes to enter into a state of semi-fusion, so as to concrete on cooling into cellular masses moderately compact. The most valuable variety of this article is called *sweet barilla.* It has a grayish-blue color, and gets covered with a saline efflorescence when exposed for some time to the air. It is hard and difficult to break; when applied to the tongue, it excites a pungent alkaline taste.

I have analyzed many varieties of barilla. Their average quantity of free or alkalimetrical soda is about 17 per cent.; though several contain only 14 parts in the hundred, and a few upwards of 20. This soda is chiefly a carbonate, with a little sulphuret and sulphite; and is mixed with sulphate and muriate of soda, carbonate of lime, vegetable carbon, &c.

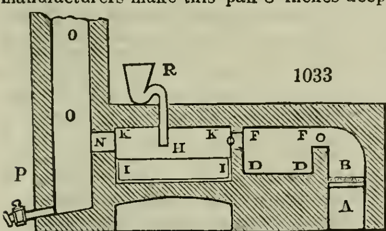
Another mode of manufacturing crude soda, is by burning sea-weed into kelp. Formerly very large revenues were derived by the proprietors of the shores of the Scottish islands and Highlands, from the incineration of sea-weed by their tenants, who usually paid their rents in kelp; but since the tax has been taken off salt, and the manufacture of a crude soda from it has been generally established, the price of kelp has fallen extremely low.

The crystals of soda-carbonate, as well as the soda-ash of British commerce, are now made altogether by the decomposition of sea salt.

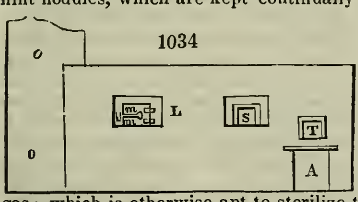
SODA MANUFACTURE.

The manufacture divides itself into three branches:—1. The conversion of sea salt, or chloride of sodium, into sulphate of soda. 2. The decomposition of this sulphate into crude soda, called *black balls* by the workmen. 3. The purification of these balls, either into a dry white soda-ash or into crystals.

1. *The preparation of the sulphate of soda.*—*Figs.* 1033, 1034, 1035, represent the furnace for converting the muriate of soda into the sulphate. The furnace must be built interiorly of the most refractory fire-bricks, such as are used for glasshouses, but of the ordinary brick size; except the bridges C, G, N, which should be formed of one mass, such as what is called a Welsh lump. A is the ash-pit; B, the grate; C, the first bridge, between the fire and the first calcining hearth D, D; F, F, is its roof; G, the second bridge, between the calcining hearth and the decomposing hearth I, I, I; the roof of which is K, K. This hearth I, I, is lined with a lead square pan, 5 or 6 inches deep, sloped at the back opening, in *fig.* 1035, marked M′; which deficient part of the upright side is filled up with two bricks placed one over the other, as shown at *m, m, fig.* 1034, and luted with clay, to confine the semi-liquid mass in the pan, I, I. Some manufacturers make this pan 8 inches deep, and line its bottom and sides with bricks



or silicious sandstone, to protect the lead from the corrosive action of the acid. There are others who consider this precaution troublesome, as the points of the pan which become leaky are thereby concealed. In the roof of the decomposing hearth, one or two syphon funnels R, of lead, are inserted when the charge of acid (sulphuric) is to be poured down upon the salt in I, I, to save the risk of any annoyance from the fumes of the muriatic acid. O, O, is a chimney filled with round flint nodules, which are kept continually moist by the trickling of a streamlet of water

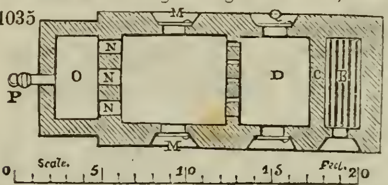


upon the topmost layer. The muriatic gas, meeting this descending film of water upon so extensive a surface, becomes absorbed, and runs out below in a liquid form. When the acid is required in a somewhat concentrated state, this chimney should be made both high and capacious. Such a plan, moreover, is very valuable for abating the nuisance caused by the disengagement of the muriatic acid gas; which is otherwise apt to sterilize the surrounding vegetation.

A fire being kindled in the grate B, *figs.* 1033 and 1034, 3 cwts. of salt in powder are to be thrown by a shovel into the pan I, through the door M, *fig.* 1035, or *m, m, fig.* 1034. Two hundred weights and a half of oil of vitriol, of specific gravity 1·844, having been diluted with from 25 to 30 per cent. of water, and well mixed, or 3 cwts. at 56° Baumé, are to be slowly poured in by the funnel, and diffused among the muriate of soda, by an occasional stir with an iron rake cased with sheet lead. Fumes of muriatic acid will now plentifully escape, and, passing up the condensing-shaft O, will flow down in the form of liquid spirit of salt, and escape by the stoneware stopcock P, into the pipe of a sunk cistern. The fire having been steadily kept up at a moderate degree, the chemical reaction will be tolerably complete in the course of two hours; but as this is relative to the nature of the fuel, and the draught of the furnace, no very precise rule in point of time can be laid down; but it is sufficient for this stage of the process, when the fumes cease to be very dense and copious, as may be ascertained by opening the door M, and looking in, or by the appearance at the top of the shaft O. Over the door M′, in the opposite side of the decomposing hearth, *fig.* 1035, there must be an arch or hood terminating in a small chimney, 15 or 20 feet high, for the ascent of the muriatic vapors, when the charge is drawn or run out of the hearth, and allowed to fall into a square shallow iron tray, placed on the ground at the back of the furnace. For this discharge, the two bricks which serve as stoppers to that orifice, must be unluted and removed.

As soon as that charge is taken out, (the fire being meanwhile checked by opening the door T, *fig.* 1034, and shutting partially the ash-pit opening at A,) a fresh charge must be introduced as above described. The nearly decomposed saline matter, during the second charging of the hearth I, will have grown cool and concrete. It must be shovelled into the calcining hearth D, D, *fig.* 1033, by the back door Q, *fig.* 1035, where it will receive a higher degree of heat; and, by the expulsion of the remaining part of the muriatic acid, it will become a perfect sulphate of soda. It should be finally brought into a state of semi-fusion. When a sample of it, taken out on the end of the rake or trowel-shaped scraper, emits no fumes, the conversion is accomplished.

1035

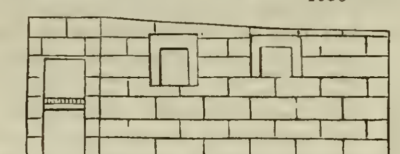


From 3 cwts. of common salt, or muriate of soda, rather more than 3½ cwts. of perfect sulphate should be obtained, quite free from metallic impurity.

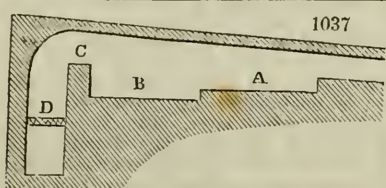
The next step is the conversion of the sulphate into a crude soda.

One of the most improved soda furnaces is that employed in a few factories, represented in *figs.* 1036, 1037, and 1038. In the section *fig.* 1037, there are two hearths in one furnace, the one elevated above the level of the other by the thickness of a brick, or about 3 inches. 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.* 1038, 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.* 1036; 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 PITCOAL, COKING OF, p. 1047. The workman, on pushing up the door lightly, makes it rise, because there is a counterweight at the other end of each chain, which balances the weight of the frame and bricks. In the ground plan, only one smoke-flue is shown; and this construction is preferred by many manufacturers; but others choose to have two flues, one from each shoulder, as at *a*, *b*; which two flues afterwards unite in one vertical chimney, from 25 to 40 feet high; because the draught of a soda-furnace must be very sharp. Having sufficiently explained the construction of this improved furnace, I shall now proceed to describe the mode of making soda with it.

1036



1037



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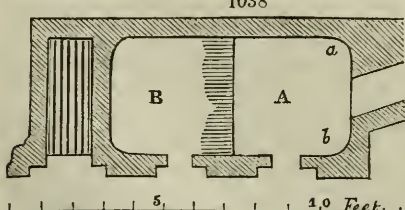


The materials with which the sulphate is decomposed into a rough carbonate of soda, are chalk or ground limestone, and ground coal or charcoal. The proportions in which these three substances are mixed, influence in a remarkable degree the success of the decomposing process. I have known a false proportion introduced, and persevered in, at a factory, with the most prejudicial effect to the product; the soda-ash produced being in a small quantity relatively to the sulphate employed, and being much charged with sulphur. After very numerous trials which I have made on the great scale, and many inquiries at the most successful soda-works, both in this country and abroad, I am warranted to offer the following proportions as the most profitable :—

Sulphate of soda, 100 parts; carbonate of lime (chalk or limestone), from 110 to 120 parts; if pure, 110; if a little impure or damp, 120; pitcoal, 50 parts.

These materials must be separately ground by an edge-stone mill, and sifted into a tolerably fine powder. They must be then very carefully mixed. Attention to these particulars is of no little importance to the success of the soda process.

One hundred parts or pounds of sulphate of soda are equivalent to 75 parts of carbonate, and when skilfully decomposed, will generally yield fully 70 pounds. A charge for the decomposing furnace with the preparatory shelf should not exceed 200 lbs., or perhaps 180; therefore if 75 pounds of ground sulphate of soda, with 80 pounds of chalk or limestone (ground), and 37 pounds of ground coal, be well mixed, they will constitute one charge. This charge must be shovelled in upon the hearth A, or shelf of preparation, (*fig.* 1037); 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 like a garden hoe at the end; and another, a small shovel, consisting of a long iron rod terminated with a piece of iron plate, about 6 inches long, 4 broad, sharpened and tipped with steel, for cleaning the bottom of the hearth from adhering cakes or crusts. Whenever the charge is shoved by the sliding motion of the oar down upon the working hearth, a fresh charge should be thrown into the preparation shelf, and evenly spread over its surface.

The hot and partially carbonized charge being also evenly spread upon the hearth B, is to be left untouched for about ten minutes, during which time it becomes ignited, and begins to fuse upon the surface. A view may be taken of it through a peep-hole in the door, which should be shut immediately, in order to prevent the reduction of the temperature. When the mass is seen to be in a state of incipient fusion, the workman takes the oar and turns it over breadth by breadth in regular layers, till he has reversed the position of the whole mass, placing on the surface the particles which were formerly in contact with the hearth. Having done this, he immediately shuts the door, and lets the whole get another decomposing heat. After five or six minutes, jets of flame begin to issue from various parts of the pasty-consistenced mass. Now is the time to incorporate the materials together, turning and spreading by the oar, gathering them together by the rake, and then distributing them on the reverse part of the hearth; that is, the oar should transfer to the part next the fire-bridge the portion of the mass lying next the shelf, and *vice versa*. The dexterous management of this transposition characterizes a good soda-furnacer. A little practice and instruction will render this operation easy to a robust clever workman. After this transposition, incorporation, and spreading, the door may be shut again for a few minutes, to raise the heat for the finishing off. Lastly, the rake must be dexterously employed to mix, shift, spread, and incorporate. The jets, called *candles*, are very numerous, and bright at first; and whenever they begin to fade, the mass must be raked out into cast-iron moulds, placed under the door of the laboratory to receive the ignited paste.

One batch being thus worked off, the other, which has lain undisturbed on the shelf, is to be shoved down from A to B, and spread equally upon it, in order to be treated as above described. A third batch is then to be placed on the shelf.

The article thus obtained should contain at least 22 per cent. of real soda, equivalent to 37 per cent. of dry carbonate, or to 100 of crystals. A skilful workman can turn out a batch in from three quarters of an hour to an hour, producing a perfect carbonate, which yields on solution an almost colorless liquid, nearly destitute of sulphur, and containing hardly any decomposed sulphate.

In some soda-works, where the decomposing furnace is very large, and is charged with a ton of materials at a time, it takes two men to work it, and from five to six hours to complete a batch. Having superintended the operation of the above-described small furnace, and examined its products, I feel warranted to recommend its adoption.

The following materials and products show the average state of this soda process :—

Materials.—100 parts of sulphate of soda, ground, equivalent to 75 of carbonate; 110 of chalk or ground limestone; 55 of ground coal; in the whole, 265.

Products.—168 parts of crude soda, at 33 per cent. = 55·5 of dry carbonate.

Or, { 130 — crystals of carbonate of soda = 48 of dry carbonate; and
{ 100 — insoluble matter.

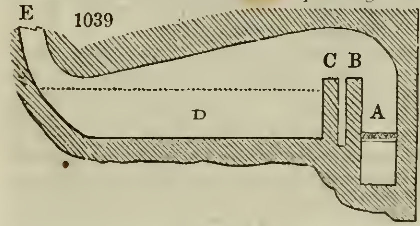
But these products necessarily vary with the skill of the workman.

In another manufactory the following proportions are used :—Six stones, of 14 lbs. each, of dry ground sulphate of soda, are mixed with 3 of chalk and 3 of coal. This mixture, weighing 1½ cwt., forms a batch, which is spread upon the preparation shelf of the furnace (*figs.* 1037 and 1038), as above described, and gradually heated to incipient ignition. It is then swept forwards to the lower area B, by the iron oar, and spread evenly by the rake. Whenever it begins to soften under the rising heat of the laboratory (the side doors being meanwhile shut), the mass must be laboriously turned over and incorporated; the small shovel, or paddle, being employed to transfer, by the interchange of small portions at a time, in rapid but orderly succession, the whole materials from the colder to the hotter, and from the hotter to the colder parts of the hearth. The process of working one batch takes about an hour, during the first half of which period it remains upon the preparation shelf. The average weight of the finished ball is 1 cwt., and its contents in alkalimetrical soda are 33 pounds.

Where the acidulous sulphate of iron from pyrites may be had at a cheap rate, it has been long ago employed, as at Hurlett in Scotland, instead of sulphuric acid, for decomposing the chloride of sodium. Mr. Turner's process of preparing soda, by decomposing sea salt with litharge and quicklime, has been long abandoned, the resulting patent yellow, or sub-chloride of lead, having a very limited sale.

2. *The extraction of pure soda from the crude article.*—The black balls must be broken into fragments, and thrown into large square iron cisterns, furnished with false bottoms of wooden spars; when the cisterns are nearly full of these lumps, water is pumped in upon them, till they are all covered. After a few days, the lixiviation is effected, and the ley is drawn off either by a syphon or by a plug-hole near the bottom of the cistern, and run into evaporating vessels. These may be of two kinds. The surface-evaporating furnace, shown in *fig.* 1039, is a very admirable invention for economizing vessels, lime, and fuel. The grate A, and fireplace, 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 ley, 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 vapor 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 ley 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.

1039



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.* 1038, but with the sole all upon one level. Here it must be exposed to a heat not exceeding 650° or 700° F.; that is, a little above the melting heat of lead; the only object being to volatilize the sulphur present in the mass, and carbonate the alkali. Now, it has been found, that if the heat be raised to distinct redness, the sulphur will not go off, but will continue in intimate union with the soda. This process is called calking, and the furnace is called a calker furnace. It may be six or eight feet long, and four or five feet broad in the hearth, and requires only one door in its side, with a hanging iron frame filled with a fire-tile or bricks, as above described.

This carbonating process may be performed upon several cwts. of the impure soda, mixed with sawdust, at a time. It takes three or four hours to finish the desulphuration; and it must be carefully turned over by the oar and the rake, in order to burn the coal into carbonic acid, and to present the carbonic acid to the particles of caustic soda diffused through the mass, so that it may combine with them.

When the blue flames cease, and the saline matters become white, in the midst of the coaly matter, the batch may be considered as completed. It is raked out, and when cooled, lixiviated in great iron cisterns with false bottoms, covered with mats. The watery solution being drawn off clear by a plug-hole, is evaporated either to dryness, in hemispherical cast-iron pans, as above described, or only to such a strength that it shows a pellicle upon its surface, when it may be run off into crystallizing cisterns of cast iron, or lead-lined wooden cisterns. The above dry carbonate is the best article for the glass manufacture.

Crystallized carbonate of soda contains 62$\frac{3}{4}$ per cent. of water. The crystals are colorless transparent rhomboids, which readily effloresce in the air, and melt in their own water of crystallization. On decanting the liquid from the fused mass, it is found that one part of the salt has given up its water of crystallization to another. By evaporation of that fluid, crystals containing one fifth less water than the common carbonate are obtained. These do not effloresce in the air.

Mineral soda, the sesquicarbonate (*Anderthalb kohlensaures natron*, Germ.), is found in the province of Sukena, in Africa, between Tripoli and Fezzan. It forms a stratum no more than an inch thick, just below the surface of the soil. Its texture is striated crystalline, like fibrous gypsum. Several hundred tons of it are collected annually, which are chiefly consumed in Africa. This species of soda does not effloresce like the Egyptian, or the manufactured soda crystals, owing to its peculiar state of composition and density. It was analyzed by Klaproth, under its native name of *trona*, and was found to consist, in 100 parts, of—soda, 37; carbonic acid, 38; sulphate of soda, 2·5; water, 22·5, in 100.

This soda is, therefore, composed of—3 atoms of carbonic acid, associated with 2 atoms of soda, and 4 of water; while our commercial soda crystals are composed of—1 atom of carbonic acid, 1 atom of soda, and 10 atoms of water.

There are six natron lakes in Egypt. They are situated in a barren valley, called Bahr-bela-ma, about thirty miles to the west of the Delta.

There are natron lakes also in Hungary, which afford in summer a white saline efflorescent crust of carbonate of soda, mixed with a little sulphate.

There are several soda lakes in Mexico, especially to the north of Zacatecas, as also in many other provinces. In Columbia, 48 English miles from Merida, mineral soda is extracted from the earth in great abundance, under the name of *urao*.

Bicarbonate of soda (*Doppelt kohlensaures natron*, Germ.), is prepared, like bicarbonate of potassa, by transmitting carbonic acid gas through a cold saturated solution of pure carbonate of soda, till crystalline crusts be formed. The bicarbonate may also be obtained in four-sided tables grouped together. It has an alkaline taste and reaction upon litmus paper, dissolves in 13 parts of cold water, and is converted by boiling water into the sesquicarbonate, with the disengagement of one fourth of its carbonic acid. It consists of—37 of soda, 52·35 carbonic acid, and 10·65 water.

SODA-WATER, is the name given to water containing a minute quantity of soda, and highly charged with carbonic acid gas, whereby it acquires a sparkling appearance, an agreeable pungent taste, an exhilarating quality, and certain medicinal powers. It constitutes a considerable object of manufacture in this kingdom. The following figure represents, I understand, the best system of apparatus for preparing it. A very dilute solution of soda is put into the globular vessel H, and the carbonic acid gas is forced into it from the gasometer E, by means of the powerful pump-work, as will be understood from the subjoined explanation.

The same apparatus may serve for making any species of aerated water, in imitation of any natural spring. All that is necessary for this purpose, is to put into the cistern Q, the neutro-saline matter, earths, metallic oxydes, pure water, &c., each in due proportion, according to the most accredited analysis of the mineral water to be imitated, to agitate that mixture, to suck it into the condenser H, through the pipe R, and then to impregnate it to the due degree, by pumping in the appropriate gas, previously contained in the gasometer F.

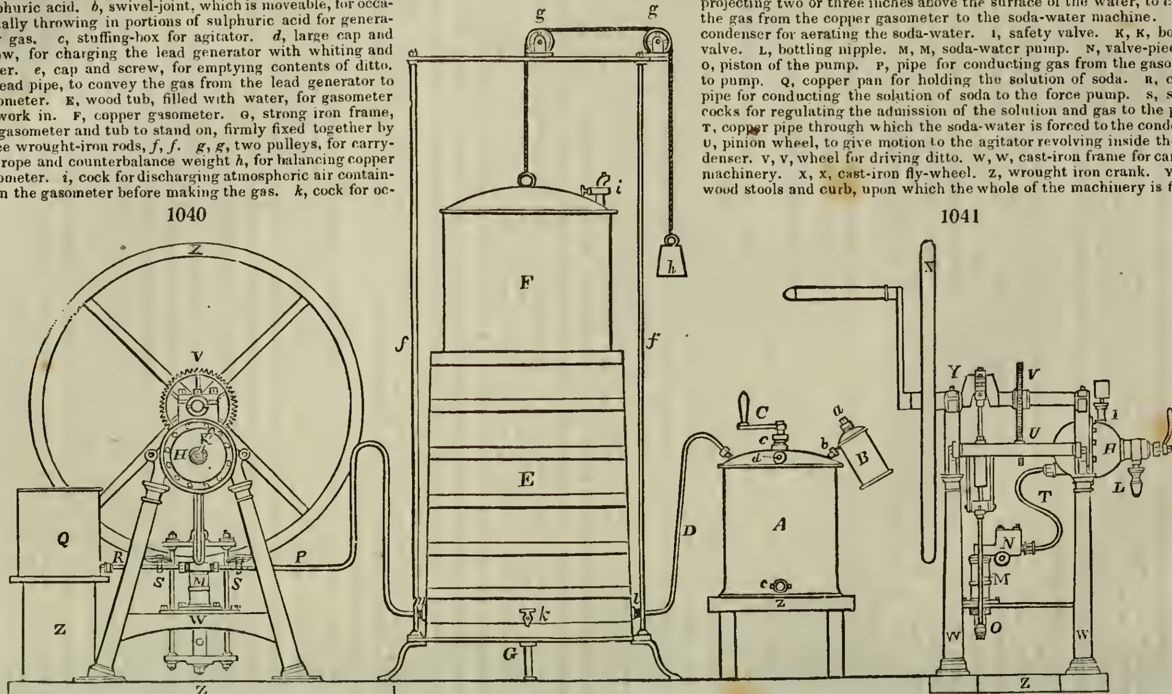
Thus, to make Seltzer water, for each 12 pounds troy, = 69,120 grains, or 1 gallon imperial very nearly, take 55 grains of dry carbonate of soda, 17 of carbonate of lime, 18 of carbonate of magnesia, 3$\frac{1}{2}$ of subphosphate of alumina, 3 of chloride of potassium, 155 of chloride of sodium, and 3 of finely precipitated silica. Put these materials into the cistern Q, and charge the gasometer F with 353 cubic inches of carbonic acid gas. Then work the machine by the handle of the wheel X, as explained below, and regulate the introduction of the liquid and the gas in aliquot portions; for example, if the condenser H admits half a gallon of water at a time, that quantity of liquid should be charged with 176 cubic inches of the gas, being one half of the whole quantity. The sulphureted mineral waters may be imitated in like manner, by taking the proportions of their constituents, as given in Table II. of WATERS, MINERAL.

IMPROVED SODA-WATER APPARATUS, AS MADE BY MR. HAYWARD TYLER, OF MILTON STREET.

Fig. 1040, front view of the soda water machine. *Fig.* 1041, end view of the same.

A, lead generator, for making the ga·. 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 moveable, 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. Z, wrought iron crank. Y, Z, Z, wood stools and curb, upon which the whole of the machinery is fixed.

1040 1041



SODIUM, the metallic basis of soda, is obtained by processes similar to those by which potassium is procured. By fusing hydrate of soda with a little hydrate of potassa, a mixture is obtained, which yields more readily than soda by itself to the decomposing action of iron-turnings at a high heat, in a bent gun-barrel. The portion of potassium produced may be got rid of, by digesting the alloy for a few days in some naptha or oil of turpentine contained in an open vessel. The sodium remains at the bottom of the liquid. Pure sodium may, however, be prepared at once, by subjecting incinerated tartrate of soda to heat in the apparatus of Brunner, described under POTASSIUM. It is white, like silver; softer and more malleable than any other metal, and may be readily reduced into very thin leaves. It preserves its malleability till it approaches the melting point. Its specific gravity is 0·970. It softens at the temperature of 122° F., and at 200° it is perfectly fluid; but it will not rise in vapor until heated to nearly the melting point of glass. In the air it oxydizes slowly, and gets covered with a crust of soda; but it does not take fire till it is made nearly red-hot; and then it emits brilliant scintillations. When thrown upon water, it is rapidly oxydized, but without kindling, like potassium. If a drop of water be thrown upon it, it becomes so hot by the chemical action as to take fire. There are three oxydes of sodium; 1. the suboxyde; 2. the oxyde, or the basis of common soda; and, 3. the suroxyde; the last being formed when sodium is heated to redness upon a plate of silver.

SOLDERING (*Souder*, Fr.; *Löthen*, Germ.), is the process of uniting the surfaces of metals, by the intervention of a more fusible metal, which being melted upon each surface, serves, partly by chemical attraction, and partly by cohesive force, to bind them together. The metals thus united may be either the same or dissimilar; but the uniting metal must always have an affinity for both. Solders must be, therefore, selected in reference to their appropriate metals. Thus tin-plates are soldered with an alloy consisting of from 1 to 2 parts of tin, with 1 of lead; pewter is soldered with a more fusible alloy, containing a certain proportion of bismuth added to the lead and tin; iron, copper, and brass are soldered with spelter, an alloy of zinc and copper, in nearly equal parts; silver, sometimes with pure tin, but generally with silver-solder, an alloy consisting of 5 parts of silver, 6 of brass, and 2 of zinc; zinc and lead, with an alloy of from 1 to 2 parts of lead with 1 of tin; platinum, with fine gold; gold, with an alloy of silver and gold, or of copper and gold; &c.

In all soldering processes, the following conditions must be observed; 1. the surfaces to be united must be entirely free from oxyde, bright, smooth, and level; 2. the contact of air must be excluded during the soldering, because it is apt to oxydize one or other of the surfaces, and thus to prevent the formation of an alloy at the points of union. This exclusion of air is effected in various ways. The locksmith encases in loam the objects of iron, or brass, that he wishes to subject to a soldering heat; the silversmith and brasier mix their respective solders with moistened borax powder; the coppersmith and tinman apply sal ammoniac, rosin, or both, to the cleaned metallic surfaces, before using the soldering-iron to fuse them together with the tin alloy. The strong solder of the coppersmith consists of 8 parts of brass and 1 of zinc; the latter being added to the former, previously brought into a state of fusion. The crucible must be immediately covered up for two minutes till the combination be completed. The melted alloy is to be then poured out upon a bundle of twigs held over a tub of water, into which it falls in granulations. An alloy of 3 parts of copper and 1 of zinc forms a still stronger solder for the coppersmiths. When several parts are to be soldered successively upon the same piece, the more fusible alloys, containing more zinc, should be used first. A softer solder for coppersmiths is made with 6 parts of brass, 1 of tin, and 1 of zinc; the tin being first added to the melted brass, then the zinc; and the whole well incorporated by stirring.

The edges of sheet lead for sulphuric acid chambers, and its concentration pans, are joined together by melted lead itself, because any solder containing tin would soon be corroded. With this view, the two edges being placed in contact, are flattened down into a long wooden groove, and secured in their situation by a few brass pins driven into the wood. The surfaces are next brightened with a triangular scraper, rubbed over with candle grease, and then covered with a stream of hot melted lead. The riband of lead thus applied is finally equalized by being brought into partial fusion with the plumber's conical iron heated to redness; the contact of air being prevented by sprinkling rosin over the surface. The sheets of lead are thus *burned* together, in the language of the workmen.

SOOT (*Noir de fumée*, *Suie*, Fr.; *Rus*, *Flatterrus* Germ.), is the pulverulent charcoal condensed from the smoke of wood or coal fuel. A watery infusion of the former is said to be antiseptic, probably from its containing some creosote.

The soot of pitcoal has not been analyzed with any minuteness. It contains some sulphate and carbonate of ammonia, along with bituminous matter.

SORBIC ACID, is the same with malic acid; which see.

SOY, is a liquid condiment, or sauce, imported chiefly from China. It is prepared with a species of white haricots, wheat flour, common salt, and water; in the proportions respectively of 50, 60, 50, and 250 pounds. The haricots are washed, and boiled in water till they become so soft as to yield to the fingers. They are then laid in a flat dish to cool, and kneaded along with the flour, a little of the hot water of the decoction being added from time to time. This dough is next spread an inch or an inch and a half thick upon the flat vessel (made of thin staves of bamboo), and when it becomes hot and mouldy, in two or three days, the cover is raised upon bits of stick, to give free access of air. If a rancid odor 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 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.

SPECIFIC GRAVITY, designates the relative weights of different bodies under the same bulk; thus a cubic foot of water weighs 1000 ounces 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 ALLOY.

SPECULUM METAL, is an alloy of copper and tin; described under COPPER.

SPERMACETI; the *Cetine* of Chevreul. In certain species of the *cachalot* whale, as the *Physeter macrocephalus, tursio, microps*, and *orthodon*, as also the *Delphinus edentulus*, the fat of some parts of their bodies contains a peculiar kind of stearine, called spermaceti. The oil obtained from cavities in the bones of the cranium of the above cetaceæ is the richest in this kind of stearine. This being thrown into great filter-bags, the spermaceti oil passes through, and is subsequently purified by the addition of a small quantity of potash ley, which precipitates certain matters by neutralizing the acid that held them in solution. The solid which remains on the filter is next squeezed in bags, by means of a horizontal hydraulic press incased in steam, then digested with a weak potash ley, in order to dissolve out any oil which may continue to adhere to it, washed with water, finally dissolved in a tub by the agency of steam, laded into tin pans, and allowed slowly to concrete into a white, semi-transparent, brittle, lamellar crystalline mass, which forms elegant candles.

At 60° its specific gravity is 0·943. It melts at 112·5°; 100 parts of alcohol at 0·821 dissolve $3\frac{1}{2}$ of it, of which 0·9 are deposited on cooling. Warm ether dissolves it in very large quantities. It is soluble also in the fat of volatile oils; and if the solutions have been saturated while hot, the greater part of the spermaceti crystallizes on cooling. When this substance has been purified by digesting alcohol upon it repeatedly, what remains is the *cetine* of Chevreul, or pure spermaceti. Its melting point has now become 116° F., and its boiling point 616° F., at which it distils without alteration. Caustic alkaline leys saponify it with difficulty.

SPIRIT OF AMMONIA is, properly speaking, alcohol combined with ammonia gas; but the term is often applied to water of ammonia.

SPIRITS, VINOUS. This subject has been fully discussed in the articles ALCOHOL, DISTILLATION, and FERMENTATION. I have shown that the progressive increase of alcohol in the wash tends progressively to prevent the conversion of the wort into spirit, or checks the fermenting process, though a great deal of fermentable matter remains unchanged. Mr. Sheridan has sought to remove this obstacle to the thorough transmutation of saccharine matter into alcohol, by drawing off the spirit as it is formed. For this purpose he ferments his wash in close tuns, connected with a powerful air-pump worked by machinery, thus continually removing the carbonic acid as it is formed, and maintaining a diminished pressure under which the alcohol readily distils at a temperature of 120° or 130° F. He finds that this degree of heat is not injurious to the fermentation, provided that it be communicated by the air of a stove-room, and not by water or steam pipes traversing the liquid, which would inevitably scald or seeth the particles in succession, and thereby extinguish the fermenting principle.

By the above ingenious plan, Mr. Sheridan tells me he has obtained 28 gallons of proof spirit from a quarter of grain, instead of the average product 21, being an increase of 25 per cent. The experiment was tried upon a considerable scale at Messrs. Currie's great distillery near London; but could not be established as a mode of manufacture, on account of the excise laws, which prohibit the distillers from carrying on the two processes of fermentation and distillation at the same time.

SPIRIT OF WINE; Alcohol.

SPONGE (*Eponge*, Fr.; *Schwamm*, Germ.), is a cellular fibrous tissue produced by small animals, almost imperceptible, called polypi by naturalists, which live in the sea. This tissue is said to be covered in its recent state with a kind of semi-fluid thin coat of animal jelly, susceptible of a slight contraction or trembling on being touched; which is the only symptom of vitality displayed by the sponge. After death, this jelly disappears, and leaves merely the sponge; formed by the combination of a multitude of small capillary tubes, capable of receiving water in their interior, and of becoming thereby distended. Sponges occur attached to stones at the bottom of the sea; and abound particularly upon the shores of the islands in the Grecian Archipelago. Although analogous in their origin to coral, sponges are quite different in their nature; the former being composed almost entirely of carbonate of lime; while the latter are formed of the same elements as animal matters, and afford, on distillation, a considerable quantity of ammonia.

Dilute sulphuric acid has been recommended for bleaching sponges, after the calcareous impurities have been removed by muriatic acid. Chlorine water answers better.

SPOON MANUFACTURE. See STAMPING OF METALS.

STAINED GLASS. When certain metallic oxydes or chlorides, ground up with proper fluxes, are painted upon glass, their colors 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 colors of stained glass are all transparent, and are therefore to be viewed only by transmitted light. Many metallic pigments, which afford a fine effect when applied cold on canvass or paper, are so changed by vitreous fusion as to be quite inapplicable to painting in stained glass.

The glass proper for receiving these vitrifying pigments, should be colorless, uniform, and difficult of fusion; for which reason crown glass, made with little alkali, or with kelp, is preferred. When the design is too large to be contained on a single pane, several are fitted together, and fixed in a bed of soft cement while painting, and then taken asunder to be separately subjected to the fire. In arranging the glass pieces, care must be taken to distribute the joinings so that the lead frame-work may interfere as little as possible with the effect.

A design must be drawn upon paper, and placed beneath the plate of glass; though the artist cannot regulate his tints directly by his palette, but by specimens of the colors producible from his palette 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 colors, 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 color, 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 color to produce the shades, which will harmonize best with the color 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 colors 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 colors 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 colors to be presently mentioned, are all fast colors, which do not run, except the yellow, which must therefore be laid on the opposite side. After coloring, the artist proceeds to bring out the lighter effects by taking off the color in the proper place, with a goose quill cut like a pen without a slit. By working this upon the glass, he removes the color 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 colors. The furnace or kiln best adapted for this purpose, is similar to that used by enamellers. See ENAMEL, and the *Glaze-kiln*, under POTTERY. It consists of a muffle or arch of fire-clay, or pottery, so set over a fireplace, and so surrounded by flues, as to receive a very considerable heat within, in the most equable and regular manner; otherwise some parts of the glass will be melted; while, on others, the superficial film of colors will remain unvitrified. The mouth of the muffle, and the entry for introducing fuel to the fire, should be on opposite sides, to prevent as much as possible the admission of dust into the muffle, whose mouth should be closed with double folding-doors of iron, furnished with small peep-holes, to allow the artist to watch the progress of the staining, and to withdraw small trial slips of glass, painted with the principal tints used in the picture.

The muffle must be made of very refractory fire-clay, flat at its bottom, and only 5 or 6 inches high, with such an arched top as may make the roof strong, and so close on all sides as to exclude entirely the smoke and flame. On the bottom of the muffle a smooth bed of sifted lime, freed from water, about half an inch thick, must be prepared for receiving the pane of glass. Sometimes several plates of glass are laid over each other with a layer of dry pulverulent lime between each. The fire is now lighted, and most gradually raised, lest the glass should be broken; and after it has attained to its full heat, it must be kept up for 3 or 4 hours, more or less, according to the indications of the trial slips; the yellow color being principally watched, as it is found to be the best criterion of the state of the others. When the colors are properly burnt in, the fire is suffered to die away, so as to anneal the glass.

STAINED-GLASS PIGMENTS.

Flesh color.—Take an ounce of red lead, 2 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 color.

Black color.—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 and grind these ingredients together with strong vinegar. A brilliant black may also be obtained by a mixture of cobalt blue with the oxydes of manganese and iron. Another black is made from three parts of crystal glass, two parts of oxyde of copper, and one of (glass of) antimony worked up together, as above.

Brown color.—An ounce of white glass or enamel, half an ounce of good manganese; ground together.

Red, rose, and brown colors, are made from peroxyde of iron, prepared by nitric acid. The flux consists of borax, sand, and minium in small quantity.

Red color, may be likewise obtained from one ounce of red chalk pounded, mixed with two ounces of white hard enamel, and a little peroxyde of copper.

A red, may also be composed of rust of iron, glass of antimony, yellow glass of lead, such as is used by potters, (or litharge,) each in equal quantity; to which a little sulphuret of silver is added. This composition, well ground, produces a very fine red color on glass. When protoxyde of copper is used to stain glass, it assumes a bright red or green color, according as the glass is more or less heated in the furnace, the former corresponding to the orange protoxyde, the latter having the copper in the state of peroxyde.

Bistres and brown reds, may be obtained by mixtures of manganese, orange oxyde of copper, and the oxyde of iron called umber, in different proportions. They must be previously fused with vitreous solvents.

Green color.—Two ounces of brass calcined into an oxyde, 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. Oxyde of chrome has been also employed to stain glass green.

A fine yellow color.—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 colors.

Another yellow can be made by mixing sulphuret of silver with glass of antimony, and yellow ochre previously calcined to a red-brown tint. Work all these powders together, and paint on the back of the glass. Or silver *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, oxyde of zinc, white-clay, and rust of iron. This mixture, simply ground, is applied on the glass.

Orange color.—Take 1 part of silver powder, as precipitated from the nitrate of that metal by plates of copper, and washed; mix it with 1 part of red ochre and 1 of yellow, by careful trituration; grind into a thin pap with oil of turpentine or lavender, and apply this with a brush, dry, and burn in.

In the Philosophical Magazine, of December, 1836, the anonymous author of an ingenious essay, "On the Art of Glass-painting," says, that if a large proportion of ochre has been employed with the silver, the stain is yellow; if a small proportion, it is orange-colored; and by repeated exposure to the fire, without any additional coloring-matter, the orange may be converted into red; but this conversion requires a nice management of the heat. Artists often make use of panes colored 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 colorless glass; by gathering a lump of the latter upon the end of their iron rod in one pot, covering it 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 protoxyde 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-color 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 oxyde of lead, bismuth, zinc, or antimony; for crown glass will take no color from gold. Glass combined with this metal, when removed from the crucible, is generally of a pale rose-color; nay, sometimes is as colorless as water, and does not assume its ruby color 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 color, leaving the glass of a dingy brown, but with a blue (green ?) transparency, like that of gold leaf. It is metallic gold which gives the color; and, indeed, the oxyde is too easily reduced, not to be converted into the metal by the intense heat which is necessarily required.

Upon the kindred art of painting in enamel, Mr. A. Essex has published an interesting paper in the same journal, for June, 1837, in which he says that the ancient ruby glass, on being exposed to the heat of a glass-kiln, preserves its color unimpaired, while the modern suffers considerable injury, and in some cases becomes almost black. Hence the latter cannot be painted upon, as the heat required to fix the fresh color would destroy the beauty of the original basis. To obviate this difficulty, the artist paints upon a piece of plain glass the tints and shadows necessary for blending the rich ruby glow with the other parts of his picture, leaving those parts untouched where he wishes the ruby to appear in undiminished brilliancy, and fixes the ruby glass in the picture behind the painted piece, so that in such parts the window is double glazed. Mr. Essex employs, as did the late Mr. Muss, chrome oxyde alone for greens; and he rejects the use of iron and manganese in his enamel colors.

Colored transparent glass is applied as enamel in silver and gold *bijouterie*, previously *bright-cut* in the metal with the graver or the rose-engine. The cuts, reflecting the rays of light from their numerous surfaces, exhibit through the glass, richly stained with gold, silver, copper, cobalt, &c., a gorgeous play of prismatic colors, varied with every change of aspect. When the enamel is to be painted on, it should be made opalescent by oxyde of arsenic, in order to produce the most agreeable effect.

The artist in enamel has obtained from modern chemistry, preparations of the metals platinum, uranium, and chromium, which furnish four of the richest and most useful colors of his palette. Oxyde of platinum produces a substantive rich brown, formerly unknown in enamel painting; a beautiful transparent tint, which no intensity or repetition of fire can injure. Colors proper for enamel painting, he says, are not to be purchased; those sold for the purpose, are adapted only for painting upon china. The constituents of the green enamel used by his brother, Mr. W. Essex, are, silica, borax, oxyde of lead, and oxyde of chrome.

Mr. Essex's enamelling furnace is a cubic space of about 12 inches, and contains a fire-clay muffle, without either bottom or back, which is surrounded with coke, except in front. The entire draught of air which supplies the furnace, passes through the muffle; the plates and paintings being placed on a thin slab, made of tempered fire-clay, technically termed *planche*, which rests on the bed of coke-fuel. As the greatest heat is at the back of the muffle, the picture must be turned round while in the fire, by means of a pair of spring tongs. The above furnace serves for objects up to five inches in diameter; but for larger works a different furnace is required, for the description of which I must refer to the original paper.

Relatively to the receipts for enamel colors, and for staining and gilding on glass, for which twenty guineas were voted by the Society for the Encouragement of Arts, in the session of 1817, to Mr. R. Wynn, Mr. A. Essex says, in p. 446 of his essay—"the unfortunate artist who shall attempt to make colors for the purpose of painting in enamel from these receipts, will assuredly find, to his disappointment, that they are utterly useless." In page 449 he institutes a comparison between Mr. Wynn's complex farrago for green, as published in the Transactions of the Society, with the simple receipt of his brother, as given above. It is a remarkable circumstance, that not one of our enamel artists, during a period of twenty years, should have denounced the fallacy of these receipts, and the folly of sanctioning imposture by a public reward. Should Mr. Essex's animadversions be just, the well-intentioned Society in the Adelphi may, from the negligence of its committee, come to merit the *sobriquet*, "For the Discouragement of Arts."

STAMPING OF METALS. The following ingenious machine for manufacturing metal spoons, forks, and other articles, was made the subject of a patent by Jonathan Hayne, of Clerkenwell, in May, 1833. He employs a stamping-machine with dies, in which the hammer is raised to a height between guides, and is let fall by a trigger. He prefers fixing the protuberant or relief portion of the die to the stationary block or bed of the stamping-machine, and the counterpart or intaglio to the falling hammer or ram.

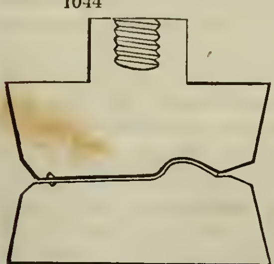
The peculiar feature of improvement in this manufacture consists in producing the spoon, ladle, or fork perfect at one blow in the stamping-machine, and requiring no further manipulation of shaping, but simply trimming off the barb or fin, and polishing the surface, to render the article perfect and finished.

Heretofore, in employing a stamping-machine, or fly-press, for manufacturing spoons, ladles, and forks, it has been the practice to give the impressions to the handles, and to the bowls or prongs, by distinct operations of different dies, and after having so partially produced the pattern upon the article, the handles had to be bent and formed by the operations of filing and hammering.

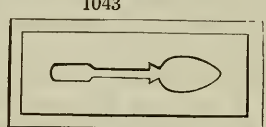
By his improved form of dies, which, having curved surfaces and bevelled edges, allow of no parts of the faces of the die and counter-die to come into contact, he is enabled to produce considerable elevations of pattern and form, and to bring up the article perfect at one blow, with only a slight barb or fin upon its edge.

In the accompanying drawings, *fig.* 1042 is the lower or bed die for producing a spoon, seen edgewise; *fig.* 1043 is the face of the upper or counter-die, corresponding;

1044



1043



1042

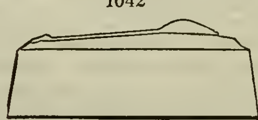
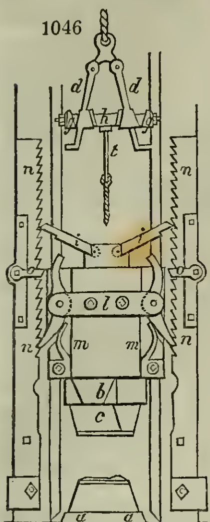


fig. 1044 is a section, taken through the middle of the pair of dies, showing the space in which the metal is pressed to form the spoon.

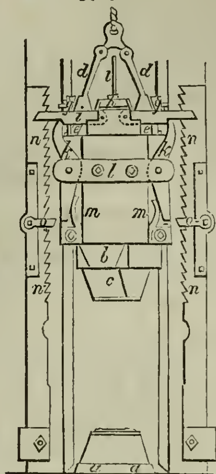
To manufacture spoons, ladles, or forks according to his improved process, he first forges out the ingot into flat pieces, of the shape and dimensions of the die of the intended article; and if a spoon or ladle is to be made, gives a slight degree of concavity to the bowl part; but, if necessary, bends 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 oxydation-scale or fire-strain, when it is ready to be introduced into the stamping-machine.

He now fixes the lower die in the bed of the stamping-machine, shown at *a*, *a*, in the elevations *figs.* 1045 and 1046, 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.

1046



1045



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 locking into racks on the face of the standards, seen in *figs.* 1045 and 1046. In *fig.* 1045 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.* 1046, 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.* 1045, the levers *k* are confined, and their palls prevented from striking into the side racks; but as the hammer falls, the ends of the latches *i* strike upon the fingers o, o, fixed to the side standards, and liberate the palls, the lower ends of which, when the hammer rebounds, after stamping, catch into the teeth of the racks, as in *fig.* 1046, and thereby prevent the hammer from again descending.

STARCH (*Amidon*, *Fecule*, Fr; *Stärke*, Germ.), is a white pulverulent substance, composed of microscopic spheroids, which are bags containing the amylaceous matter. It exists in a great many different plants, and varies merely in the form and size of its microscopic particles; as found in some plants, it consists of spherical particles $\frac{1}{1000}$ of an inch in diameter; and in others, of ovoid particles, of $\frac{1}{300}$ or $\frac{1}{400}$ of an inch. It occurs, 1. in the seeds of all the acotyledinous plants, among which are the several species of corns, and those of other *gramineæ;* 2. in the round perennial tap roots, which shoot up an annual stem; in the tuberose roots, such as potatoes, the *Convolvulus batatas* and *edulis*, the *Helianthus tuberosus*, the *Jatropha manihot*, &c., which contain a great quantity of it; 3. in the stems of several monocotyledinous plants, especially of the palm tribe, whence sago comes; but it is very rarely found in the stems and branches of the dicotyledinous 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

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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 liquor floating over it, that contains little starch. Its jelly becomes brown-gray with iodine.

1. *Ordinary starch.*—This may be extracted from the following grains:—wheat, rye, barley, oats, buckwheat, rice, maize, millet, spelt; from the siliquose seeds, as peas beans, lentiles, &c.; from tuberous and tap roots, as those of the potato, the orchis, manioc, arrow-root, batata, &c. Different kinds of corn yield very variable quantities of starch. Wheat differs in this respect, according to the varieties of the plant, as well as the soil manure, season, and climate. See 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.

1. *With unground wheat.*—The wheat being sifted clean, is to be put into cisterns, covered with soft water, and left to steep till it becomes swollen and so soft as to be easily crushed between the fingers. It is now to be taken out, and immersed in clear water of a temperature equal to that of malting-barley, whence it is to be transferred into bags, which are placed in a wooden chest containing some water, and exposed to strong pressure. The water rendered milky by the starch being drawn off by a tap, fresh water is poured in, and the pressure is repeated. Instead of putting the swollen grain into bags, some prefer to grind it under vertical edge-stones, or between a pair of horizontal rollers, and then to lay it in a cistern, and separate the starchy liquor by elutriation with successive quantities of water well stirred up with it. The residuary matter in the sacks or cisterns contains much vegetable albumen and gluten, along with the husks; when exposed to fermentation, it affords a small quantity of starch of rather inferior quality.

The above milky liquor, obtained by expression or elutriation, is run into large cisterns, where it deposites its starch in layers successively less and less dense; the uppermost containing a considerable proportion of gluten. The supernatant liquor being drawn off, and fresh water poured on it, the whole must be well stirred up, allowed again to settle, and the surface-liquor again withdrawn. This washing should be repeated as long as the water takes any perceptible color. As the first turbid liquor contains a mixture of gluten, sugar, gum, albumen, &c., it ferments readily, and produces a certain portion of vinegar, which helps to dissolve out the rest of the mingled gluten, and thus to bleach the starch. It is, in fact, by the action of this fermented or soured water, and repeated washing, that it is purified. After the last deposition and decantation, there appears on the surface of the starch a thin layer of a slimy mixture of gluten and albumen, which, being scraped off, serves for feeding pigs or oxen; underneath will be found a starch of good quality. The layers of different sorts are then taken up with a wooden shovel, transferred into separate cisterns, where they are agitated with water, and passed through fine sieves. After this pap is once more well settled, the clear water is drawn off, the starchy mass is taken out, and laid on linen cloths in wicker baskets, to drain and become partially dry. When sufficiently firm, it is cut into pieces, which are spread upon other cloths, and thoroughly desiccated in a proper drying-room, which in winter is heated by stoves. The upper surface of the starch is generally scraped, to remove any dusty matter, and the resulting powder is sold in that state. Wheat yields, upon an average, only from 35 to 40 per cent. of good starch. It should afford more by skilful management.

2. In this country, wheat crushed between iron rollers is laid to steep in as much water as will wet it thoroughly; in four or five days the mixture ferments, soon afterwards settles, and is ready to be washed out with a quantity of water into the proper fermenting vats. The common time allowed for the steep, is from 14 to 20 days. The next process consists in removing the stuff from the vats into a stout round basket set across a back below a pump. One or two men keep going round the basket, stirring up the stuff with strong wooden shovels, while another keeps pumping water, till all the *farina* is completely washed from the bran. Whenever the subjacent back is filled, the liquor is taken out and strained through hair sieves into square frames or cisterns, where it is allowed to settle for 24 hours; after which the water is run off from the deposited starch by plug taps 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 passes 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 two or three pounds 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 deposite into wooden chests, about 4 feet long, 12 inches broad, and 6 inches deep, perforated throughout, and lined with thin canvass. When it is drained and dried into a compact mass, it is turned out by inverting the chests upon a clean table, where it is broken into pieces four or five inches square, by laying a ruler underneath the cake, and giving its surface a cut with a knife, after which the slightest pressure with the hand will make the fracture. These pieces are set upon half-burned bricks, which by their porous capillarity imbibe the moisture of the starch, so that its under surface may not become hard and horny. When sufficiently dried upon the bricks, it is put into a stove, (which resembles that of a sugar refinery,) and left there till tolerably dry. It is now removed to a table, when all the sides are carefully scraped with a knife; it is next packed up in the papers in which it is sold; these packages are returned into the stove, and subjected to a gentle heat during some days; a point which requires to be skilfully regulated.

Mr. Samuel Hall obtained a patent for bleaching starch by chloride of lime in 1821. Chlorine water would probably be preferable, and might prove useful in operating upon damaged wheat.

The sour water of the starch manufacture contains, according to Vauquelin, acetic acid, acetate of ammonia, alcohol, phosphate of lime, and gluten.

During the drying, starch splits into small prismatic columns, of considerable regularity. When kept dry, it remains unaltered for a very long period. When it is heated to a certain degree in water, the envelopes of its spheroidal particles burst, and the *farina* forms a mucilaginous emulsion, magma, or paste. When this apparent solution is evaporated to dryness, a brittle horny-looking substance is obtained, quite different in aspect from starch, but similar in chemical habitudes. When the moist paste is exposed for 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.

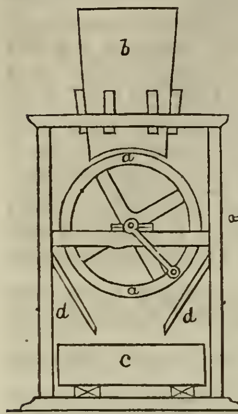
Starch from potatoes.—From the following table of analyses, it appears that potatoes contain from 24 to 30 per cent. of dry substance :—

	Starch.	Fibrous Parenchyma.	Vegetable Albumen	Gum, Sugar, and Salts.	Water.
Red potatoes, - - - -	15·0	7·0	1·4	9·2	75·0
Germinating potatoes, - -	15·2	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

Manufacture of potato starch.—The potatoes are first washed in a cylindrical cage formed of wooden spars, made to revolve upon a horizontal axis, in a trough filled with water to the level of the axis. They are then reduced to a pulp by a rasping machine, similar to that represented in *figs.* 1047, 1048, where *a* is a wooden drum covered with sheet-iron, roughened outside with numerous prominences, made by punching out holes from the opposite side. It is turned by a winch fixed upon each end of the shaft. The drum is enclosed in a square wooden box, to prevent the potato-mash from being scattered about. The hopper *b* is attached to the upper frame, has its bottom concentric with the rasp-drum, and nearly in contact with it. The pulp chest *c* is made to slide out, so as when full to be readily replaced by another. The two slanting boards *d*, *d*, conduct the pulp into it. A moderate stream of water should be made to play into the hopper upon the potatoes, to prevent the surface of the rasp from getting foul with fibrous matter. Two men, with one for a relay, will rasp, with such a machine, from 2½ to 3 tons of potatoes in 12 hours.

The potato pulp must be now elutriated upon a fine wire or hair seive, 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 five 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

1047



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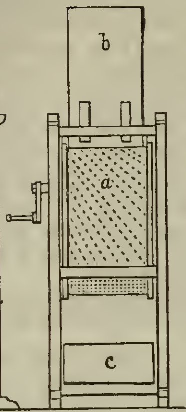


some time into a third, whereby the whole starch will be precipitated. The finest powder collects in the last vessel. The starch thus obtained, containing 33 per cent. of water, may be used either in the moist state, under the name of *green fecula*, for various purposes, as for the preparation of dextrine, and starch sirup; or it may be preserved under a thin layer of water, which must be renewed from time to time, to prevent fermentation; or lastly, it may be taken out and dried.

In trials made with St. Etienne's rasp and starch machinery, in Paris, which was driven by two horses, nearly 18 cwts. of potatoes were put through all the requisite operations in one hour, including the pumping of the water. The product in starch amounted to from 17 to 18 per cent. of the potatoes. The quicker the process of potato-starch making, the better is its quality.

Starch from certain foreign plants.—1. From the pith of the *sago palm*. See SAGO.

2. From the roots of the *Maranta arundinacea*, of Jamaica, the Bahamas, and other West India islands, the powder called arrow-root is obtained, by a process analogous to that for making potato starch.

3. From the root of the *Manioc*, which also grows in the West Indies, as well as in Africa, the *cassava* is procured by a similar process. The juice of this plant is poisonous, from which the wholesome starch is deposited. When dried with stirring upon hot iron plates, it agglomerates into small lumps, called *tapioca ;* being a gummy fecula.

The characters of the different varieties of starch can be learned only from microscopic observation; by which means also their sophistication or admixture may be readily ascertained.

Starch, from whatever source obtained, is a white soft powder, which feels crispy, like flowers of sulphur, when pressed between the fingers; it is destitute of taste and smell, unchangeable in the atmosphere, and has a specific gravity of 1·53. I have already described the particles as spheroids enclosed in a membrane. The potato contains some of the largest, and the millet the smallest. Potato starch consists of truncated ovoids, varying in size from $\frac{1}{300}$ to $\frac{1}{3000}$ of an inch; arrow-root, of ovoids varying in size from $\frac{1}{800}$ to $\frac{1}{2000}$ of an inch; flower starch, of insulated globules about $\frac{1}{1000}$ of an inch; cassava, of simular globules assembled in groups. These measurements I have made with a good achromatic microscope, and a divided glass-slip micrometer of Tully.

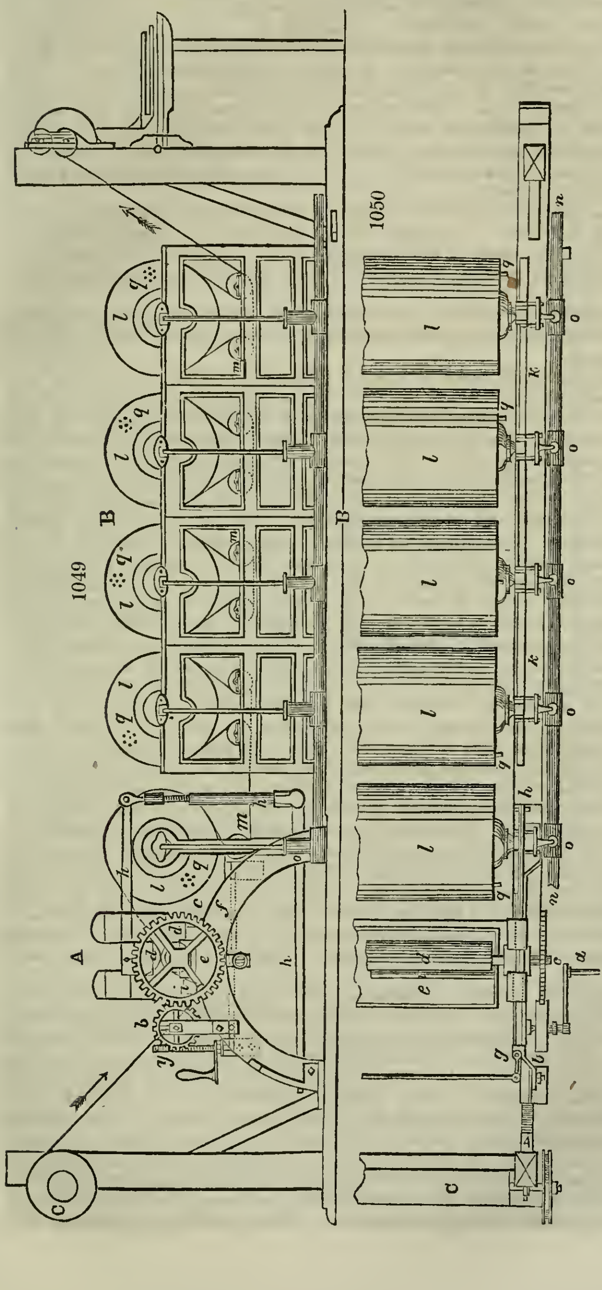
For the saccharine changes which starch undergoes by the action of *diastase*, see FERMENTATION.

Lichenine, a species of starch obtained from Iceland moss, (*Cetraria islandica*,) as well as *inuline*, from elecampane, (*Inula Helenium*,) are rather objects of chemical curiosity, than of manufactures.

There is a kind of starch made in order to be converted into gum for the calico-printer. This conversion having been first made upon the great scale in this country, has occasioned the product to be called British gum. The following is the process pursued in a large and well conducted establishment near Manchester. A range of four wooden cisterns, each about 7 or 8 feet square, and 4 feet deep, is provided. Into each of them 2000 gallons of water being introduced, 12½ loads of flour are stirred in. This mixture is set to ferment upon old leaven left at the bottom of the backs, during 2 or 3 days. The contents are then stirred up, and pumped off into 3 stone cisterns, 7 feet square and 4 feet deep; as much water being added, with agitation, as will fill the cisterns to the brim. In the course of 24 hours the starch forms a firm deposite at the bottom; and the water is then syphoned off. The gluten is next scraped from the surface, and the starch is transferred into wooden boxes pierced with holes, which may be lined with coarse cloth, or not, at the pleasure of the operator.

The starch, cut into cubical masses, is put into iron trays, and set to dry in a large apartment, two stories high, heated by a horizontal cylinder of cast iron traversed by the flame of a furnace. The drying occupies two days. It is now ready for conversion into gum, for which purpose it is put into oblong trays of sheet iron, and heated to the temperature of 300° F. in a cast-iron oven, which holds four of these trays. Here it concretes into irregular semi-transparent yellow-brown lumps, which are ground into fine flour between mill-stones, and in this state brought to the market. In this roasted starch, the vesicles being burst, their contents become soluble in cold water. British gum is not convertible into sugar, as starch is, by the action of dilute sulphuric acid; nor into mucic acid, by nitric acid; but into the oxalic; and it is tinged purple-red by iodine. It is composed, in 100 parts, of 35·7 carbon, 6·2 hydrogen, and 58·1 oxygen; while starch is composed of, 43·5 carbon, 6·8 hydrogen, and 49·7 oxygen.

To prove whether starch be quite free from gluten, or whether it be mixed with any wheat flour, diffuse 12 grains of it through six ounces of water, heat the mixture to boiling, stirring it meanwhile with a glass slip. If the starch be pure, no froth will be seen upon the surface of the pasty fluid; or if any be produced during the stirring, it will immediately subside after it; but if the smallest portion of gluten be present, much froth will be permanently formed, which may be raised by stirring into the appearance of soap-suds.



1049

1050

STARCHING AND STEAM-DRYING APPARATUS. The system of hollow cylinders, for drying goods in the processes of bleaching or calico-printing, is represented in *fig.* 1049, in a longitudinal section, and in *fig.* 1050, in a top view; but the cylinders are supposed to be broken off in the middle, as it was needless to repeat the parts at the other end, which are sufficiently shown in the section.

A is the box containing the paste, when the goods are to be starched or stiffened; *a*, a winch, when it is desired to turn the machine by hand, though it is always moved by power in considerable factories; *b*, is the driving pinion; *d*, *d′*, two brass rollers with iron shafts, the undermost of which is moved by the wheel *c*, in gear with the pinion *b*. The uppermost roller *d′*, is turned by the friction with the former, *d*, being pressed upon it by the weighted lever *h*; *e* is the trough filled with the paste, which rests upon the bars *f*, and may be placed higher or lower by means of the adjusting screws *g*, according as the roller *d* is to be plunged more or less deeply. A brass roller *i* serves to force down the cloth into the paste.

B, is the drying part of the machine; *k*, *k*, its iron framing; *l*, *l*, &c., five drums, or hollow copper cylinders, heated with steam; *m*, *m*, *m*, &c., small copper drums, in pairs, turning freely on shafts under the former, for stretching the goods, and airing them, during their passage through the machine; *n*, *n*, is the main steam-pipe, from which branch off small copper tubes, *o*, *o*, &c., which conduct the steam through stuffing-boxes into the cavity of the drying-drums. There are similar tubes upon the other ends of the drums, for discharging the condensed water through similar stuffing-boxes; *q*, *q*, are valves, opening internally, for admitting the air whenever the steam is taken off, or becomes feeble, to prevent the drums from being crushed by the unbalanced pressure of the atmosphere upon their external surfaces.

C, is the cloth-beam, from which the starching roller draws forward the goods; D, are two rollers, of which the lower is provided with a band-pulley or rigger, driven by a similar pulley fixed upon the shaft of the starching roller *d*. These two rollers pull the goods through the drying machine, and then let them fall either upon a table or the floor.

STEAM, is the vapor of hot water; the discussion of which belongs to chemistry, physics, and engineering. Certain practical applications of the subject will be found in the article EVAPORATION.

STEARIC ACID, improperly called STEARINE (*Talgsaüre*, Germ.), is the solid constituent of fatty substances, as of tallow and olive oil, converted into a crystalline mass by saponification with alkaline matter, and abstraction of the alkali by an acid. By this process, fats are convertible into three acids, called Stearic, Margaric, and Oleic; the first two being solid, and the last liquid. The stearine, of which *factitious wax* candles are made, consists of the stearic and margaric acids combined. These can be separated from each other only by the agency of alcohol, which holds the margaric acid in solution after it has deposited the stearic in crystals. Pure stearic acid is prepared, according to its discoverer, Chevreul, in the following way:—Make a soap, by boiling a solution of potash and mutton-suet in the proper equivalent proportions (see SOAP); dissolve one part of that soap in 6 parts of hot water, then add to the solution 40 or 50 parts of cold water, and set the whole into a place whose temperature is about 52° Fahrenheit. A substance falls to the bottom, possessed of pearly lustre, consisting of the bi-stearate and bi-margarate of potash; which is to be drained and washed upon a filter. The filtered liquor is to be evaporated, and mixed with the small quantity of acid necessary to saturate the alkali left free by the precipitation of the above bi-salts. On adding water to it afterwards, the liquor affords a fresh quantity of bi-stearate and bi-margarate. By repeating this operation with precaution, we finally arrive at a point when the solution contains no more of these solid acids, but only the oleic. The precipitated bi-salts are to be washed and dissolved in hot alcohol, of specific gravity 0·820, of which they require about 24 times their weight. During the cooling of the solution, the bi-stearate falls down, while the greater part of the bi-margarate, and the remainder of the oleate, remain dissolved. By once more dissolving in alcohol, and crystallizing, the bi-stearate will be obtained alone; as may be proved by decomposing a little of it in water at a boiling heat, with muriatic acid, letting it cool, washing the stearic acid obtained, and exposing it to heat, when, if pure, it will not fuse in water under the 158th degree of Fahrenheit's scale. If it melts at a lower heat, it contains more or less margaric acid. The purified bi-stearate being decomposed by boiling in water along with any acid, as the muriatic, the disengaged stearic acid is to be washed by melting in water, then cooled and dried.

Stearic acid, prepared by the above process, contains combined water, from which it cannot be freed. It is insipid and inodorous. After being melted by heat, it solidifies at the temperature of 158° Fahrenheit, and affects the form of white brilliant needles grouped together. It is insoluble in water, but dissolves in all proportions in boiling anhydrous alcohol, and on cooling to 122°, crystallizes therefrom, in pearly plates; but if the concentrated solution be quickly cooled to 112°, it forms a crystalline mass. A dilute solution affords the acid crystallized in large white brilliant scales. It dissolves in its own weight of boiling ether of 0·727, and crystallizes on cooling in beautiful scales, of changing colors. It distils over *in vacuo* without alteration; but if the retort contains a little atmospheric air, a small portion of the acid is decomposed during the distillation; while the greater part passes over unchanged, but slightly tinged brown, and mixed with traces of empyreumatic oil. When heated in the open air, and kindled, stearic acid burns like wax. It contains 3·4 per cent. of water, from which it may be freed by combining it with oxyde of lead. When this anhydrous acid is subjected to ultimate analysis, it is found to consist of—80 of carbon, 12·5 hydrogen, and 7·5 oxygen, in 100 parts. Stearic acid displaces, at a boiling heat in water, carbonic acid from its combinations with the bases; but in operating upon an alkaline carbonate, a portion of the stearic acid is dissolved in the liquor before the carbonic acid is expelled. This decomposition is founded upon the principle, that the stearic acid transforms the salt into a bicarbonate, which is decomposed by the ebullition.

Stearic acid put into a strong watery infusion of litmus, has no action upon it in the cold; but when hot, the acid combines with the alkali of the litmus, and changes its blue color to red; so that it has sufficient energy to abstract from the concentrated tincture all the alkali required for its neutralization. If we dissolve bi-stearate of potash in weak alcohol, and pour litmus water, drop by drop, into the solution, this will become red, because the litmus will give up its alkali to a portion of the bi-stearate, and will convert it into neutral stearate. If we now add cold water, the reddened mixture will resume its blue tint, and will deposite bi-stearate of potash in small spangles. In order that the alcoholic solution of the bi-stearate may redden the litmus, the alcohol should not be very strong.

From the composition of stearate of potash, the atomic weight of the acid appears to be 106·6; hydrogen being 1; for $18 : 48 \times 2 :: 100 : 533{\cdot}3 = 5$ atoms of acid.

From the stearate of soda, it appears to be 104; and from that of lime, 102. The stearate of lead, by Chevreul, gives 109 for the atomic weight of the acid.

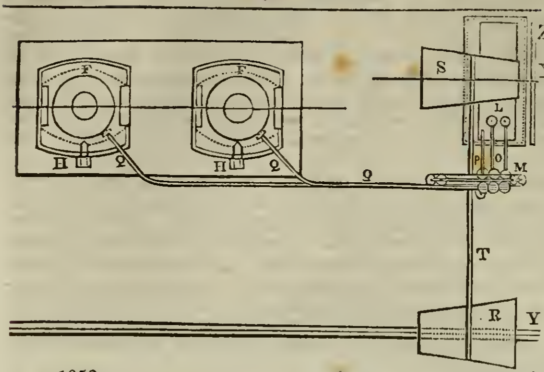
The margaric and oleic acids seem to have the same neutralizing power, and the same atomic weight.

The preceding numbers will serve to regulate the manufacture of stearic acid for the purpose of making candles. Potash and soda were first prescribed for saponifying fat, as may be seen in M. Gay Lussac's patent, under the article CANDLE; and were it not for the cost of these articles, they are undoubtedly preferable to all others in a chemical point of view. Of late years lime has been had recourse to, with perfect success, and has become subservient to a great improvement in candle-making. The stearine block now made by many London houses, though containing not more than 2 or 3 per cent. of wax, is hardly to be distinguished from the purified produce of the bee. The first process is to boil the fat with quicklime and water in a large tub, by means of perforated steam pipes distributed over its bottom. From the above statements we see that about 11 parts of dry lime are fully equivalent to 100 of stearine and oleine mixed: but as the lime is in the state of hydrate, 14 parts of it will be required when it is perfectly pure; in the ordinary state, however, as made from average good limestone, 16 parts may be allowed. After a vigorous ebullition of 3 or 4 hours, the combination is pretty complete. The stearate being allowed to cool to such a degree as to allow of its being handled, becomes a concrete mass, which must be dug out with a spade, and transferred into a contiguous tub, in order to be decomposed with the equivalent quantity of sulphuric acid diluted with water, and also heated with steam. Four parts of concentrated acid will be sufficient to neutralize three parts of slaked lime. The saponified fat now liberated from the lime, which is thrown down to the bottom of the tub in the state of sulphate, is skimmed off the surface of the watery menstruum into a third contiguous tub, where it is washed with water and steam.

The washed mixture of stearic, margaric, and oleic acids, is next cooled in tin pans; then shaved by large knives, fixed on the face of a fly-wheel, called a tallow cutter, preparatory to its being subjected in canvass 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 canvass bags, and subjected to the joint action of steam and pressure in a horizontal hydraulic press of a peculiar construction, somewhat similar to that which has been long used in London for pressing spermaceti. The cakes of stearic acid thus freed completely from the margaric and oleic acids, are subjected to a final cleansing in a tub with steam, and then melted into hemispherical masses called blocks. When these blocks are broken, they display a highly crystalline texture, which would render them unfit for making candles. This texture is therefore broken down or comminuted by fusing the stearine in a plated copper pan, along with one thousandth part of pulverized arsenious acid, after which it is ready to be cast into candles in appropriate moulds. See CANDLE.

STEARINE COLD PRESS. The cold hydraulic press, as mounted by Messrs. Maudslay and Field, for squeezing out the oleic acid from saponified fat, or the oleine from cocoa-nut lard, is represented in plan in *fig.* 1051; in side view of pump in *fig.* 1052; and in elevation, *fig.* 1053; where the same letters refer to like objects.

1051 *Scale 3-20ths of an inch to the foot.*



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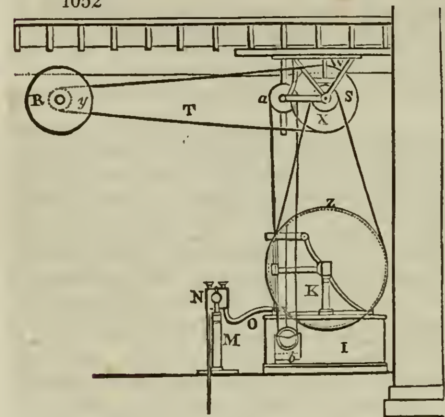
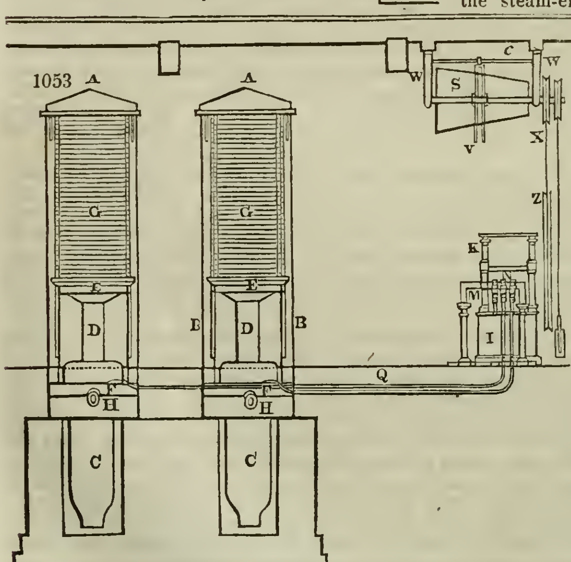


1053



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 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; 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 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.

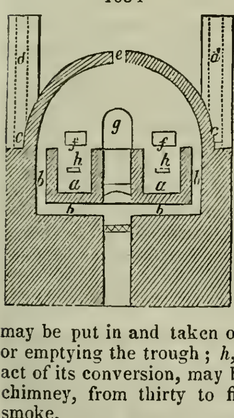
STEATITE (*Soapstone; Craie de Briançon*, Fr.; *Speckstein*, Germ.), is a mineral of the magnesian family. It has a grayish-white or greenish-white color, often marked with dendritic delineations, and occurs massive, as also in various supposititious crystalline forms; it has a dull or fatty lustre; 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 consists of—silica, 44; magnesia, 44; alumina, 2; iron, 7·3; manganese, 1·5; chrome, 2; with a trace of lime. It is found frequently in small contemporaneous veins that traverse serpentine in all directions, as at Portsoy, in Shetland, in the limestone of Icolmkiln, in the serpentine of Cornwall, in Anglesey, in Saxony, Bavaria, (at Bayruth,) Hungary, &c. It is used in the manufacture of porcelain. It makes the buiscuit 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 powders; as an ingredient in anti-attrition pastes; it is dusted in powder upon the inside of boots, to make the feet glide easily into them; when rubbed upon grease-spots in silk and woollen clothes, it removes the stains by absorption; it enters into the composition of certain crayons, and is used itself for making traces upon glass, silk, &c. The spotted steatite, cut into cameos and calcined, assumes an onyx aspect. Soft steatite forms excellent stoppers for the chemical apparatus used in distilling or subliming corrosive vapors. Lamellar steatite is TALC.

STEEL (*Acier*, Fr.; *Stahl*, Germ.), as a carburet of iron, has already been considered under that metal. I shall treat in this article more particularly of its manufacture and technical relations.

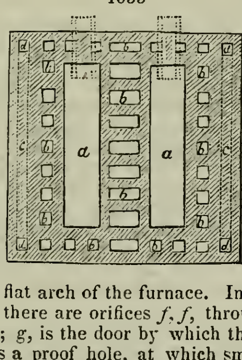
1. *Steel of cementation, bar or blistered steel.*—With the exception of the Ulverstone charcoal iron, no bars are manufactured in Great Britain capable of conversion into steel at all approaching in quality to that made from the Madras, Swedish, and Russian irons, so largely imported for that purpose. The first rank is assigned to the Swedish iron stamped with a circle enclosing the letter L (hence called hoop L); which fetches the high price of 36*l.* 10*s.* per ton, while excellent English coke-iron may be had for one fifth of the price. The other Swedish irons are sold at a much lower rate, though said to be manufactured in the same way; and therefore the superiority of the Dannemora iron must be owing to some peculiarity in the ore from which it is smelted. The steel recently made in the Indian steel-works at Chelsea, from Mr. Heath's Madras iron, rivals that from the hoop L.

The Sheffield furnace for making bar or blistered steel, called the furnace of cementation, is represented in *fig.* 1054, in a cross section, and in *fig.* 1055, in a ground plan.

1054



1055



The hearth of this oblong quadrangular furnace, is divided by a grate into two parts, upon each side of which there is a chest *a*, called a *trough*, made of fire-clay, or fire-tiles. The breadth of the grate varies according to the quality of the fuel. *b*, *b*, are air-holes; *c*, *c*, flues leading to the chimney *d*, *d*. To aid the draught of the smoke and the flame, an opening *e*, is made in the middle of the flat arch of the furnace. In one of its shorter sides (ends), there are orifices *f*, *f*, through which the long bars of iron may be put in and taken out; *g*, is the door by which the steel-maker enters, in filling or emptying the trough; *h*, is a proof hole, at which small samples of the steel, in the act of its conversion, may be drawn out. The furnace is built under a conical hood or chimney, from thirty to fifty feet high, for aiding the draught, and carrying off the smoke.

The two chests are built of fire-stone grit. They are 8, 10, or even 15 feet long, and from 26 to 36 inches in width and depth; the lower and smaller they are, the more uniform will the quality of the steel be. A great breadth and height of trough are incompatible with equability of the cementing temperature. The sides are a few inches thick. The space between them is at least a foot wide. They should never rest directly upon the sole of the furnace, but must have their bottom freely played upon by the flame, as well as the sides and top. The degree of heat is regulated by openings in the arch, or upon the long sides of the furnace, which lead to the chimney; as also by the greater or less quantity of air admitted below the grate, as in glass-house furnaces.

The *cement* consists of ground charcoal (sometimes of soot), mixed with one tenth of ashes, and some common salt; the charcoal of hard wood being preferred. Ground coke is inadmissible, on account of the sulphur, silica, and clay, which it generally contains. Possibly the salt serves to vitrify the particles of silica in the charcoal, and thus to prevent their entering into combination with the steel. As for the ashes, it is difficult to discover their use. The best steel may be made without their presence. The bottom of the trough being covered with two inches of the powder of cementation, the bars are laid along in it, upon their narrow edge, the side bar being one inch from the trough, and the rest being from one half to three fourths of an inch apart. Above this first layer of iron bars, fully half an inch depth of the powder is spread, then a new series of bars is stratified, and so on till the trough is filled within six inches of the top. This space is partially filled with old cement powder, and is covered with refractory damp sand. Sometimes the trough is filled to the surface with the old cement, and then closely covered with fire-tiles. The bars should never be allowed to touch each other, or the trough. The fire must be carefully urged from two to four days, till it acquires the temperature of 100° Wedgewood; which must be steadily maintained during the four, six, eight, or ten days requisite for the cementation; a period dependant on the size of the furnace, and which is determined by the examination of the proof pieces, taken out from time to time.

In the front or remote end of the furnace, *fig.* 1054, a door is left in the outer building, corresponding to a similar one in the end of the interior vault, through which the workman enters for charging the furnace with charcoal and iron bars, as also for taking out the steel after the conversion. Small openings are likewise made in the ends of the chests, through which the extremities of a few bars are left projecting, so that they may be pulled out and examined, through small doors opposite to them in the exterior walls. These *tap* holes, as they are called, should be placed near the centre of the end stones of the chests, that the bars may indicate the average state of the process. The joinings of the fire-stones are secured with a finely ground Stourbridge clay.

The interval between the two chests (in furnaces containing two, for many have only one) being covered with an iron platform, the workman stands on it, and sifts a layer of charcoal on the bottom of the chests evenly, about half an inch thick; he then lays a row of bars, cut to the proper length, over the charcoal, about an inch from each other; he next sifts on a second stratum of charcoal-dust, which, as it must serve for the bars above, as well as below, is made an inch thick; thus, he continues to stratify, till the chest be filled within two inches of the top; and he covers the whole with the earthy detritus found at the bottom of grindstone troughs, or any convenient fire-loam. It is obvious that the second series of bars should correspond vertically with the interstices between the first series, and so in succession. The trial-rods are left longer than the others, and their projecting ends are incrusted with fire-clay, or imbedded in sand. The iron platform being removed, and all the openings into the vault closed, the fire is lighted, and very gradually increased, to avoid every risk of cracking the grit-stone by too sudden a change of temperature; and the ignition being finally raised to about 100° Wedgewood, but not higher, for fear of melting the metal, must be maintained at a uniform pitch, till the iron have absorbed the desired quantity of carbon, and have been converted as highly as the manufacturer intends for his peculiar object. From six to eight days may be reckoned a sufficient period for the production of steel of moderate hardness, and fit for tilting into shear steel. A softer steel, for saws and springs, takes a shorter period; and a harder steel, for fabricating chisels used in cutting iron, will need longer exposure to the ignited charcoal. But, for a few purposes, such as the bits for boring cast iron, the bars are exposed to two or three successive processes of cementation, and are hence said to be twice or thrice converted into steels. The higher the heat of the furnace, the quicker is the process of conversion.

The furnace being suffered to cool, the workman enters it again, and hands out the steel bars, which being covered with blisters, from the formation and bursting of vesicles on the surface filled with gaseous carbon, is called *blistered steel.* This steel is very irregular in its interior texture, has a white color, like frosted silver, and displays crystalline angles and facettes, which are larger the further the cementation has been urged, or the greater the dose of carbon. The central particles are always smaller than those near the surface of the bar.

In such a furnace as the above, twelve tons of bar iron may be converted at a charge.

But other furnaces are constructed with one chest, which receives six or eight tons at a time; the small furnaces, however, consume more fuel in proportion than the larger.

The absorption and action of the carbonaceous matter, to the amount of about a half per cent., occasions fissures and cavities in the substance of the blistered bars, which render the steel unfit for any useful purpose in tool-making, till it be condensed and rendered uniform by the operation of *tilting*, under a powerful hammer driven by machinery. See Iron.*

The heads of the tilt-hammers for steel weigh from one and a half to two hundred pounds. Those in the neighborhood of Sheffield are much simpler than the one referred to in the note. They are worked by a small water-wheel, on whose axis is another wheel, bearing a great number of cams or wipers on its circumference, which strike the tail of the hammer in rapid succession, raise its head, and then let it fall smartly on the hot metal rod, dexterously presented on its several parts to the anvil beneath it, by the workman. The machinery is adapted to produce from 300 to 400 blows per minute; which on this plan requires an undue and wasteful velocity of the float-boards. Were an intermediate toothed wheel substituted between the water-wheel and the wiper-wheel, so that while the former made one turn, the latter might make three, a much smaller force of water would do the work. The anvils of the tilt-hammer are placed nearly on a level with the floor of the mill-house; and the workman sits in a fosse, dug on purpose, in a direction perpendicular to the line of the helve, on a board suspended from the roof of the building by a couple of iron rods. On this swinging seat, he can advance or retire with the least impulse of his feet, pushing forward the steel bar, or drawing it back with equal rapidity and convenience.

At a small distance from each tilt, stands the forge-hearth, for heating the steel. The bellows for blowing the fire are placed above-head, and are worked by a small crank fixed on the end of the axis of the wheel, the air being conveyed by a copper pipe down to the nozzle. Each workman at the tilt has two boys in attendance, to serve him with hot rods, and to take them away after they are hammered. In small rods, the bright ignition originally given at the forge soon declines to darkness; but the rapid impulsions of the tilt revive the redness again in all the points near the hammer; so that the rod, skilfully handled by the workman, progressively ignites where it advances to the strokes. Personal inspection alone can communicate an adequate idea of the precision and celerity with which a rude steel rod is stretched and fashioned into an even, smooth, and sharp-edged prism, under the operation of the tilt-hammer. The heat may be clearly referred to the prodigious friction among the particles of so cohesive a metal, when they are made to slide so rapidly over each other in every direction during the elongation and squaring of the rod.

2. *Shear steel* derives its name from the accidental circumstance of the shears for dressing woollen cloth being usually forged from it. It is made by binding into a bundle, with a slender steel rod, four parallel bars of blistered steel, previously broken into lengths of about 18 inches, including a fifth of double length, whose projecting end may serve as a handle. This fagot, as it is called, is then heated in the forge-hearth to a good welding-heat, being sprinkled over with sand to form a protecting film of iron slag, carried forthwith to the tilt, and notched down on both sides to unite all the bars together, and close up every internal flaw or fissure. The mass being again heated, and the binding rings knocked off it, is drawn out into a uniform rod of the size required. Manufacturers of cutlery are in the habit of purchasing the blistered bars at the conversion furnaces, and sending them to tilt-mills to have them drawn out to the proper size, which is done at regular prices to the trade; from 5 to 8 per cent. discount being allowed on the rude bars for waste in the tilting. The metal is rendered so compact by the welding and hammering, as to become susceptible of a much finer polish than blistered steel can take; while the uniformity of its body, tenacity, and malleability are at the same time much increased; by which properties it becomes well adapted for making table knives and powerful springs, such as those of gun-locks. The steel is also softened down by this process, probably from the expulsion of a portion of its carbon during the welding and subsequent heats; and if these be frequently or awkwardly applied, it may pass back into common iron.

3. *Cast steel* is made by melting, in the best fire-clay crucibles, blistered steel, broken down into small pieces of convenient size for packing; and as some carbon is always dissipated in the fusion, a somewhat highly converted steel is used for this purpose. The furnace is a square prismatic cavity, lined with fire-bricks, 12 inches in each side, and 24 deep, with a flue immediately under the cover, 3½ inches by 6, for conducting the smoke into an adjoining chimney of considerable height. In some establishments a dozen such furnaces are constructed in one or two ranges, their tops being on a level with the floor of the laboratory, as in brass-foundries, for enabling the workmen more

* For minute details of the parts, see the excellent article Tilting-hammer, in *Rees's Cyclopædia.*

conveniently to inspect, and lift out, the crucibles with tongs. The ash-pits terminate in a subterraneous passage, which supplies the grate with a current of cool air, and serves for emptying out the ashes. The crucible stands, of course, on a sole-piece of baked fire-clay; and its mouth is closed with a well-fitted lid. Sometimes a little bottle-glass, or blast-furnace slag, is put into the crucible, above the steel pieces, to form a vitreous coating, that may thoroughly exclude the air from oxydizing the metal. The fuel employed in the cast-steel furnace is a dense coke, brilliant and sonorous, broken into pieces about the size of an egg, one good charge of which is sufficient. The tongs are furnished at the fire end with a pair of concave jaws, for embracing the curvature of the crucible, and lifting it out whenever the fusion is complete. The lid is then removed, the slag or scoriæ cleared away, and the liquid metal poured into cast-iron octagonal or rectangular moulds, during which it throws out brilliant scintillations.

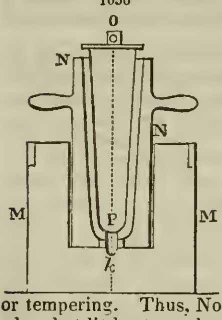
Cast-steel works much harder under the hammer than shear steel, and will not, in its usual state, bear much more than a cherry-red heat without becoming brittle; nor can it bear the fatigue incident to the welding operation. It may, however, be firmly welded to iron, through the intervention of a thin film of vitreous boracic acid, at a moderate degree of ignition. Cast steel, indeed, made from a less carbureted bar steel, would be susceptible of welding and hammering at a higher temperature; but it would require a very high heat for its preparation in the crucible.

Iron may be very elegantly plated with cast steel, by pouring the liquid metal from the crucible into a mould containing a bar of iron polished on one face. In this circumstance the adhesion is so perfect as to admit of the two metals being rolled out together; and in this way the chisels of planes and other tools may be made, at a moderate rate and of excellent quality, the cutting-edge being formed in the steel side. Such instruments combine the toughness of iron with the hardness of steel.

For correcting the too high carbonization of steel, or equalizing the too highly converted exterior of a bar with the softer steel of the interior, the metal requires merely to be imbedded, at a cementing heat, in oxyde of iron or manganese; the oxygen of which soon abstracts the injurious excess of carbon, so that the outer layers may be even converted into soft iron, while the axis continues steely; because the decarbonizing advances far more rapidly than the carbonizing.

Fig. 1056 represents the mould for making crucibles for the cast-steel works. M M, is a solid block of wood, to support the two-handled outside mould N, N. This being rammed full of the proper clay dough or compost (see CRUCIBLE), the inner mould is to be then pressed vertically into it, till it reaches the bottom P, being directed and facilitated in its descent by the point *k*. A cord passes through O, by which the inner mould is suspended over a pulley, and guided in its motions.

1056



When a plate of polished steel is exposed to a progressive heat, it takes the following colors in succession: 1, a faint yellow; 2, a pale straw-color; 3, a full yellow; 4, a brown yellow; 5, a brown with purple spots; 6, a purple; 7, a bright blue; 8, a full blue; 9, a dark blue, verging on black; after which the approach to ignition supersedes all these colors. If the steel plate has been previously hardened by being dipped in cold water or mercury when red-hot, then those successive shades indicate or correspond to successive degrees of softening or tempering. Thus, No. 1 suits the hard temper of a lancet, which requires the finest edge, but little strength of metal; No. 2 a little softer, for razors and surgeons' amputating instruments; No. 3, somewhat more toughness, for penknives; No. 4, for cold chisels and shears for cutting iron; No. 5, for axes and plane-irons; No. 6, for table knives and cloth shears; No. 7, for swords and watch-springs; No. 8, for small fine saws and daggers; No. 9, for large saws, whose teeth need to be set with pliers, and sharpened with a file. After ignition, if the steel be very slowly cooled, it becomes exceedingly soft, and fit for the engraver's purposes. Hardened steel may be tempered to the desired pitch, by plunging it in metallic baths heated to the proper thermometric degree, as follows: for No. 1, 430° Fahr.; No. 2, 450°; No. 3, 470°; No. 4, 490°; No. 5, 510°; No. 6, 530°; No. 7, 550°; No. 8, 560°; No. 9, 600°.

Small steel tools are most frequently tempered, after hardening, by covering their surface with a thin coat of tallow, and heating them in the flame of a candle till the tallow diffuses a faint smoke, and then thrusting them into the cold tallow. Rinman long ago defined steel to be any kind of iron which, when heated to redness, and then plunged in cold water, becomes harder. But several kinds of cast iron are susceptible of such hardening. Every malleable and flexible iron, however, which may be hardened in that way is a steel. Moreover, steel may be distinguished from pure iron by its giving a dark-gray spot when a drop of dilute nitric acid is let fall on its surface, while iron affords a green one. Exposed to the air, steel rusts less rapidly than iron; and the more highly carbureted, the more slowly does it rust, and the blacker is the spot left by an acid.

After hardening, steel seems to be quite a different body; even its granular texture becomes coarser or finer, according to the degree of heat to which it was raised; it grows so hard as to scratch glass, and resist the keenest file, while it turns exceedingly brittle. When a slowly cooled steel rod is forged and filed, it becomes capable of affording agreeable and harmonious sounds by its vibrations; but hard-tempered steel affords only dull deafened tones, like those emitted by a cracked instrument.

The good quality of steel is shown by its being homogeneous; being easily worked at the forge; by its hardening and tempering well; by its resisting or overcoming forces; and by its elasticity. To ascertain the first point, the surface should be ground and polished on the wheel; when its lustre and texture will appear. The second test requires a skilful workman to give it a heat suitable to its nature and state of conversion. The size and color of the grain are best shown by taking a bar forged into a razor form; hardening and tempering it; and then breaking off the thin edge in successive bits with a hammer and anvil. If it had been fully ignited only at the end, then, after the hardening, it will display, on fracture, a succession in the aspect of its grains from that extremity to the other; as they are whiter and larger at the former than the latter. The other qualities become manifest on filing the steel; using it as a chisel for cutting iron; or bending it under a heavy weight.

Much interest was excited a few years back by the experiments of Messrs. Stodart and Faraday on the alloys of steel with silver, platinum, rhodium, and iridium. Steel refuses to take up in fusion more than one five-hundredth part of silver; but with this minute quantity of alloy, it is said to bear a harder temper, without losing its tenacity. When pure iron is substituted for steel, the alloys so formed are much less subject to oxydation in damp air than before. With three *per cent.* of iridium and osmium, an alloy was obtained which had the property of tempering like steel, and of remaining clean and bright, in circumstances when simple iron became covered with rust. "Upon the whole," says the editor of the Quarterly Journal of Science, giving a report of these experiments in his 14th volume, p. 378, "though we consider these researches upon the alloys of steel as very interesting, we are not sanguine as to their important influence upon the improvement of the manufacture of cutlery, and suspect that a bar of the best ordinary steel, selected with precaution, and most carefully forged, wrought, and tempered, *under the immediate inspection of the master*, would afford cutting instruments as perfect and excellent as those composed of wootz, or of the alloys."

Case-hardening of iron, is a process for converting a thin film of the outer surface into steel, while the interior remains as before. Fine keys are generally finished in this way. See Case-hardening.

So great is the affinity of iron for carbon, that, in certain circumstances, it will absorb it from carbureted hydrogen, or coal-gas, and thus become converted into steel. On this principle, Mr. Mackintosh of Glasgow obtained a patent for making steel. His furnace consists of one cylinder of bricks built concentrically within another. The bars of iron are suspended in the innermost, from the top; a stream of purified coal-gas circulates freely round them, entering below and escaping slowly above, while the bars are maintained in a state of bright ignition by a fire burning in the annular space between the cylinders. The steel so produced is of excellent quality; but the process does not seem to be so economical as the ordinary cementation with charcoal powder.

Damasking of steel, is the art of giving to sabre blades a variety of figures in the style of watering. See Damascus Blades.

Several explanations have been offered of the change in the constitution of steel, which accompanies the tempering operation; but none of them seems quite satisfactory. It seems to be probable that the ultimate molecules are thrown by the sudden cooling into a constrained state, so that their poles are not allowed to take the position of strongest attraction and greatest proximity; and hence the mass becomes hard, brittle, and somewhat less dense. An analogous condition may be justly imputed to hastily cooled glass, which, like hardened steel, requires to be annealed by a subsequent nicely graduated heat, under the influence of which the particles assume the position of repose, and constitute a denser, softer, and more tenacious body. The more sudden the cooling of ignited steel, the more unnatural and constrained will be the distribution of its particles, and also the more refractory, an effect produced by plunging it into cold mercury. This excess of hardness is removed in any required degree by judicious annealing or tempering. The state of the carbon present in the steel may also be modified by the rate of refrigeration, as Mr. Karsten and M. Bréant conceive happens with cast iron and the damask metal. If the uniform distribution and combination of the carbon through the mass, determine the peculiarity of white cast iron, which is a hard and brittle substance, and if its transition to the dark-gray and softer cast metal be effected by a partial formation of plumbago during slow cooling, why may not something similar be supposed to occur with steel, an analogous compound?

Mr. Oldham, printing engineer of the Bank of England, who has had great experience in the treatment of steel for dies and mills, says that, for hardening it, the fire should never be heated above the redness of sealing-wax, and kept at that pitch for a sufficient time. On taking it out, he hardens it by plunging it, not in water, but in olive oil, or rather naptha, previously heated to 200° F. It is kept immersed only till the ebullition ceases, then instantly transferred into cold spring water, and kept there till quite cold. By this treatment the tools come out perfectly clean, and as hard as it is possible to make cast-steel, while they are perfectly free from cracks, flaws, or twist. Large tools are readily brought down in temper by being suspended in the red-hot muffle till they show a straw color; but for small tools, he prefers plunging them in the oil heated to 400 degrees; and leaves them in till they become cold.

Mr. Oldham softens his steel dies by exposing them to ignition for the requisite time, imbedded in a mixture of chalk and charcoal.

"The common mode of softening steel," says Mr. Baynes, "is to put it into an iron case, surrounded with a paste made of lime, cow's gall, and a little nitre and water; then to expose the case to a slow fire, which is gradually increased to a considerable heat, and afterwards allowed to go out, when the steel is found to be soft and ready for the engraver."*

Indian steel or wootz.—The wootz ore consists of the magnetic oxyde of iron, united with quartz, in proportions which do not seem to differ much, being generally about 42 of quartz, and 58 of magnetic oxyde. 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 four to five feet high; it is somewhat pear-shaped, being about two feet wide at bottom, and one 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

* History of the Cotton Manufacture, p. 275. If that strange farrago be employed by Mr. Locket of Manchester, for softening his dies and mills, it deserves consideration. Should the nitre be used in too great quantity to be all carbonated by the gall, its oxygen may serve to consume some of the carbon of the steel and thus bring it nearer to iron. The recipe may be old, but it is a novelty to me.

the *Convolvulus laurifolius*. As soon as the clay plugs of the crucibles are dry, from 20 to 24 of them are built up in the form of an arch, in a small blast furnace; they are kept covered with charcoal, and subjected to heat urged by a blast for about two hours and a half, when the process is considered to be complete. The crucibles being now taken out of the furnace and allowed to cool, are broken, and the steel is found in the form of a cake, rounded by the bottom of the crucible. When the fusion has been perfect, the top of the cake is covered wirh 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 re-melting the cakes, and running them into ingots; but it is obvious, that when the cakes consist partially of malleable iron and of unreduced oxyde, simple fusion cannot convert them into good steel. When care is taken, however, to select only such cakes as are perfect, to re-melt them thoroughly, and tilt them carefully into rods, an article has been produced which possesses all the requisites of fine steel in an eminent degree. In the Supplement to the Encyclopædia Britannica, article *Cutlery*, the late Mr. Stodart, of the Strand, a very competent judge, has declared "that for the purposes of fine cutlery, it is infinitely superior to the best English cast steel."

The natives prepare the cakes for being drawn into bars by annealing them for several hours in a small charcoal furnace, actuated by bellows; the current of air being made to play upon the cakes while turned over before it; whereby a portion of the combined carbon is probably dissipated, and the steel is softened; without which operation the cakes would break in the attempt to draw them. They are drawn by a hammer of a few pounds weight.

The natives weld two pieces of cast steel, by giving to each a sloping face jagged all over with a small chisel; then applying them with some calcined borax between, and tying them together with a wire, they are brought to a full red heat, and united by a few smart blows of a hammer.

The ordinary bar iron of Sweden and England, when converted by cementation into steel, exhibits upon its surface numerous small warty points, but few or no distinct vesicular eruptions; whereas the Dannemora and the Ulverston steels present, all over the surface of the bars, well raised blisters, upwards of three eighths of an inch in diameter horizontally, but somewhat flattened at top. Iron of an inferior description, when highly converted in the cementing-chest, becomes gray on the outer edges of the fracture; while that of Dannemora acquires a silvery color and lustre on the edges, with crystalline facets within. The highly converted steel is used for tools that require to be made very hard; the slightly converted, for softer and more elastic articles, such as springs and sword blades.

STEREOTYPE PRINTING signifies printing by fixed types, or by a cast typographic plate. This plate is made as follows:—The form, composed in ordinary types, and containing one, two, three, or more pages, inversely as the size of the book, being laid flat upon a slab, with the letters looking upwards, the faces of the types are brushed over with oil, or preferably, with plumbago (black lead.) A heavy brass rectangular frame of three sides, with bevelled borders, adapted exactly to the size of the pages, is then laid down upon the chase,* to circumscribe three sides of its typography; but the fourth side, which is one end of the rectangle, is formed by placing near the types, and over the hollows of the chase, a single brass bar, having the same inwards sloping bevel as the other three sides. The complete frame resembles that of a picture, and serves to define the area and thickness of the cast, which is made by pouring the pap of Paris plaster into its interior space, up to a given line on its edges. The plaster mould, which soon sets, or becomes concrete, is lifted gently off the types, and immediately placed upright on its edge in one of the cells of a sheet-iron rack, mounted within the cast-iron oven. An able workman will mould ten sheets octavo in a day, or 160 pages. The moulds are here exposed to air heated to fully 400° F., and become perfectly dry in the course of two hours. As they are now friable and porous, they require to be delicately handled. Each mould, containing generally two pages octavo, is laid, with the impression downwards, upon a flat cast-iron plate, called the floating-plate; this plate being itself laid on the bottom of the dipping-pan, which is a cast-iron square tray, with its upright edges sloping outwards. A cast-iron lid is applied to the dipping-pan, and secured in its place by a screw. The pan having been heated to 400° in a cell of the oven, under the mould-rack, previous to receiving the hot mould, is ready to be plunged into the bath of melted alloy contained in an iron pot placed over a furnace, and it is dipped with a slight deviation from the horizontal plane, in order to facilitate the escape of the air. As there is a minute space between the back or top surface of

* Chase (*chassis*, frame, Fr.), quoin, (*coin*, wedge, Fr.), are terms which show that the art of printing came directly from France to England.

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 upon refrigeration. As it thus progressively contracts in volume, more melted metal is fed into the corners of the pan by a ladle, in order to keep up the hydrostatic pressure upon the mould, and to secure a perfect impression, as well as a solid cast. Were the pan more slowly and equably cooled, by being left in the air, the thin film of metal upon the back of the inverted plaster cake would be apt to solidify first, and intercept the hydrostatic action indispensable to the purpose of filling all the lines in its face. A skilful workman makes five dips, containing two pages octavo each, in the course of an hour, or about nine and a half octavo sheets per day. The pan being taken asunder, the compound cake of mould and metal is removed, and beat upon its edges with a wooden mallet, to detach the superfluous metal. The stereotype plate is then handed over to the picker, who planes its edges truly square, turns its back flat upon a lathe to a determinate thickness, and carefully removes the little imperfections occasioned by dirt or air left among the letters when the mould was cast. Should any of them be damaged in the course of the operation, they must be cut out, and replaced by soldering in separate types of the same size and form.

STILL (*Alambic*, Fr.; *Blase*, Germ.), is a chemical apparatus, for vaporizing liquids by heat in one part, called the *cucurbit*, and condensing the vapors into liquids in another part, called the *refrigeratory*; the general purpose of both combined being to separate the more volatile fluid particles from the less volatile. In its simplest form, it consists of a retort and a receiver, or of a pear-shaped matrass and a capital, furnished with a slanting tube for conducting away the condensed vapors in drops; whence the term *still*, from the Latin verb *stillare*, to drop. Its chief employment in this country being to eliminate alcohol, of greater or less strength, from fermented wash, I shall devote this article to a description of the stills best adapted to the manufacture of British spirits, referring to chemical authors* for those fitted for peculiar objects.

In respect of rapidity and extent of work, stills had attained to an extraordinary pitch of perfection in Scotland about thirty years ago, when legislative wisdom thought fit to levy the spirits duty, per annum, from each distiller, according to the capacity of his still. It having been shown, in a report presented to the House of Commons in 1799, that an 80-gallon still could be worked off in eight minutes, this fact was made the basis of a new fiscal law, on the supposition that the maximum of velocity had been reached. But, instigated by the hopes of enormous gains at the expense of the revenue, the distillers soon contrived to do the same thing in three minutes, by means of broad-bottomed shallow stills, with stirring-chains, and lofty capitals. In the year 1815, that preposterous law, which encouraged fraud and deteriorated the manufacture, was repealed. The whiskey duties having been since levied, independently of the capacity of the still, upon the quantity produced, such rapid operations have been abandoned, and processes of economy in fuel, and purity in product, have been sought after.

One of the greatest improvements in modern distilleries, is completing the analysis of crude spirit at one operation. Chemists had been long familiar with the contrivance of Woulfe, for impregnating with gaseous matter, water contained in a range of bottles; but they had not thought of applying that plan to distillation, when Edouard Adam, an illiterate workman of Montpellier, after hearing accidentally a chemical lecture upon that apparatus, bethought himself of converting it into a still. He caused the boiling-hot vapors to chase the spirits successively out of one bottle into another, so as to obtain in the successive vessels alcohol of any desired strength and purity, "*at one and the same heat*." He obtained a patent for this invention in 1801, and was soon afterwards enabled, by his success on the small scale, to set up in his native city a magnificent distillery, which excited the admiration of all the practical chemists of that day. In November, 1805, he obtained a certificate of certain improvements for extracting from wine, at one process, the whole of its alcohol. Adam was so overjoyed, after making his first experiments, that he ran about the streets of Montpellier, telling everybody of the surprising results of his invention. Several competitors soon entered the lists with him, especially Solimani, professor of chemistry in that city, and Isaac

* The treatises of Le Normand and Dubrunfaut may also be consulted. The French stills are in general so much complicated with a great many small pipes and passages, as to be unfit for distilling the glutinous wash of grains.

Berard, distiller in the department of Gard; who, having contrived other forms of continuous stills, divided the profits with the first inventor.

The principles of spirituous distillation may be stated as follows:—The boiling point of alcohol varies with its density or strength, in conformity with the numbers in the following table:—

Specific gravity.	Boiling point, by Fahrenheit's scale.	Specific gravity.	Boiling point, by Fahrenheit's scale.
0·7939	168·5°	0·8875	181·0°
0·8034	168·0	0·8631	183·0
0·8118	168·5	0·8765	187·0
0·8194	169·0	0·8892	190·0
0·8265	172·5	0·9013	194·0
0·8332	173·5	0·9126	197·0
0·8397	175·0	0·9234	199·0
0·8458	177·0	0·9335	201·0
0·8518	179·0		

See also the table under Alcohol, page 22.

Hence, the lower the temperature of the spirituous vapor which enters the refrigeratory apparatus, the stronger and purer will the condensed spirit be; because the offensive oils, which are present in the wash or wine, are less volatile than alcohol, and are brought over chiefly with the aqueous vapor. A perfect still should, therefore, consist of three distinct members; first, the cucurbit, or kettle; second, the rectifier, for intercepting more or less of the watery and oily particles; and third, the refrigerator, or condenser of the alcoholic vapors.

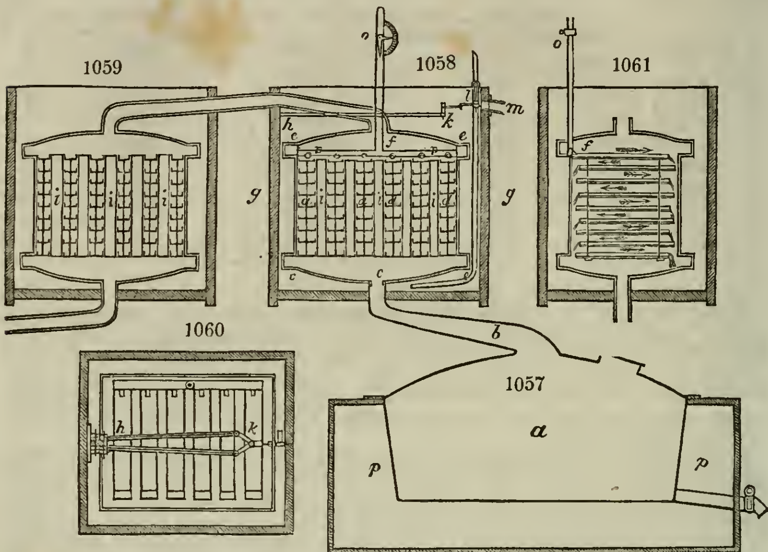
These principles are illustrated in the construction of the still represented in *figs.* 1057, 1058, 1059, 1060, 1061; in which the resources of the most refined French stills are combined with a simplicity and solidity suited to the grain distilleries of the United Kingdom. Three principal objects are obtained by the arrangement here shown; first, the extraction from fermented wort or wine, at one operation, of a spirit of any desired cleanness and strength; second, great economy of time, labor, and fuel; third, freedom from all danger of blowing up or boiling over, by mismanaged firing. When a combination of water, alcohol, and essential oil, in the state of vapor, is passed upwards through a series of winding passages, maintained at a determinate degree of heat, between 170° and 180°, the alcohol alone, in any notable proportion, will retain the elastic form, and will proceed onwards into the refrigeratory tube, in which the said passages terminate; while the water and the oil will be in a great measure condensed, arrested, and thrown back into the body of the still, to be discharged with the effete residuum.

The system of passages or channels, represented in *fig.* 1058, is so contrived as to bring the mingled vapors which rise from the alembic *a*, into ample and intimate contact with metallic surfaces, maintained, in a water-bath, at a temperature self-regulated by a heat-governor. See Thermostat.

The neck of the alembic tapers upwards, as shown at *b*, *fig.* 1057; and at *c*, *fig.* 1058, it enters the bottom, or ingress vestibule, of the rectifier *c*, *f*. *f* is its top or egress vestibule, which communicates with the bottom one by parallel cases or rectangular channels *d*, *d*, *d*, of which the width is small, compared with the length and height. These cases are open at top and bottom, where they are soldered or riveted into a general frame within the cavity, enclosed by the two covers *f*, *c*, which are secured round their edges *e*, *e*, *e*, *e*, with bolts and packing. Each case is occupied with a numerous series of shelves or trays, placed at small distances over each other, in a horizontal or slightly inclined position, of which a side view is given in *fig.* 1059, and cross sections at *d*, *d*, *d*, *fig.* 1058. Each shelf is turned up a little at the two edges, and at one end, but sloped down at the other end, that the liquor admitted at the top may be made to flow slowly backwards and forwards in its descent through the system of shelves or trays, as indicated by the darts and spouts in *fig.* 1059. The shelves of each case are framed together by two or more vertical metallic rods, which pass down through them, and are fixed to each shelf by solder, or by screw-nuts. By this means, if the cover *f*, be removed, the sets of shelves may be readily lifted out of the cases and cleaned; for which reason they are called *moveable*.

The intervals *i*, *i*, *i*, *fig.* 1058, between the cases, are left for the free circulation of the water contained in the bath-vessel *g*, *g*; these intervals being considerably narrower than the cases.

Fig. 1060 represents in plan the surface of the rectifying cistern, shown in two different sections in *figs.* 1058 and 1059. *h*, *k*, *figs.* 1058 and 1060, is the heat-governor, shaped somewhat like a pair of tongs. Each leg is a compound bar, consisting of a flat bar or ruler of steel, and one of brass alloy, riveted facewise together, having their edges up and down. The links, at *k*, are joined to the free ends of these compound bars, which, receding by increase and approaching by decrease of temperature, act by a lever on



the stopcock *l*, fixed to the pipe of a cold-water back, and are so adjusted by a screw-nut, that whenever the water in the bath vessel *g*, *g*, rises above the desired temperature, cold water will be admitted, through the stopcock *l*, and pipe *n*, into the bottom of the cistern, and will displace the over-heated water by the overflow-pipe *m*. Thus a perfect equilibrium of caloric may be maintained, and alcoholic vapor of correspondent uniformity transmitted to the refrigeratory.

Fig. 1061 is the cold condenser, of similar construction to the rectifier, *fig.* 1058; only the water cells should be here larger in proportion to the vapor channels *d*, *d*. This refrigeratory system will be found very powerful, and it presents the great advantage of permitting its interior to be readily inspected and cleansed. It is best made of laminated tin, hardened with a little copper alloy.

The mode of working the preceding apparatus will be understood by the following instructions. Into the alembic, *a*, let as much fermented liquor be admitted as will protect its bottom from being injured by the fire, reserving the main body in the charging-back. Whenever the ebullition in the alembic has raised the temperature of the water-bath *g*, *g*, to the desired pitch, whether that be 170°, 175°, or 180°, the thermostatic instrument is to be adjusted by its screw-nut, and then the communication with the charging-back is to be opened by moving the index of the stopcock *o*, over a proper portion of its quadrantal arch. The wash will now descend in a slender equable stream, through the pipe *o*, *f*, thence spread into the horizontal tube *p*, *p*, and issue from the orifices of distribution, as seen in the figure, into the respective flat trays or spouts. The manner of its progress is seen for one set of trays, in *fig.* 1059. The direction of the stream in each shelf is evidently the reverse of that in the shelf above and below it; the turned-up end of one shelf corresponding to the discharge slope of its neighbor.

By diffusing the cool wash or wine in a thin film over such an ample range of surfaces, the constant tendency of the bath to exceed the proper limit of temperature is counteracted to the utmost, without waste of time or fuel; for the wash itself, *in transitu*, becomes boiling-hot, and experiences a powerful steam distillation. By this arrangement a very moderate influx of cold water, through the thermostatic stopcock, suffices to temper the bath; such an extensive vaporization of the wash producing a far more powerful refrigerant influence than its simple heating to ebullition. It deserves to be remarked, that the maximum distillatory effect, or the bringing over the greatest quantity of pure spirits in the least time, and with the least labor and fuel, is here accomplished without the least steam pressure in the alembic; for the passages are all pervious to the vapor; whereas, in almost every wash-still heretofore contrived for similar purposes, the spirituous vapors must force their way through successive layers of liquid, the total pressure produced by which causes undue elevation of temperature, and obstruction to the process. Whatever supplementary refrigeration of the vapors in their passage through the bath may be deemed proper, will be administered by the thermostatic regulator.

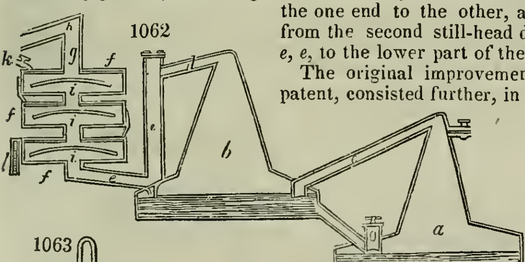
Towards the end of the process, after all the wash has entered the alembic, it may be sometimes desirable, for the sake of despatch, to modify the thermostat, by its adjusting-screw, so that the bath may take a higher temperature, and allow the residuary feints to run rapidly over, into a separate cistern. This weak fluid may be pumped back into the alembic, as the preliminary charge of a fresh operation.

The above plan of a water-bath regulated by the thermostat, may be used simply as a rectifying cistern, without transmitting the spirit or wash down through it. The series of shelves will cause the vapors from the still to impinge against a most extensive system of metallic surfaces, maintained at a steady temperature, whereby their watery and crude constituents will be condensed and thrown back, while their fine alcoholic particles will proceed forwards to the refrigeratory. Any ordinary still may be readily converted into this self-rectifying form, by merely interposing the cistern, *fig.* 1058, between the alembic and the worm-tub. The leading novelty of the present invention is the *moveable* system of shelves or trays, enclosed in metallic cases, separated by water, combined with the thermostatic regulator. By this combination, any quality of spirits may be procured at one step from wash or wine, by an apparatus, simple, strong, and easily kept in order.

The empyreumatic taint which spirits are apt to contract from the action of the naked fire on the bottom of the still, may be entirely prevented by the use of a bath of potash ley, *p*, *p*, *fig.* 1057; for thus a safe and effectual range of temperature, of 300° F., may be conveniently obtained. The still may also be used without the bath vessel.

Mr. D. T. Shears, of Southwark, obtained a patent in March, 1830, for certain improvements and additions to stills, which are ingenious. They are founded upon a previous patent, granted to Joseph Corty, in 1818; a section of whose contrivance is shown in *fig.* 1062, consisting of a first still *a*, a second still *b*, a connecting tube *c*, from the one end to the other, and the tube *d*, which leads from the second still-head down through the bent tube *e*, *e*, to the lower part of the condensing apparatus.

1062



The original improvements described under Corty's patent, consisted further, in placing boxes *f*, *f*, *f*, of the condensing apparatus in horizontal positions, and at a distance from each other, in order that the vapor might ascend through them, for the purpose of discharging the spirit by the top tube *g*, and pipe *h*, into the worm, in a highly rectified or concentrated state. In each of the boxes *f*, there is a convex plate or inverted dish *i*, *i*, *i*, and the vapor in rising from the tube *e*, strikes against the concave or under part of the first dish, and then escapes round its edges, and over its convex surface, to the under part of the second dish, and so on to the top, the condensed part of the vapor flowing down again into the still, and the spirit passing off by the pipe *h*, at top; and as the process of condensation will be assisted by cooling the vapor as it rises, cold water is made to flow over the tops of the boxes *f*, from a cock *k*, and through small channels or tubes on the sides of the boxes, and is ultimately discharged by the pipe *l*, at bottom.

1063

1064

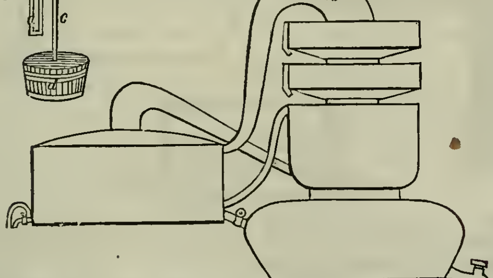


Fig. 1063 represents a peculiarly shaped tube *a*, through which the spirit is described as passing after leaving the end of the worm at *b*, which tube is open to the atmospheric air at z; c, is the passage through which the carbonic acid gas is described as escaping into the vessel of water d.

Now the improvements claimed under the present patent, are exhibited in *figs*. 1064, 1065, and 1066. *Fig*. 1064 represents the external appearance of a still, the head of which is made very capacious, to guard against over-boiling by any mismanagement of the fire; *fig*. 1065 is the same, partly in section. On the top of the still-head is formed the first-described rectifying apparatus, or series of condensing boxes. The vapor from the body of the still filling the head, meets with the first check from the dish or lower vessel i, and after passing under its edges, ascends and strikes against the lower part of the second dish or vessel i, and so on, till it ultimately leaves the still-head by the pipe at top.

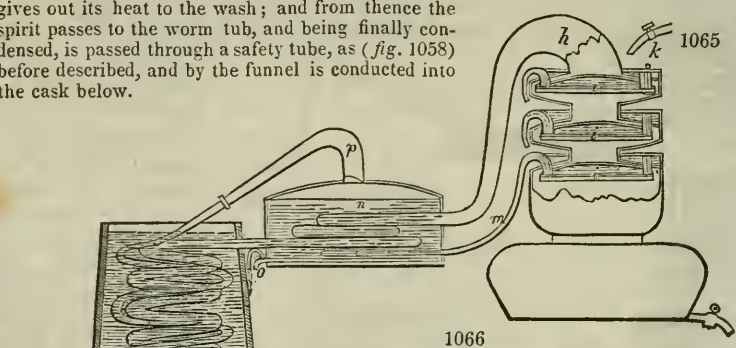
This part of the apparatus is slightly altered from the former, by the substitution of hollow convex vessels, instead of the inverted dishes before described, which vessels have rims descending from their under surfaces, for the purpose of retaining the vapor. The cold water, which, as above described, flowed over the tops of the boxes f, for the purpose of cooling them, now flows also through the hollow convex vessels i, within the boxes, and by that means greatly assists the refrigerating process, by which the aqueous parts of the vapor are more readily condensed, and made to fall down and flow back again into the body of the still, while the spirituous parts pass off at top to the worm, in a very high state of rectification.

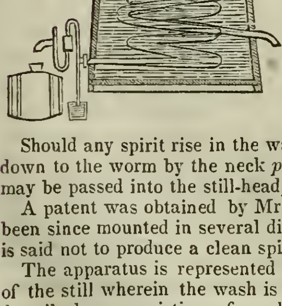
After the water employed for the refrigeration has passed over all the boxes, and through all the vessels, it is carried off by the pipe m, through the vessel n, called the wash-heater; that is, the vessel in which the wash is placed previous to introducing it into the still. The pipe m, is coiled round in the lower part of the vessel n, in order that the heated water may communicate its caloric to the wash, instead of losing the heat by allowing the water to flow away. After the heated water has made several turns round the wash heater, it passes out at the curved pipe o, which is bent up, in order to keep the coils of the pipe within always full of water.

Instead of the coiled pipe n, last described, the patentee proposes sometimes to pass the hot water into a chamber in a tub or wooden vessel, as at n, in *fig*. 1061, in which the wash to be heated occupies the upper part of the vessel, and is separated from the lower part by a thin metallic partition.

The swan-neck h, *figs*. 1064 and 1065, which leads from the head of the still, conducts the spirit from the still through the wash-heater, where it becomes partially cooled, and gives out its heat to the wash; and from thence the spirit passes to the worm tub, and being finally condensed, is passed through a safety tube, as (*fig*. 1058) before described, and by the funnel is conducted into the cask below.

1065





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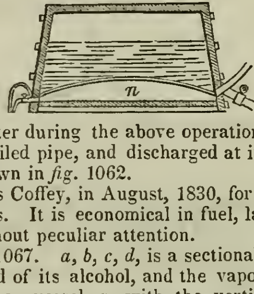

Should any spirit rise in the wash-heater during the above operation, it will be carried down to the worm by the neck p, and coiled pipe, and discharged at its lower end; or it may be passed into the still-head, as shown in *fig*. 1062.

A patent was obtained by Mr. Æneas Coffey, in August, 1830, for a still, which has been since mounted in several distilleries. It is economical in fuel, labor, and time, but is said not to produce a clean spirit, without peculiar attention.

The apparatus is represented in *fig*. 1067. a, b, c, d, is a sectional view of that part of the still wherein the wash is deprived of its alcohol, and the vapors analyzed. It is described as consisting of a chamber or vessel a, with the vertical chamber b, c, placed above it; the lower half of this chamber is divided into compartments by horizontal plates *e*, *e*, *e*, of thin copper or other metal; each of these plates is turned down at one side, until it nearly touches the plate next underneath it, as shown in the figure; thus

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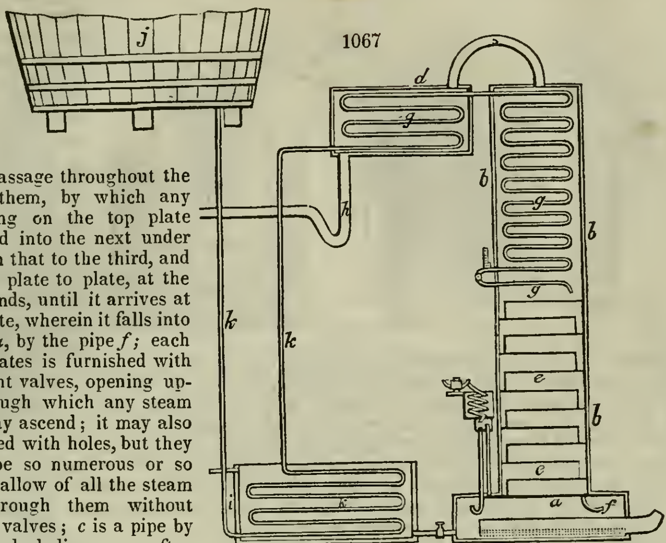

leaving a passage throughout the whole of them, by which any liquid falling on the top plate may descend into the next under it, and from that to the third, and so on, from plate to plate, at the alternate ends, until it arrives at the last plate, wherein it falls into the vessel *a*, by the pipe *f*; each of these plates is furnished with several light valves, opening upwards, through which any steam or vapor may ascend; it may also be perforated with holes, but they must not be so numerous or so large as to allow of all the steam passing through them without raising the valves; *c* is a pipe by which the alcoholic vapor, after it has been analyzed, and has acquired the proper strength, is conducted into the vessel *d*, which is made perfectly close; the vapor will here be condensed on the surface of the pipe *g*, *g*, *g*; from this chamber it will descend in a liquid state into the pipe *h*, whence it may be conducted to a worm or refrigerator, to be cooled in the ordinary way; *i* is a vessel through which the spent wash flows, after being operated upon in the distilling apparatus, and is discharged in a state of ebullition; *j* is a vessel or chamber containing the wash to be distilled. A force pump may be substituted, to force the wash through the pipes *k*, and distilling apparatus, with the velocity required.

The patentee states that it is requisite the wash should be passed through the pipe *k* with sufficient velocity and force, so as to prevent the deposition of sediment in the pipe; the wash, in its passage through the pipe *k*, will gradually become increased in temperature as it passes through the spent wash in the chamber, and the close vessel *d*, until it is discharged nearly at the boiling point on the upper plate in the chamber, where it comes in contact with the vapors arising from the vessel *a*.

It is to be observed that the wort does not reach the boiling point while in the pipe *k*, *k*; to ascertain which, a thermometer is placed on the pipe, and by increasing or diminishing the quantity of wash, its temperature may be regulated. The wash, after being discharged from the pipe *k*, descends from plate to plate as before mentioned, at which time a supply of steam from a boiler, or generator, is admitted into the apparatus, through the pipe.

The lower part of this pipe in the vessel *a* is pierced with a number of small holes, so as to spread the steam over the vessel; it then rises upwards, passing through the plate by the small holes and valves, and through the stratum or sheet of wash flowing over them; the wash, as it descends, gives out a portion of its alcohol to the steam, as it passes over every plate, until it is entirely deprived of its spirit, which it will generally do by the time it arrives at the 7th or 8th plate; but it is better to employ a greater number, to guard against accidents or neglect.

A small steam pipe rises from the chamber *a*, with its upper end opening into the box or chamber; into this chamber the end of a worm projects from the cistern of cold water; the steam rising up the pipe is nearly all condensed in the worm, and flows back into the chamber *a*, by the pipe. The small portion of the steam uncondensed is allowed to escape at the upper end of the worm, and the flame of a small lamp or taper is to be constantly kept over the orifice; when, should the least quantity of alcohol descend with the wash into the chamber *a*, it will rise with the steam through the pipe and worm, and immediately take fire from the flame of the lamp or taper, thereby warning the attendant to increase the supply of steam or diminish the quantity of wash, as may seem necessary.

I shall conclude this article with a description of the cheap still which is commonly employed by the chemists in Berlin for rectifying alcohol. *a* is the ash-pit; *b*, the fire-place; *c*, *c*, the flues, which go spirally round the sides of the cucurbit *d*; *e*, the capital, made of block tin, and furnished with a brass edge, which fits tight to a corresponding edge on the mouth of *d*; *f*, *f*, the slanting pipes of the capital; *g*, the oval refrigeratory, made of copper; *h*, the water-gauge glass tube; *i*, a stop-cock for emptying the vessel; *k*, ditto for drawing off the hot water from the surface; *l*, tube for the supply of cold water. A double cylinder of tin is placed in the refrigeratory, of which the outer one, *m*, *m*, stands upon three feet, and is furnished with a discharge pipe *n*. The inner one, *o*, *o*, which is open above, receives cold water through the pipe *p*, and lets the warm water flow off through the short tube *q* into the refrigeratory. In the narrow space between the two cylinders, the vapors proceeding from the capital are condensed, and pass off in the liquid state through *n*. The refrigeratory is made oval, in order to receive two condensers alongside of each other in the line of the longer axis; though only one, and that in the middle, is represented in the figure.

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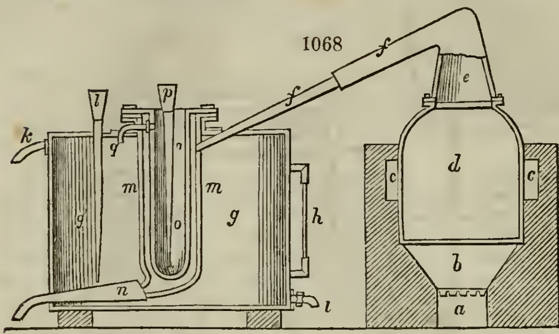
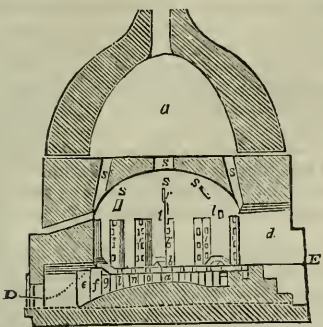


STOCKING MANUFACTURE. See Hosiery.

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, if compared with the date of those erected in ancient Italy, Greece, and Egypt. This is remarkably the case with the three bridges of London, Westminster, and Blackfriars; the foundations of which began to perish most visibly in the very lifetime of their constructors. Every stone intended for a durable edifice, ought to be tested as to its durability, by immersion in a saturated solution of sulphate of soda, and exposure during some days to the air. The crystallization which ensues in its interior, will cause the same disintegration of its substance which frost would occasion in a series of years.

STONE, ARTIFICIAL, for statuary and other decorations of architecture, has been made for several years with singular success at Berlin, by Mr. Feilner. His materials are nearly the same with those of English pottery; and the plastic mass is fashioned either in moulds or by hand. His kilns, which are peculiar in form, and economical in fuel, deserve to be generally known. *Figs.* 1069 and 1070 represent his round kiln; *fig.* 1069 being an oblique section in the line A, B, C, of *fig.* 1070, which is a ground plan in the line D, *a*, *b*, E, of *fig.* 1069. 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 tops, the flame may be directed inwards and downwards; *s* are the vents for carrying off the

1069



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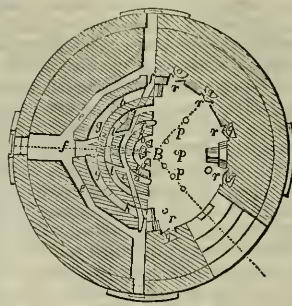
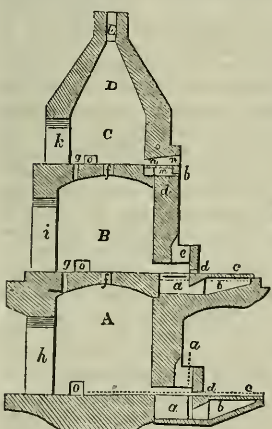


flames into the upper space *u*, which is usually left empty. These vents can be closed by iron damper-plates, pushed in through the side-slits of the dome. *t, t*, are peep-holes, for observing the state of ignition in the furnace; but they are most commonly bricked up. *Fig.* 1071 is a vertical section, and *fig.* 1072, a plan of an excellent kiln for baking clay to a stony consistence, for the above purpose, or for burning of bricks. A, is the lower; B, the middle; C, the upper kiln; and E, the hood, terminating in the chimney; *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 fire-places; *h, i, k*, are apertures for introducing the articles to be baked; *l*, a grate for the fire in the uppermost kiln; *m*, the ash-pit; *n*, the fire-door; o, openings through which the flames of a second fire are thrown in. At first, only the ground kiln A, is fired, with cleft billets of pine-wood, introduced at the opening *e;* when this is finished, the second is fired; and then the third, in like manner. This kiln is very like the porcelain kiln of Sèvres, and is employed in many places for baking stoneware.

1071



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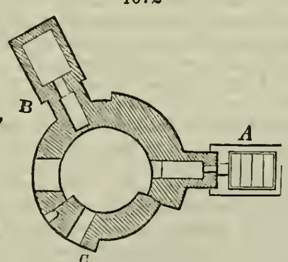


Mr. Keene obtained a patent, about a year ago, for making a factitious stone-paste in the following way:—He dissolves one pound of alum in a gallon of water, and in this solution he soaks eighty-four pounds of gypsum calcined in small lumps. He exposes these lumps in the open air for about eight days, till they become apparently dry, and then calcines them in an oven at a dull-red heat. The waste heat of a coke oven is well adapted for this purpose. (See PITCOAL, COKING OF.) These lumps being ground and sifted, afford a fine powder, which, when made up into a paste with the proper quantity of water, forms the petrifying ground. The mass soon concretes, and after being brushed over with a thin layer of the petrifying paste, may be polished with pumice, &c., in the usual way. It then affords a body of great compactness and durability. If half a pound of copperas be added to the solution of the alum, the gypsum paste, treated as above, has a fine cream or yellow color. This stone stands the weather well.

STONEWARE. (*Fayence*, Fr.; *Steingut*, Germ.) See POTTERY.

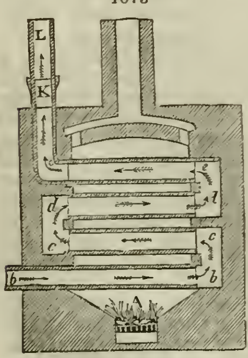
STORAX, STYRAX, flows from the twigs and the trunk of the *Liquidamber styraciflua*, a tree which grows in Louisiana, Virginia, and Mexico. Liquidamber, as this resin is also called, is a brown or ash-gray substance, of the consistence of turpentine, which dries up rapidly, has an agreeable smell, like benzoin, and a bitterish, sharp, burning taste. It dissolves in four parts of alcohol, and affords 1·4 per cent. of benzoic acid.

STOVE (*Poële, Calorifère*, Fr.; *Ofen*, Germ.), is a fire-place, more or less close, for warming apartments. When it allows the burning coals to be seen, it is called a stove-grate. Hitherto stoves have rarely been had recourse to in this country for heating our sitting-rooms; the cheerful blaze and ventilation of an open fire being generally preferred. But last winter, by its inclemency, gave birth to a vast multitude of projects for increasing warmth and economizing fuel, many of them eminently insalubrious, by preventing due renewal of the air, and by the introduction of noxious fumes into it. When coke is burned very slowly in an iron box, the carbonic acid gas which is generated, being half as heavy again as the atmospherical air, cannot ascend in the chimney at the temperature of 300° F.; but regurgitates into the apartment through every pore of the stove, 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 fire-place and ash-pit immediately above the hearth-stone.

I have recently performed some careful experiments upon this subject, and find that when the fuel is burning so slowly in the stove 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 subacetate 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° F., and burned briskly under it three and a half pounds of coke in an hour; at the end of which time, four and a half pounds of water were boiled off. On burning the same weight of coke *slowly* in the same furnace, mounted by the same pan, in the course of twelve hours, little more than one half the quantity of water was exhaled. Yet, in the first case, the aerial products of combustion swept so rapidly over the bottom of the pan, as to communicate to it not more than one fourth of the effective heat which might have been obtained by one of the plans described in the article EVAPORATION; while in the second case, these products moved at least twelve 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.

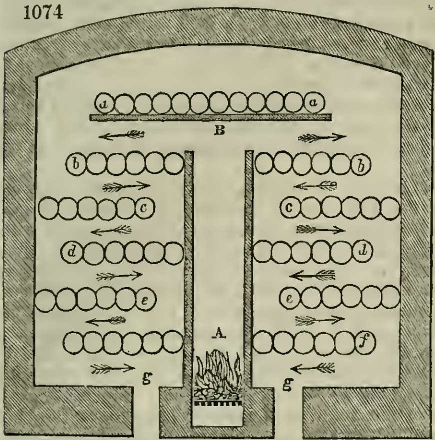
1073



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.* 1073 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. 1074 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 gas-light retorts. It is known, that two thirds of the fuel have been saved in the gas-works by this distribution of the furnace. For the purpose of heating apartments, the great object is to supply a vast body of genial air; and, therefore, merely such a moderate fire should be kept up in A, as will suffice to warm all the pipes pretty equably to the temperature of 220° Fahr.; and, indeed, as they are laid with a slight slope, are open to the air at their under ends, and terminate at the upper in a common main pipe or tunnel, they can hardly be rendered very hot by any intemperance of firing. I can safely recommend this stove to my readers. If the tubes be made of stoneware, its construction will cost very little; and they may be made of any size, and multiplied so as to carry off the whole effective heat of the fuel, leaving merely so much of it in the burned air, as to waft it fairly up the chimney.

1074



I shall conclude this article by a short extract of a paper which was read before the Royal Society, on the 16th of June, 1836, *upon warming and ventilating apartments;* a subject to which my mind had been particularly turned at that time, by the Directors of the Customs Fund of Life Assurance, on account of the very general state of indisposition and disease prevailing among those of their officers (nearly 100 in number) engaged on duty in the Long Room of the Custom House, London.

"The symptoms of disorder experienced by the several gentlemen (about twenty in number) whom I examined, out of a great many who were indisposed, were of a very uniform character. The following is the result of my researches:—

"A sense of tension or fulness of the head, with occasional flushings of the countenance, throbbing of the temples, and vertigo, followed, not unfrequently, with a 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 Examiner's Room, undergoes no such mollification, and comes forth at once in an ardent blast of fully 170°; not unlike the simoom of the desert, as described by travellers. Had a similar nuisance, on the greater scale, existed in the Long Room, it could not have been endured by the merchants and other visiters 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 flavor 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 in depth of water from a cistern in the course of twenty-four hours; and its influence on the cutaneous exhalants must be proportionably great.

"As cast iron always contains, besides the metal itself, more or less carbon, sulphur, phosphorus, or even arsenic, it is possible that the smell of air passed over it in an incandescent state, may be owing to some of these impregnations; for a quantity of noxious effluvia, inappreciably small, is capable of affecting not only the olfactory nerves, but the pulmonary organs. I endeavored to test the air as it issued from the valve in the Examiner's Room, by presenting to it pieces of white paper moistened with a solution of nitrate of silver, and perceived a slight darkening to take place, as if by sulphurous fumes. White paper, moistened with sulphureted hydrogen water, was not in the least discolored. The faint impression on the first test paper, may be, probably, ascribed to sulphurous fumes, proceeding from the ignition of the myriads of animal and vegetable matters which constantly float in the atmosphere, as may be seen in the sunbeam admitted into a dark chamber: to this cause, likewise, the offensive smell of air, transmitted over red-hot iron, may in some measure be attributed, as well as to the hydrogen resulting from the decomposition of aqueous vapor, always present in our atmosphere in abundance; especially close to the banks of the Thames, below London Bridge.

"When a column of air sweeps furiously across the burning deserts of Africa and Arabia, constituting the phenomenon called simoom by the natives, the air becomes not only very hot and dry, but highly electrical, as is evinced by lightning and thunder. Dry sands, devoid of vegetation, cannot be conceived to communicate any noxious gas or vapor to the atmosphere, like the malaria of marshes, called miasmata; it is, hence, highly probable that the blast of the simoom owes its deadly malignity, in reference to animal as well as vegetable life, simply to extreme heat, dryness, and electrical disturbance. Similar conditions, though on a smaller scale, exist in what is called the bell, or cockle, apparatus for heating the Long Room and the Examiner's apartment in the Custom-house. It consists of a series of inverted, hollow, flattened pyramids of cast iron, with an oblong base, rather small in their dimensions, to do their work sufficiently in cold weather, when moderately heated. The inside of the pyramids is exposed to the flames of coke furnaces, which heat them frequently to incandescence, while currents of cold air are directed to their exterior surfaces by numerous sheet-iron channels. The incandescence of these pyramids, or bells, as they are vulgarly called, was proved by pieces of paper taking fire when I laid them on the summits. Again, since air becomes electrical when it is rapidly blown upon the surfaces of certain bodies, it occurred to me that the air which escapes into the Examiner's Room might be in this predicament. It certainly excites the sensation of a cobweb playing round the head, which is well known to all who are familiar with electrical machines. To determine this point, I presented a condensing gold-leaf electrometer to the said current of hot air, and obtained faint divergence with negative electricity. The electricity must be impaired in its tension, however, in consequence of the air escaping through an iron grating, and striking against the flat iron valves, both of which tend to restore the electric equilibrium. The air blast, moreover, by being diffused round the glass of the condenser apparatus, would somewhat mask the appearances. Were it worth while, an apparatus might be readily constructed for determining this point, without any such sources of fallacy. The influence of an atmosphere charged with electricity in exciting headache and confusion of thought in many persons, is universally known.

"The fetid burned odor of the stove air, and its excessive avidity for moisture, are of themselves, however, sufficient causes of the general indisposition produced among the gentlemen who are permanently exposed to it in the discharge of their public duties.

"From there being nearly a vacuum, as to aqueous vapor, in the said air, while there is nearly a plenum in the external atmosphere round about the Custom-house, the vicissitudes of feeling in those who have occasion to go out and in frequently, must be highly detrimental to health. The permanent action of an artificial desiccated air on the animal economy may be stated as follows :—

"The living body is continually emitting a transpirable matter, the quantity of which, in a grown up man, will depend partly on the activity of the cutaneous exhalants, and partly on the relative dryness or moisture of the circumambient medium. Its average amount, in common circumstances, has been estimated at 20 ounces in twenty-four hours.

"When plunged in a very dry air, the insensible perspiration will be increased; and, as it is a true evaporation or gasefaction, it will generate cold proportionably to its amount. Those parts of the body which are most insulated in the air, and furthest from the heart, such as the extremities, will feel this refrigerating influence most powerfully. Hence the coldness of the hands and feet, so generally felt by the inmates of the apartment, though its temperature be at or above 60°. The brain, being screened by the scull from this evaporating influence, will remain relatively hot, and will get surcharged, besides, with the fluids which are repelled from the extremities by the condensation, or contraction, of the blood-vessels, caused by cold. Hence the affections of the head, such as tension, and its dangerous consequences. If sensible perspiration happen, from debility, to break forth from a system previously relaxed, and plunged into dry air, so attractive of vapor, it will be of the kind called a cold clammy sweat on the sides and back, as experienced by many inmates of the Long Room.

"Such, in my humble apprehension, is a rationale of the phenomena observed at the Custom-house. Similar effects have resulted from hot-air stoves of a similar kind in many other situations.

"After the most mature physical and medical investigation, I am of opinion that the circumstances above specified cannot act permanently upon human beings, without impairing their constitutions, and reducing the value of their lives. The Directors of the Customs Fund are therefore justified in their apprehensions, 'that the mode of heating the Long Room is injurious to the health of persons employed therein, and that it must unduly shorten the duration of life.'

"It may be admitted, as a general principle, that the comfort of sedentary individuals, occupying large apartments during the winter months, cannot be adequately secured by the mere influx of hot air from separate stove rooms: it requires the genial influence of radiating surfaces in the apartments themselves, such as of open fires, of pipes, or other vessels filled with hot water or steam. The clothing of our bodies, exposed to such radiation in a pure, fresh, somewhat cool and bracing air, absorbs a much more agreeable warmth than it could acquire by being merely immersed in an atmosphere heated even to 62° Fahr., like that of the Long Room. In the former predicament, the lungs are supplied with a relatively dense air, say at 52° Fahr.; while the external surface of the body or the clothing is maintained at, perhaps, 70° or 75°. This distinctive circumstance has not, I believe, been hitherto duly considered by the stove doctors, each intent on puffing his own pecuniary interest; but it is obviously one of great importance, and which the English people would do well to keep in view; because it is owing to our domestic apartments being heated by open fires, and our factories by steam pipes, that the health of our population, and the expectation of life among all orders in this country, are so much better than in France and Germany, where hot-air stoves, neither agreeable nor inoffensive, and in endless variety of form, are generally employed.

"In conclusion, I take leave to state to you my firm conviction that the only method of warming your Long Room and subsidiary apartments, combining salubrity, safety, and economy, with convenience in erection and durable comfort in use, is by a series of steam pipes laid along the floor, at the line of the desk partitions, in suitable lengths, with small arched junction-pipes rising over the several doorways, to keep the passages clear, and at the same time to allow a free expansion and contraction in the pipes, thereby providing for the permanent soundness of the joints."

It would not be difficult to construct a stove or stove-grate which should combine economy and comfort of warming an apartment, with briskness of combustion and durability of the fire, without any noxious deflux of carbonic acid. See Chimney.

STRASS; see Pastes.

STRAW-HAT MANUFACTURE. The mode of preparing the Tuscany or Italian straw, is by pulling the bearded wheat while the ear is in a soft milky state, the corn having been sown very close, and of consequence produced in a thin, short, and dwindled condition. The straw, with its ears and roots, is spread out thinly upon the ground in fine hot weather, for three or four 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 color, and then to a fumigation of sulphur, to complete the bleaching, the straws are in a condition to be platted or woven into hats and bonnets, and are in that state imported into England in bundles, the dried ears of the wheat being still on the straw.

Straw may be easily bleached by a solution of chloride of lime, and also by sulphuring. For the latter purpose, a cask open at both ends, with its seams papered, is to be set upright a few inches from the ground, having a hoop nailed to its inside, about six inches beneath the top, to support another hoop with a net stretched across it, upon which the straw is to be laid in successive handfuls loosely crossing each other. The cask having been covered with a tight overlapping lid, stuffed with lists of cloth, a brasier of burning charcoal is to be inserted within the bottom, and an iron dish containing pieces of brimstone is to be put upon the brasier. 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 colors, see their respective titles in this Dictionary.

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.

STRONTIA, one of the alkaline earths, of which *strontium* is the metallic basis, occurs in a crystalline state, as a carbonate, in the lead mines of Strontian in Argyleshire, whence its name. The sulphate is found crystallized near Bristol, and in several other parts of the world; but strontitic minerals are rather rare. The pure earth is prepared exactly like baryta, from either the carbonate or the sulphate. It is a grayish-white powder, infusible in the furnace, of a specific gravity approaching that of baryta, having an acrid, burning taste, but not so corrosive as baryta, though sharper than lime. It becomes hot when moistened, and slakes into a pulverulent hydrate, dissolves in 150 parts of water at 60°, and in much less at the boiling point, forming an alkaline solution called *strontia* water, which deposites crystals in four-sided tables as it cools. These contain 68 per cent. of water, are soluble in 52 parts of water at 60°, and in about 2 parts of boiling water; when heated they part with 53 parts of water, but retain the other 15 parts, even at a red heat. The dry earth consists of 84·55 of base, and 15·45 of oxygen. It is readily distinguished from baryta, by its inferior solubility, and by its soluble salts giving a red tinge to flame, while those of baryta give a yellow tinge. Fluosilicic acid and iodate of soda precipitate the salts of the latter earth, but not those of the former. The compounds of strontia are not poisonous, like those of baryta. The only preparation of strontia used in the arts is the Nitrate, which see.

STRYCHNIA is an alkaline base, extracted from the *Strychnos nux vomica*, *Strychnos ignatia*, and the *Upas tiente;* which has been employed in medicine by some of the poison doctors, but is of no use in any of the arts. When introduced into the stomach, strychnia acts with fearful energy, causing lock-jaw immediately, and the death of the animal in a very short time. Half a grain, blown into the throat of a rabbit, proves fatal in five minutes.

STUCCO. See GYPSUM.

SUBERIC ACID, is prepared by digesting grated cork with nitric acid. It forms crystals, which sublime in white vapors when heated.

SUBLIMATE, is any solid matter resulting from condensed vapors, and,

SUBLIMATION, is the process by which the volatile particles are raised by heat, and condensed into a crystalline mass. See CALOMEL and SAL-AMMONIAC, for examples.

SUBSALT, is a salt in which the base is not saturated with acid; as subacetate of lead.

SUCCINIC ACID, *Acid of amber* (*Acide succinique*, Fr.; *Bernsteinsaüre*, Germ.), is obtained by distilling coarsely pounded amber in a retort by itself, with a heat gradually raised; or mixed with one twelfth of its weight of sulphuric acid, diluted with half its weight of water. The acid which sublimes is to be dissolved in hot water, to be saturated with potassa or soda, boiled with bone black, to remove the foul empyreumatic oily matter, filtered, and precipitated by nitrate of lead, to convert it into an insoluble succinate; which being washed, is to be decomposed by the equivalent quantity of sulphuric acid. Pure succinic acid forms transparent prisms. The succinate of ammonia is an excellent reagent for detecting and separating iron.

SUGAR (*Sucre*, Fr.; *Zucher*, Germ.), is the sweet constituent of vegetable and animal products. It may be distinguished into two principal species. The first, which occurs in the sugar-cane, the beet-root, and the maple, crystallizes in oblique four-sided prisms, terminated by two-sided summits; it has a sweetening power which may be represented by 100; and in circumpolarization it bends the luminous rays to the right. The second occurs 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 circumpolarization it bends the rays to the left. Besides these two principal kinds of sugar, some others are distinguished by chemists; as the sugar of milk, of manna, of certain mushrooms, of liquorice-root, and that obtained from saw-dust and glue by the action of sulphuric acid; but they have no importance in a manufacturing point of view.

Sugar, extracted either from the cane, the beet, or the maple, is identical in its properties and composition, when refined to the same pitch of purity; only that of the beet seems to surpass the other two in cohesive force, since larger and firmer crystals of it are obtained from a clarified solution of equal density. It contains 5·3 per cent. of combined water, which can be separated only by uniting it with oxyde of lead, into what has been called a saccharate; made by mixing sirup with finely ground litharge, and evaporating the mixture to dryness upon a steam-bath. When sugar is exposed to a heat of 400° F., it melts into a brown pasty mass, but still retains its water of composition. Sugar thus fused is no longer capable of crystallization, and is called caramel by the French. It is used for coloring liqueurs. Indeed, sugar is so susceptible of change by heat, that if a colorless solution of it be exposed for some time to the temperature of boiling water, it becomes brown and partially uncrystallizable. Acids exercise such an injurious influence upon sugar, that after remaining in contact with it for a little while, though they be rendered thoroughly neutral, a great part of the sugar will refuse to crystallize. Thus, if three parts of oxalic or tartaric acid be added to sugar in solution, no crystals of sugar can be obtained by evaporation, even though the acids be neutralized by chalk or carbonate of lime. By boiling cane sugar with dilute sulphuric acid, it is changed into starch sugar. Manufacturers of sugar should be, therefore, particularly watchful against every acidulous taint or impregnation. Nitric acid converts sugar into oxalic and malic acids. Alkaline matter is likewise most detrimental to the grain of sugar; as is always evinced by the large quantity of molasses formed, when an excess of temper lime has been used in clarifying the juice of the cane or the beet. When one piece of lump sugar is rubbed against another in the dark, a phosphorescent light is emitted.

Sugar is soluble in all proportions in water; but it takes four parts of spirits of wine, of spec. grav. 0·830, and eighty of absolute alcohol, to dissolve it, both being at a boiling temperature. As the alcohol cools, it deposites the sugar in small crystals. Caramelized and uncrystallizable sugar dissolves readily in alcohol. Pure sugar is unchangeable in the air, even when dissolved in a good deal of water, if the solution be kept covered and in the dark; but with a very small addition of gluten, the solution soon begins to ferment, whereby the sugar is decomposed into alcohol and carbonic acid, and ultimately into acetic acid.

Sugar forms chemical compounds with the salifiable bases. It dissolves readily in caustic potash ley, whereby it loses its sweet taste, and affords on evaporation a mass which is insoluble in alcohol. When the ley is neutralized by sulphuric acid, the sugar recovers its sweet taste, and may be separated from the sulphate of potash by alcohol, but it will no longer crystallize.

That sirup possesses the property of dissolving the alkaline earths, lime, magnesia, strontites, barytes, was demonstrated long ago by Mr. Ramsay of Glasgow, by experiments published in Nicholson's Journal, volume xviii. page 9, for September, 1807. He found that sirup is capable of dissolving half as much lime as it contains of sugar; and as much strontites as sugar. Magnesia dissolved in much smaller quantity, and barytes, seemed to decompose the sugar entirely. These results have been since confirmed by Professor Daniell. Mr. Ramsay characterized sugar treated with lime as weak, from its sweetening power being impaired; from its solution he obtained, after some time, a deposite of calcareous carbonate. M. Pelouze has lately shown, that the carbonic acid in this case is derived from the atmosphere, and is not formed at the expense of the elements of the sugar, as Mr. Daniell had asserted.

Sugar forms with oxyde of lead two combinations; the one soluble, the other insoluble. Oxyde of lead digested in sirup dissolves to a certain amount, forms a yellowish liquor, which possesses an alkaline reaction, and leaves after evaporation an uncrystallizable, viscid, deliquescent mass. If sirup be boiled with oxyde of lead in excess, if the solution be filtered boiling hot, and if the vial be corked in which it is received, white bulky flocks will fall to its bottom in the course of 24 hours. This compound is best dried *in vacuo.* It is in both cases light, tasteless, and insoluble in cold and boiling water; it takes fire like German tinder, (Amadou,) when touched at one point with an ignited body, and burns away, leaving small globules of lead. It dissolves in acids, and also in neutral acetate of lead, which forms with the oxyde a subsalt, and sets the sugar free. Carbonic acid gas passed through water, in which the above saccharate is diffused, decomposes it with precipitation of carbonate of lead. It consists of 58·26 parts of oxyde of lead, and 41·74 sugar, in 100 parts. From the powerful action exercised upon sugar by acids and oxyde 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 oxyde, 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 protoxyde of copper; when boiled with the nitrates of mercury and silver, or the chloride of gold, it reduces the respective bases to the metallic state.

The following Table shows the quantities of Sugar contained in Sirups of the annexed specific gravities.* It was the result of experiments carefully made.

Experimental specific gravity of solution at 60° F.	Sugar in 100, by weight.	Experimental specific 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	1·0685	16·666
1·1340	31·250	1·0500	12·500
1·1250	29·412	1·0395	10·000
1·1110	26·316		

If the decimal part of the number denoting the specific gravity of sirup be multiplied by 26, the product will denote very nearly the quantity of sugar per gallon in pounds weight, at the given specific gravity.†

Sugar has been analyzed by several chemists; the following Table exhibits some of their results:—

	Gay Lussac and Thenard.	Berzelius.	Prout.	Ure.	
Oxygen, - -	56·63	49·856	53·35	50·33	in 100.
Carbon, - - -	42·47	43·265	39·99	43·38	—
Hydrogen, - -	6·90	6·875	6·66	6·29	—

* The author, in minutes of evidence of Molasses Committee of the House of Commons, 1831, p. 142.

† This rule was annexed to an extensive table, representing the quantities of sugar per gallon corresponding to the specific gravities of the sirup, constructed by the author for the Excise, in subserviency to the Beet-root Bill.

Of the sugar cane, and the extraction of sugar from it.—Humboldt, after the most elaborate historical and botanical researches in the New World, has arrived at the conclusion that before America was discovered by the Spaniards, the inhabitants of that continent and the adjacent islands were entirely unacquainted with the sugar canes, with any of our corn plants, and with rice. The progressive diffusion of the cane has been thus traced out by the partisans of its oriental origin. From the interior of Asia it was transplanted first into Cyprus, and thence into Sicily, or possibly by the Saracens directly into the latter island, in which a large quantity of sugar was manufactured in the year 1148. Lafitau relates the donation made by William the Second, king of Sicily, to the convent of St. Benoit, of a mill for crushing sugar canes, along with all its privileges, workmen, and dependencies: which remarkable gift bears the date of 1166. According to this author, the sugar cane must have been imported into Europe at the period of the Crusades. The monk Albertus Aquensis, in the description which he has given of the processes employed at Acre and at Tripoli to extract sugar, says, that in the Holy Land, the Christian soldiers being short of provisions, had recourse to sugar canes, which they chewed for subsistence. Towards the year 1420, Dom Henry, regent of Portugal, caused the sugar cane to be imported into Madeira from Sicily. This plant succeeded perfectly in Madeira and the Canaries; and until the discovery of America these islands supplied Europe with the greater portion of the sugar which it consumed.

The cane is said by some to have passed from the Canaries into the Brazils; but by others, from the coast of Angola in Africa, where the Portuguese had a sugar colony. It was transported in 1506, from the Brazils and the Canaries, into Hispaniola or Hayti, where several crushing-mills were constructed in a short time. It would appear, moreover, from the statement of Peter Martyr, in the third book of his first Decade, written during the second expedition of Christopher Columbus, which happened between 1493 and 1495, that even at this date the cultivation of the sugar cane was widely spread in St. Domingo. It may therefore be supposed to have been introduced here by Columbus himself, at his first voyage, along with other productions of Spain and the Canaries, and that its cultivation had come into considerable activity at the period of his second expedition. Towards the middle of the 17th century, the sugar cane was imported into Barbadoes from Brazil, then into the other English West Indian possessions, into the Spanish Islands on the coast of America, into Mexico, Peru, Chile, and, last of all, into the French, Dutch, and Danish colonies.

The sugar cane, *Arundo saccharifera*, is a plant of the graminiferous family, which varies in height from 8 to 10, or even to 20 feet. Its diameter is about an inch and a half; its stem is dense, brittle, and of a green hue, which verges to yellow at the approach of maturity. It is divided by prominent annular joints of a whitish-yellow color, the plane of which is perpendicular to the axis of the stem. These joints are placed about 3 inches apart; and send forth leaves, which fall off with the ripening of the plant. The leaves are 3 or 4 feet long, flat, straight, pointed, from 1 to 2 inches in breadth, of a sea-green tint, striated in their length, alternate, embracing the stem by their base. They are marked along their edges with almost imperceptible teeth. In the 11th or 12th month of their growth, the canes push forth at their top a sprout 7 or 8 feet in height, nearly half an inch in diameter, smooth, and without joints, to which the name *arrow* is given. This is terminated by an ample panicle, about 2 feet long, divided into several knotty ramifications, composed of very numerous flowers, of a white color, apetalous, and furnished with 3 stamens, the anthers of which are a little oblong. The roots of the sugar cane are jointed and nearly cylindrical; in diameter they are about one twelfth of an inch; in their utmost length 1 foot, presenting over their surface a few short radicles.

The stem of the cane in its ripe state is heavy, very smooth, brittle, of a yellowish-violet, or whitish color, according to the variety. It is filled with a fibrous, spongy, dirty-white pith, which contains very abundant sweet juice. This juice is elaborated separately in each internodary portion, the functions of which are in this respect independent of the portions above and below. The cane may be propagated by seeds or buds with equal facility; but it is usually done by cuttings or joints of proper lengths, from 15 to 20 inches, in proportion to the nearness of the joints, which are generally taken from the tops of the canes, just below the leaves.

There are several varieties of the sugar-cane plant. The first, and longest known, is the creole, or common sugar cane, which was originally introduced at Madeira. It grows freely in every region within the tropics, on a moist soil, even at an elevation of 3000 feet above the level of the sea. In Mexico, among the mountains of Caudina-Masca, it is cultivated to a height of more than 5000 feet. The quantity and quality of sugar which it yields, is proportional to the heat of the place where it grows, provided it be not too moist and marshy.

The second variety of this plant is the 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 displays a better inflorescence, weighs a third more, affords a sixth more juice, and a fourth more sugar, than the common variety. Its main advantage, however, is to yield four crops in the same time that the creole cane yields only three. Its juice contains less feculency and mucilage, whence its sugar is more easily crystallized, and of a fairer color.

Besides these two varieties, another kind is described by Humboldt and Bonpland, under the name of the *violet* sugar-cane, for its haum and leaves are of this color. It was transported from Batavia in 1782. It flowers a month sooner than the rest, that is, in August, but it yields less solid sugar, and more liquid, both of which have a violet tint.

In saying that the cane may be propagated by seeds as well as buds, we must remark that in all the colonies of the New World, the plant flowers, indeed, but it then sends forth a shoot (*arrow*), that is, its stem elongates, and the seed-vessel proves abortive. For this reason, the bud-joints must there be used for its propagation. It grows to seed, however, in India. This circumstance occurs with some other plants, which, when propagated by their roots, cease to yield fertile seeds; such as the banana, the bread-fruit, the lily, and the tulip.

In the proper season for planting, the ground is marked out by a line into rows three or four feet asunder, in which rows the canes are planted about two 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 labor 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. Favored by the autumnal weather, the young plants become luxuriant enough to shade the ground before the dry season sets in; thereby keeping the roots cool and moderately moist. By this arrangement the creole canes are ripe for the mill in the beginning of the second year, so as to enable the manager to finish his crop early in June. There is no greater error in the colonist than planting canes at an improper season of the year, whereby his whole system of operations becomes disturbed, and, in a certain degree, abortive.

The withering and fall of a leaf afford a good criterion of the maturity of the cane-joint to which it belonged; so that the eight last leafless joints of two canes, which are cut the same day, have exactly the same age and the same ripeness, though one of the canes be 15 and the other only 10 months old. Those, however, cut towards the end of the dry season, before the rains begin to fall, produce better sugar than those cut in the rainy season, as they are then somewhat diluted with watery juice, and require more evaporation to form sugar. It may be reckoned a fair average product, when one pound of sugar is obtained from one gallon (English) of juice.

Rattoons (a word corrupted from *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 labor and expense attending the different systems. The common yielding on proper land, such as the red soil of Trelawney, in Jamaica, is 7 hogsheads, of 16 cwts. each, to 10 acres of rattoons cut annually; and such a plantation lasts from 6 to 10 years.

When the planted canes are ripe, they are cut close above the ground, by an oblique section, into lengths of 3 or 4 feet, and transported in bundles to the mill-house. If the roots be then cut off, a few inches below the surface of the soil, and covered up with fine mould, they will push forth more prolific offsets or rattoons, than when left projecting in the common way.

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.

SUGAR-CANE MILL.

Specification of, and Observations on, the Construction and Use of the best Horizontal Sugar-mill.

Fig. 1075. Front elevation of the entire mill. *Fig.* 1076. Horizontal plan. *Fig.* 1077. End elevation. *Fig.* 1078. Diagram, showing the dispositions of the feeding and delivering rollers, feeding board, returner, and delivering board.

Fig. 1075. A, A, solid foundation of masonry; B, B, bed plate; C, C, headstocks or standards; D, main shaft (seen only in *fig.* 1076); E, intermediate shaft; F, F, plummer-blocks of main shaft D (seen only in *fig.* 1076); H, driving pinion on the fly-wheel shaft of engine; I, first motion mortise wheel driven by the pinion; K, second motion pinion, on the same shaft; L, second motion mortise-wheel, on the main shaft; M, brays of wood, holding the plummer-blocks for shaft D; N, wrought-iron straps connecting the brays to the standards C, C; O, O, regulating screws for the brays; 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.* 1076); T, T, the drain gutters of the mill-bed (seen only in *fig.* 1076).

The same letters of reference are placed respectively on the same parts of the mill in each of *figs.* 1075, 1076, and 1077.

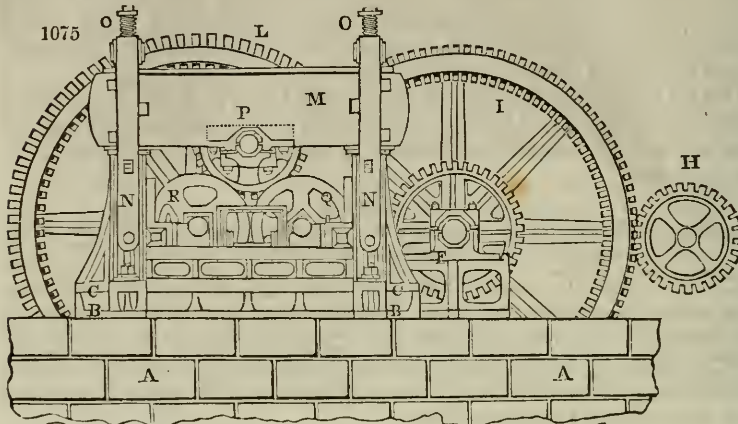
The relative disposition of the rollers is shown in the diagram, *fig.* 1078, in which A is the top roller; B, the feeding roller; C, the delivering roller; D, the returner; E, the feed board; F, the delivering board.

The rollers are made two inches and a quarter to two inches and a half thick, and ribbed in the centre. The feeding and delivering rollers have small flanges at their ends (as shown in *fig.* 1075), between which the top roller is placed; these flanges prevent the pressed canes or begass from working into the mill-bed. The feeding and top rollers are generally fluted, and sometimes diagonally, enabling them the better to seize the canes from the feed-board. It is, however, on the whole, considered better to flute the feeding roller only, leaving the top and delivering 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 begass, as well as in breaking the begass itself, and thus causing great waste.

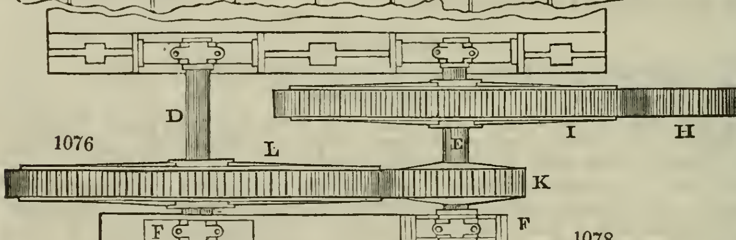
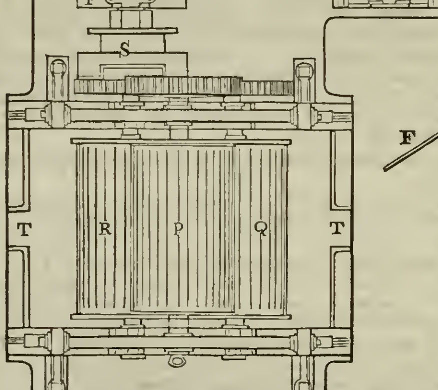
The feed board is now generally made of cast iron, and is placed at a considerable inclination, to allow the canes to slip the more easily down to the rollers. The returner is also of cast iron, serrated on the edge, to admit the free flowing of the liquor to the mill-bed. The concave returner, formerly used, was pierced with holes to drain off the liquor, but it had the serious disadvantage of the holes choking up with the splinters of the cane, and has therefore been discarded. The delivering board is of cast iron, fitted close to the roller, to detach any begass that may adhere to it, and otherwise mix with the liquor.

In Demerara, Surinam, Cayenne, and the alluvial district of Trinidad, it is usual to attach to the mill a liquor-pump, with two barrels and three adjustments of stroke. This

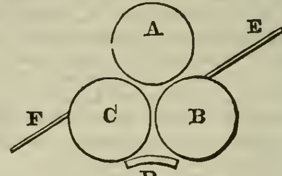
1075



1076

1078

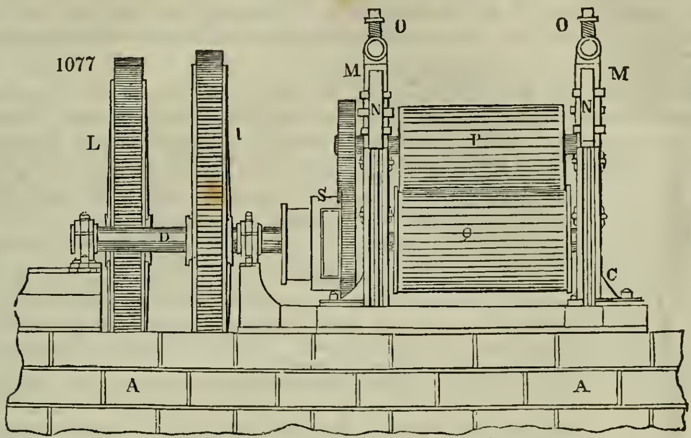


is worked from the gudgeon of the top roller. In action, the liquor from the gutter of the mill-bed runs into the cistern of the pump, and is raised by the pump to the gutter which leads to the clarifier or coppers. Such pumps have brass barrels and copper discharging pipes, are worked with a very slow motion, and require to be carefully adjusted to the quantity of liquor to be raised, which, without such precaution, is either not drawn off sufficiently quick, or is agitated with air in the barrels, and delivered to the gutter in a state of fermentation.

In working this mill, the feeding roller is kept about half an inch distant from the upper roller, but the delivering roller is placed so close to it, as to allow the begass to pass through unbroken.

The practice with this mill is to cut the sugar canes into short lengths of about three feet, and bring them to the mill tied up in small bundles; there the feeder unites them, throws them on the feed board, and spreads them so that they may cross each other as little as possible. They are taken in by the feed rollers, which split and slightly press them; the liquor flows down, and, the returner guiding the canes between the top

1077



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 begass, 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 begass-house for fuel. By an important improvement in this stage of the process, recently introduced, the begass is carried to the begass-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 labor, and in a much superior manner; the returner guides the canes to receive the last pressure more perfectly; and the begass 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 labor of feeding the vertical mill renders it nearly inapplicable to any higher power than that of about ten horses. In situations where the moving power is a windmill, or a cattle-gin, the vertical mill may be preferred.

The scale of produce of such mills varies according to the climate and soil. In Demerara, a well-constructed engine and mill will produce about 100 gallons of liquor per hour for each horse power.

The dimensions of the most approved horizontal mills are these:—

Horse-power of Engine.	Length of Rollers.		Diameter of Rollers.
	ft.	*in.*	*inches.*
8	4	0	25
10	4	6	27
12	4	8	28

The surface speed of the rollers is 3·4 or 3·6 feet per minute; and to provide for the varying resistance arising from irregular feeding, or the accidental crossing of the canes, by which the engine is often *brought up* so suddenly as to break the fly-wheel shaft, it is necessary to make both the shaft and the fly-wheel of unusual strength and weight.

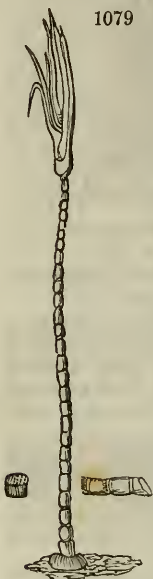
Sugar is manufactured in the East Indies by two distinct classes of persons; the *ryots*, who raise the sugar cane, extract its juice, and inspissate it to a sirupy consistence; and the *goldars*, who complete the conversion into sugar.

The *ryots* are the farmers, or actual cultivators of the soil; but, properly speaking, they are merely peasants, toiling under oppressive landlords, and miserably poor. After they cut the canes, they extract the juice by one or other of the rude mills or mortars presently to be described, and boil it down to an entire mass, which is generally called *goor*, without making any attempt to clarify it, or separate the granular sugar from the uncrystallizable molasses. This goor is of various qualities; one of which, in most common use for making sugar, is known amongst the English settlers under the name of *jaggery*. There is a caste in Ceylon, called *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.)

Several sorts of cane are cultivated in India.

The *Cadjoolee* (*fig*. 1079) is a purple-colored cane; yields a sweeter and richer juice than the yellow or light-colored, 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.

1079



The *Pooree* is a light-colored 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-colored, and grows to a great height. Its juice is more watery, and yields a weaker sugar also than the cadjoolee. However, since much of Bengal consists of low grounds, and since the upland canes are apt to suffer from drought, it deserves encouragement in certain localities.

It is only large farms that cut an acre of cane in a year; one mill, therefore, and one set of the implements used in inspissating the juice, although very rude and simple, serve for several farms, and generally belong to some wealthy man, who lets them out for hire to his poorer neighbors, the whole of whom unite to clear each other's fields by turns; so that though many people and cattle are employed at one of these miserable sets of works, very few indeed are hired, and the greater part of the labor is performed by the common stock of the farms.

The inspissated juice, or extract of cane, called by the natives *goor*, is of two kinds; one of which may be termed cake extract, and the other pot extract; both being often denominated *jaggery*, as above stated, by the English residents.

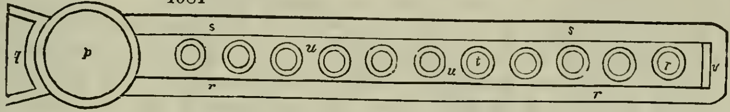
One third of an acre of good land in the southern districts, is reckoned by the farmers to produce 18,891 pounds of cane, and 1,159 pounds of pot extract. Its produce in cake extract is about 952 pounds.

1080

I shall now describe the primitive rude mill and boiler used in preparing the extract of sugar cane, and which are usually let to the ryots by the day. The mill in Dinajpur, *fig*. 1080, 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*, *a*, *a*, *a*, may be about two feet high, and a foot and a half in diameter; and in the upper end a hollow is cut, like the small segment of a sphere. In the centre of this, a channel descends a little way perpendicularly, and then obliquely to one side of the mortar, so that the juice, as squeezed from the cane, runs off, by means of a spout *b*, into a strainer *c*, through which it falls into an earthen pot, that stands in a hole *d*, under the spout. The pestle *e*, is a tree about 18 feet in length, and 1 foot in diameter, rounded at its bottom, which rubs against the mortar, and which is secured in its place by a button or knob, that goes into the channel of the mortar. The moving force is applied to a horizontal beam *f*, about 16 feet in length, which turns round about the mortar, and is fastened to it by a bent bamboo *b*. It is suspended from the upper end of the pestle by a bamboo *g*, which has been cut with part of the root, in which is formed a pivot that hangs on the upper point of the pestle. The cattle are yoked to the horizontal beam, at about ten feet from the mortar, move round it in a circle, and are driven by a man, who sits on the beam, to increase the weight of the triturating power. Scarcely any machine more miserable can be conceived; and it would be totally ineffectual, were not the cane cut into thin slices. This is a troublesome part of the operation. The grinder sits on the ground, having before him a bamboo stake, which is driven into the earth, with a deep notch formed in its upper end. He passes the canes gradually through this notch, and at the same time cuts off the slices with a kind of rude chopper.

The *boiling apparatus* is somewhat better contrived, and is placed under a shed, though the mill is without shelter. The fireplace is a considerable cavity dug in the ground, and covered with an iron boiler *p*, *fig.* 1081. At one side of this, is an opening *q*, for throwing in fuel; and opposite to this, is another opening, which communicates

1081



with the horizontal flue. This is formed by two parallel mud walls *r*, *r*, *s*, *s*, about 20 feet long, 2 feet high, and 18 inches distant from each other. A row of eleven earthen boilers *t*, is placed on these walls, and the interstices *u*, are filled with clay, which completes the furnace-flue, an opening *v*, being left at the end, for giving vent to the smoke.

The juice, as it comes from the mill, is first put into the earthen boiler that is most distant from the fire, and is gradually removed from one boiler to another, until it reaches the iron one, where the process is completed. The fireplace is manifestly on the same model as the boiler range in the West Indies, and may possibly have suggested it, since the Hindostan furnace is, no doubt, of immemorial usage. The execution of its parts is very rude and imperfect. The inspissated juice that can be prepared in 24 hours by such a mill, with 16 men and 20 oxen, amounts to no more than 476 lbs.; and it is only in the southern parts of the district, where the people work night and day, that the sugar-works are so productive. In the northern districts, the people work only during the day, and inspissate about one half the quantity of juice. The average daily make of a West India sugar-house, is from 2 to 3 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 ten cwts.; the other, about eight and a half. The latter is the segment of a sphere, nine feet diameter at the mouth; the former is larger. The boiler is sunk into a cylindrical cavity in the ground, which serves as a fireplace, so that its edge is just above the floor of the boiling-house. The fuel is thrown in by an aperture close to one side of the boiler, and the smoke escapes by a horizontal chimney that passes out on the opposite side of the hut, and has a small round aperture, about ten feet distant from the wall, in order to lessen the danger from fire. Some manufacturers have only one boiler; others as many as four; but each boiler has a separate hut, in one end of which is some spare fuel; and in the other, some bamboo stages, which support cloth strainers, that are used in the operation. This hut is about twenty-four cubits long, and ten broad; has mud walls, six cubits high; and is raised about one cubit above the ground.

For each boiler, two other houses are required: one in which the cane extract is separated by straining from the molasses, is about twenty cubits long by ten wide; another, about thirty cubits long, by eight wide, is that in which, after the extract has been strained, boiled, and clarified, the treacle is separated from the sugar by an operation analogous to claying.

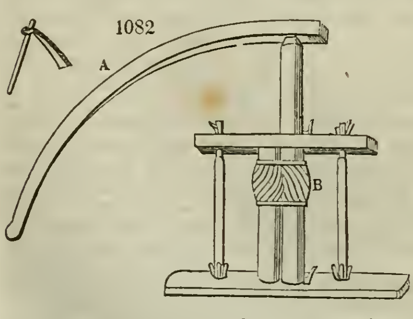
Each sugar manufacturer has a warehouse besides, of a size proportional to the number of his boilers.

About 960 pounds of pot extract being divided into four parts, each is put into a bag of coarse sackcloth, hung over an equal number of wide-mouthed earthen vessels, and is besprinkled with a little water. These drain from the bags about 240 pounds of a substance analogous to West Indian molasses. The remainder in the bags is a kind of coarse muscovado sugar; but is far from being so well drained and freed from molasses as that of the Antilles. The 720 pounds 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 sirup, whereby a thick scum is raised, which is removed. After 24 minutes, four and a half pounds of alkaline solution, and about two fifths of a pound of raw milk, are added; after which the boiling and skimming are continued 24 minutes. This must be repeated from five to seven times, until no more scum appears. 240 pounds of water being now added, the liquor is to be poured into a number of strainers. These are bags of coarse cotton cloth, in the form of inverted quadrangular pyramids, each of which is suspended from a frame of wood, about two feet square. The operation of straining occupies about 96 minutes. The strained liquor is divided into three parts: one of these is put into a boiler, with from half a pound to a pound and a half of alkaline solution, one twelfth of a pound of milk, and 12 pounds of water. After having boiled for between 48 and 72 minutes, three quarters of a pound of milk are added, and the liquor is poured, in equal portions, into four refining pots. These are wide at the mouth, and pointed at the bottom; but are not conical, for the sides are curved. The bottom is perforated, and the stem of a plantain leaf forms a plug for closing the aperture. The two remaining portions of the strained liquor are managed in exactly the same manner; so that each refining pot has its share of each portion. When they have cooled a little, the refining pot is removed to the curing-house, and placed on the ground for 24 hours; next day they are placed on a frame, which supports them at some distance from the ground. A wide-mouthed vessel is placed under each, to receive the viscid liquor that drains from them. In order to draw off this more completely, moist leaves of the *Valisneria spiralis* are placed over the mouth of the pot, to the thickness of two inches; after 10 or 12 days, these are removed; when a crust of sugar, about half an inch in thickness, is found on the surface of the boiled liquor. The crust being broken and removed, fresh leaves are repeatedly added, until the whole sugar has formed; which requires from 75 to 90 days. When cake extract is used, it does not require to be strained before it be put into the boiler.

On the above-described operose and preposterous process, it is needless to make any remarks. While it is adhered to with the tenacity of Hindoo habit, the West Indies has no reason to fear the competition of the East, in the manufacture of sugar, provided the former avail themselves of the aids which chemical and mechanical science are ready to supply.

In every part of the Behar and Putna districts, several of the confectioners prepare the coarse article called *shukkur*, which is entirely similar in appearance to the inferior Jamaica sugars. They prepare it by putting some of the thin extract of sugar cane into coarse sackcloth bags, and by laying weights on them, they squeeze out the molasses; a process perfectly analogous to that contemplated in several English patents.

1082



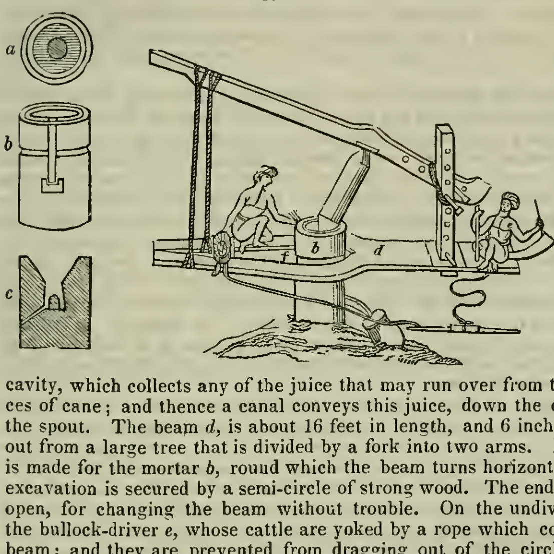
The sugar-mill at Chica Ballapura is worked by a single pair of buffaloes or oxen, *fig.* 1082, going round with the lever A, which is fixed on the top of the right-hand roller. The two rollers have endless screw heads B, which are formed of 4 spiral grooves and 4 spiral ridges, cut in opposite directions, which turn into one another, when the mill is working. These rollers and their heads are of one piece, made of the toughest and hardest wood that can be got, and such as will not impart any bad taste to the juice. They are supported in a thick strong wooden frame, and their distance from each other is regulated by means of wedges, which pass through mortises in the frame planks, and a groove made in a bit of some sort of hard wood, and press upon the axis of one of the rollers. The axis of the other presses against the left-hand side of the hole in the frame-boards. The cane juice runs down the rollers, and through a hole in the lower frame-board, into a wooden conductor, which carries it into an earthen pot. Two long-pointed stakes or piles are driven into the earth, to keep the mill steady, which is all the fixing it requires. The under part of the lowermost plank of the frame rests upon the surface of the ground, which is chosen level and very firm, that the piles may hold the faster. A hole is dug in the earth, immediately below the spout of the conductor, to receive the pot.

The mill used in Burdwan and near Calcutta, is simply two small wooden cylinders, grooved, placed horizontally, close to each other, and turned by two men, one at each end. This simple engine is said completely, but slowly, to express the juice. It is very cheap, the prime cost not being two rupees; and being easily moved from field to field, it saves much labor 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.* 1083, 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

1083



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 semi-circle of strong wood. The end towards the fork is quite open, for changing the beam without trouble. On the undivided end of the beam sits the bullock-driver *e*, whose cattle are yoked by a rope which comes from the end of the beam; and they are prevented from dragging out of the circle by another rope, which passes from the yoke to the forked end of the beam. On the arms *f*, a basket is placed, to hold the cuttings of cane; and between this and the mortar sits the man who feeds the mill. Just as the pestle comes round, he places the pieces of cane sloping down into the cavity of the mortar; and after the pestle has passed, he removes those that have been squeezed.

OF THE MANUFACTURE OF SUGAR IN THE WEST INDIES.

Cane-juice varies exceedingly in richness, with the nature of the soil, the culture, the season, and variety of the plant. It is an opaque fluid, of a dull gray, olive, or olive-green color; in taste, balmy and saccharine; exhaling the balsamic odor of the cane; slightly viscid; and of a specific gravity varying from 1·033 to 1·106, according to circumstances. When fresh, it consists of two parts; the one liquid, the other solid; the latter of which being merely suspended in the former, and, therefore, separable in a great measure by filtration or repose. The solid matter consists of fragments of the cellular parenchyma of the cane, its fibres, and bark, mechanically protruded through the mill; mixed with a very abundant greenish substance, like that called *chlorophyle* by chemists.

When left to itself in the colonial climates, the juice runs rapidly into the acetous fermentation; twenty minutes being, in many cases, sufficient to bring on this destructive change. Hence arises the necessity of subjecting it immediately to clarifying processes, speedy in their action. When deprived of its green fecula and glutinous extractive, it is still subject to fermentation; but this is now of the vinous kind. The juice flows from the mill through a wooden gutter lined with lead, and being conducted into the sugar-house, is received in a set of large pans or caldrons, called clarifiers. On estates which make on an average, during crop time, from 15 to 20 hogsheads of sugar a week, three clarifiers, of from 300 to 400 gallons' capacity each, are sufficient. With pans of this dimension, the liquor may be drawn off at once by a stop-cock or syphon, without disturbing the feculencies after they subside. Each clarifier is hung over a separate fire, the flue being furnished with a damper for checking the combustion, or extinguishing it altogether. The clarifiers are sometimes placed at one end, and sometimes in the middle of the house, particularly if it possesses a double set of evaporating pans.

Whenever the stream from the mill cistern has filled the clarifier with fresh juice, the fire is lighted, and the *temper*, or dose of slaked lime, diffused uniformly through a little juice, is added. If an albuminous emulsion be used to promote the clarifying, very little lime will be required; for recent cane-liquor contains no appreciable portion of acid to be saturated. In fact, the lime and alkalis 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 favorable 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 sirup, 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 brick-work. The skimmings of the *grand* are thrown into a separate pan, placed at its side. A large cylindrical *cooler,* about six feet wide and two feet deep, has been placed in certain sugar-works near the teache, for receiving successive charges of its inspissated sirup. 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 sirup in a state of incipient granulation in the cooler, a second skipping is poured, this second congeries of saccharine particles agglomerates round the first as *nuclei* of crystallization, and produces a larger grain; a result improved by each successive skipping. This principle has been long known to the chemist, but does not seem to have been always properly considered or appreciated by the sugar-planter.

From the above described *cooler,* the sirup is transferred into wooden chests or boxes, open at top, and of a rectangular shape; also called *coolers,* but which are more properly crystallizers or granulators. These are commonly six in number; each being about one foot deep, seven feet long, and five or six feet wide. When filled, such a mass is collected, as to favor slow cooling, and consequent large-grained crystallization. If these boxes be too shallow, the grain is exceedingly injured, as may be easily shown by pouring some of the same sirup on a small tray; when, on cooling, the sugar will appear like a muddy soft sand.

The criterion by which the negro boilers judge of the due concentration of the sirup in the teache, is difficult to describe, and depends almost entirely on the sagacity and experience of the individual. Some of them judge by the appearance of the incipient grain on the back of the cooling ladle; but most decide by "*the touch,*" that is, the feel and appearance of a drop of the sirup 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 sirup. But the appearance of granulation in the thread must also be considered; for a viscid and damaged sirup may give a long enough thread, and yet yield almost no crystalline grains when cooled. Tenacity and granular aspect must, therefore, be both taken into the account, and will continue to constitute the practical guides to the negro boiler, till a less barbarous mode of concentrating cane-juice be substituted for the present *naked teache*, or *sugar frying-pan*.

That weak sugars are such as contain an inferior proportion of carbon in their composition, was first deduced by me from my experiments on the ultimate analysis of vegetable and animal bodies; an account of which was published in the Philosophical Transactions of the Royal Society for 1822. Since then, Dr. Prout has arrived at results confirmatory of my views. See Philosophical Transactions for 1827. Thus, he found pure sugar-candy, and the best refined sugar, to contain 42·85 parts of carbon per cent.; East India sugar-candy, 41·9 parts; East India raw sugar in a thoroughly dry state, but of a low quality, 40·88; manna sugar, well refined, 28·7; sugar from Narbonne honey, 36·36; sugar from starch, 36·2. Hence, by *caramelizing* the sirup in the *teache*, not only is the crystallizable sugar blackened, but its faculty of crystallizing impaired, and the granular portion rendered weaker.

A viscous sirup containing much gluten and sugar, altered by lime, requires a higher temperature to enable it to granulate than a pure saccharine sirup; and therefore the thermometer, though a useful adjuvant, can by no means be regarded as a sure guide, in determining the proper instant for *striking* the *teache*.

The colonial *curing-house* is a capacious building, of which the earthen floor is excavated to form the molasses reservoir. This is lined with sheet lead, boards, 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 crystallizers 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 favor the liquefaction and drainage of the viscid caramel.

Out of 120 millions of pounds of raw sugar, which used to be annually shipped by the St. Domingo planters, only 96 millions were landed in France, according to the authority of Dutrone, constituting a loss by drainage in the ships of 20 per cent. The average transport waste at present in the sugars of the British colonies cannot be estimated at less than 12 per cent., or altogether upwards of 27,000 tons! What a tremendous sacrifice of property!

Within these few years a very considerable quantity of sugar has been imported into Great Britain in the state of concentrated cane-juice, containing nearly half its weight of granular sugar, along with more or less molasses, according to the care taken in the boiling operations. I was at first apprehensive that the sirup might undergo some change on the voyage; but among more than a hundred samples which I have analyzed for the custom-house, I have not perceived any traces of fermentation. Since sugar softens in its grain at each successive solution, whatever portion of the crop may be destined for the refiner, should upon no account be granulated in the colonies; but should be transported in the state of a rich cane-sirup to Europe, transferred at once into the blowing-up cistern, subjected there to the reaction of bone black, and passed through bag-filters, or through layers of the coarsely ground black, previously to its final concentration in the vacuum pan. Were this means generally adopted, I am convinced that 30 per cent. would be added to the amount of home-made sugar loaves corresponding to a given quantity of average cane-juice; while 30 per cent. would be taken from the amount of molasses. The saccharine matter now lost by drainage from the 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 labor in the colonies, and might be exported 5 or 6 weeks earlier than at present, because the period of drainage in the curing-house would be spared.

It does not appear that our sugar colonists have availed themselves of the proper chemical method of counteracting that incipient fermentation of the cane-juice, which sometimes supervenes, and proves so injurious to their products. It is known that grape-must, feebly impregnated with sulphurous acid, by running it slowly into a cask in which a few sulphur matches have been burned, will keep without alteration for a year; and if *must*, so *muted*, is boiled into a sirup within a week or ten days, it retains no sulphureous odor. A very slight muting would suffice for the most fermentable cane-juice; and it could be easily given, by burning a sulphur match within the cistern immediately before charging it from the mill. The cane-juice should, in this case, be heated in the clarifier, so as to expel the sulphurous acid, before adding the temper lime; for otherwise a little calcareous sulphite might be introduced into the sugar. Thus the acescence so prejudicial to the saccharine granulation would be certainly prevented.

An Account of Sugar Imported into the United Kingdom during the years ending 5th January, 1837, and 5th January, 1838.

	Quantities imported.		Quantities entered for Home Consumption.		Gross amount of Duty received.	
	1837.	1838.	1837.	1838.	1837.	1838.
Sugar, unrefined; viz.—of the	Cwt. qr. lb.	Cwt. qr. lb.	Cwt. qr. lb.	Cwt. qr. lb.	£.	£.
British possessions in America,	3,600,516 3 2	3,304,092 2 2	3,296,641 1 19	3,562,703 1 24	3,956,879	4,275,207
Of Mauritius,	497,303 0 8	537,054 1 21	518,228 0 5	522,348 3 11	621,596	626,131
East India British possessions,	152,229 1 13	296,677 2 12	110,236 2 0	270,146 1 2	176,376	368,672
East India Foreign possessions,	71,464 2 0	77,090 0 18	20 3 18	3 3 11	66	12
Other sorts	327,647 1 12	266,559 2 24	31 1 6	37 3 10	41	95
Total,	4,649,161 0 7	4,481,474 1 21	3,925,140 0 20	4,355,240 1 2	4,754,958	5,270,117

An Account of Sugar Exported in the year ending 5th January, 1838, compared with the Exports of the preceding Year.

	1837.	1838.
	Cwts. qrs. lbs.	Cwts. qrs. lbs.
Sugar, of the British possessions in America	8,774 1 15	9,267 0 21
Mauritius - - - - - -	2,687 3 14	3,065 0 19
East India, of British possessions	22,290 3 16	13,283 0 22
Foreign do.	52,384 0 4	68,252 2 18
Other sorts - - - - - -	191,961 0 20	354,513 1 23

Sirup 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, or *formes*, made of coarse pottery, having a small orifice at the apex, which is stopped with a plug of wood wrapped in a leaf of maize. These pots are arranged with the base upwards. As their capacity, when largest, is greatly less than that of the smallest potting-casks, and as the process lasts several weeks, the claying-house requires to have very considerable dimensions. Whenever the sirup 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 sirup 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 color, according to the part of the cone from which they were cut; under the denomination in French commerce of *premier, second, troisième, petit, commun,* and *tête;* the last or the tip being an indifferent article. The clayed sugar of Cuba is called Havana sugar, from the name of the shipping port.

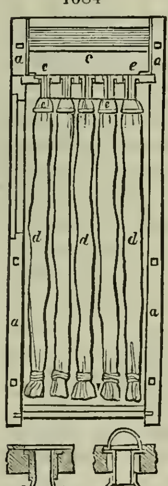
Clayed sugar can be made only from the ripest cane-juice, for that which contains much gluten would be apt to get too much burned by the ordinary process of boiling, to bear the claying operation. The sirups that run off from the second, third, and fourth applications of the clay-paste, are concentrated 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.

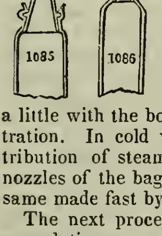
Claying is seldom had recourse to in the British plantations, on account of the increase of labor, and diminution of weight in the produce, for which the improvement in quality yields no adequate compensation. Such, however, was the esteem in which the French consumers held clayed sugar, that it was prepared in 400 plantations of St. Domingo alone.

SUGAR REFINING.

Raw, or muscovado sugar, as imported from the colonies, is contaminated more or less with gluten, lime, but particularly *caramel*, which give its grains a yellow brown tint, an empyreumatic odor, and a soft clammy feel in the hand. If such sugar be dissolved in water, and the sirup be evaporated by a gentle heat, it will afford a sugar of still inferior quality and appearance. This rapid deterioration is in some measure owing to the injurious operation of a prolonged heat upon the crystalline structure, but chiefly to the chemical reaction of the glutinous ferment and lime upon the sugar. The first care of the refiner should therefore be the immediate abstraction of these noxious alteratives, which he effects by the process called *meltings;* that is, mixing up the sugar in a pan with hot water or steam into a pap, and transferring this pap into large sugar-moulds. Whenever these become cool, their points are unplugged, and they are set to drain for a few days in a warm apartment. Sugar thus cleansed is well prepared for the next refining process; which consists in putting it into a large square copper cistern along with some lime-water, (a little bullock's blood,) and from 5 to 20 per cent. of bone black, and blowing it up with steam; or, in other words, injecting steam through the mixture from numerous orifices in copper pipes laid along the bottom and sides of the vessel. Under the influence of the heat and agitation thus occasioned, the saccharine matter is perfectly dissolved and incorporated with the albumen of the blood and the bone black. Instead of the blood, many refiners employ a mixture of gelatinous alumina and gypsum, called *finings*, prepared by adding a solution of alum to a body of lime-water, collecting, washing, and draining the precipitate upon a filter.

1084





Other refiners use both the blood and finings, with advantage. Bone black is now very frequently employed by the sugar-refiner, not in a fine meal, but in a granular state, like corned gunpowder, for the purpose of decoloring his sirups; in which case, he places it in a box, in a stratum 8 or 10 inches thick, and makes the sirup percolate downwards through it, into a cistern placed beneath. By this means it is deprived of color, and forms the *clairce* of the French refiner. When the blowing up cistern is charged with sugar, finely ground bone black, and blood, the mixture must be passed through a proper system of filters. That now most in use is the creased bag filter, represented in *figs.* 1084 1085, 1086.

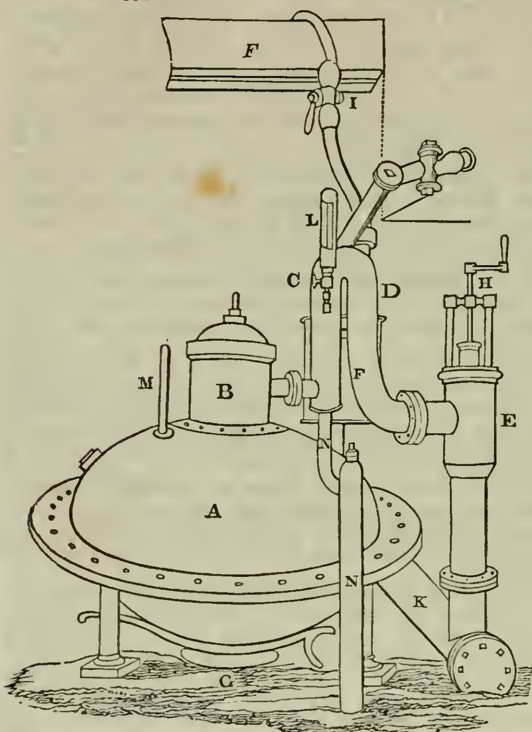
The apparatus consists of an upright square wooden case *a*, *a*, about 6 or 8 feet high, furnished with a door of admission to arrange the interior objects; beneath is a cistern with an educting-pipe for receiving and carrying off the filtered liquor; and above the case is another cistern *e*, which, like the rest, is lined with tinned sheet copper. Into the upper cistern, the sirup mixed with animal charcoal is introduced, and passes thence into the mouths *e*, *e*, of the several filters *d*, *d*. These consist each of a bag of thick tweeled cotton cloth, about 12 or 15 inches in diameter, and 6 or 8 feet long, which is inserted into a narrow bottomless bag of canvass, 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 copper bottom of the upper cistern. From 40 to 60 bags are mounted in each filter case. The liquor which first passes is generally tinged a little with the bone black, and must be pumped back into the upper cistern, for refiltration. In cold weather the interior of the case may be kept warm by a proper distribution of steam-pipes. *Fig.* 1085 shows one mode of forming the funnel-shaped nozzles of the bags, in which they are fixed by a bayonet catch. *Fig.* 1086 shows the same made fast by means of a screwed cap, which is more secure.

The next process in sugar-refining is the evaporation of the clarified sirup to the granulating or crystallizing pitch. The more rapidly this is effected, and with the less scorching injury from fire, the better and greater is the product in sugar-loaves. No apparatus answers the refiner's double purpose of safety and expedition so well as the acuum-pan of Howard.

Fig. 1087 shows the structure of a single vacuum-pan. The horizontal diameter of the copper spheroid A, is not less than 5 feet; the depth of the under hemisphere is at least 18 inches from the level of the plane; and the height of the dome-cover is 2 feet. The two hemispheres (of which the inferior one is double, or has a steam-jacket) are put together by bolts and screws, with packing between the flanges to preserve the joints tight against atmospheric pressure. The jacket of the lower hemisphere forms the case of the steam, which communicates heat to the sirup enclosed in the inner hemisphere. In general, the pans contain, when filled to the flange, 100 gallons of sirup, and yield about 11 cwts. of granulated sugar, at every charge.

A, represents the vacuum spheroid; B, the neck with the lid. From the side of B, a pipe passes into the lower extremity of the bent pipe C, D, which terminates in the vertical pipe E, connected with the vacuum main-pipe K, proceeding horizontally from the air-pump (not shown in the figure). At the top of E, a valve, moveable by a screw H, is placed for establishing or cutting off the connexion with the air-pump at pleasure. Behind F, is the measure cistern, from which the successive charges are admitted into the pan. This measure is filled with the clear sirup, by opening the stopcock I, on the pipe under the ceiling, which communicates with the filter-cistern placed above. G is the valve or plug-hole, at the bottom of the pan, for discharging the granulating sirup. This plug is opened by means of a powerful lever attached to it; the connexion with the air-pump being previously intercepted. L, is the barometer, or manometer, for showing the state of the vacuum corresponding to the temperature. N, N, is a cistern-pipe for receiving any little sirup which may accidentally boil over the neck B. Its contents are let off by a stopcock at its bottom from time to time. M shows the place of the *proof-stick*, an ingenious brass rod for taking out a sample of sirup without admitting air. See *infrà*.

1087

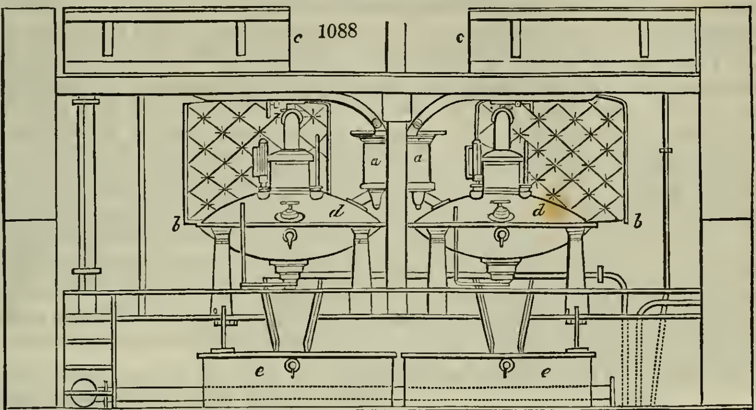


The charging-cistern contains about 20 gallons. This quantity of sirup being first admitted, and brought to a certain pitch of concentration, a second measure is introduced, the inspissation of which is supposed by some refiners to cause an agglomeration of saccharine matter round the first crystalline particles. The repetition of this process for two or three times is imagined to produce the large brilliant grain of vacuum-pan sugar. This hypothesis is more specious than sound, because the granulating sirup discharged from the pan is subjected to a heat of 180° or 190° in the subjacent steam-cased receiver, whereby the granulations are again reduced to a very small size. Into this receiver, two or three skippings or discharges of the pan are admitted in succession, and the whole are diligently mixed and agitated by a stirring oar. It is by this process that the granulating tendency is promoted and determined. From this receiver (absurdly enough called a cooler) the moulds are filled in the usual way, by means of copper basins or large ladles.

The case of the under hemisphere of the vacuum-pan is filled with steam, generated under a pressure of four or five pounds on the square inch; the heat of which causes the interior sirup to boil rapidly while the air-pump is kept in action. A small escape-pipe for waste steam must be placed at the opposite side of the case or jacket, to ensure its equal distribution ; as also a stopcock below, to let off the water of condensation. The pans are mounted on iron feet, or short pillars, which insulate them from the floor, and allow their whole surface to be inspected, and any flaw to be repaired. The air-pump usually stands in a cold-water cistern, to favor the condensation of the aqueous vapor, which it draws out of the pans; and it is kept in constant action by the steam-engine, being attached to the working-beam of its piston.

Fig. 1088 exhibits the general arrangement of the vacuum-pans, and their subsidiary apparatus. Here are shown, on the ground floor, the heaters *e*, *e*, (miscalled coolers), into

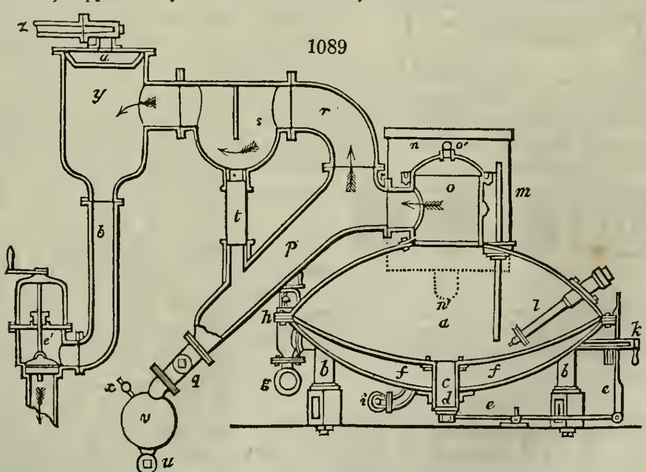
1088



which the concentrated sirup is let down. These heaters are made of copper, in one piece, surrounded with a cast-iron jacket, bolted at the flange or brim to it. Each pan contains, when full, about 350 gallons, equivalent to nearly 35 cwts. of crystallized sugar. They are furnished with steam-cocks and waste steam-pipes. Under the level of the spheroids *d*, *d*, the horizontal main-pipe is seen, for supplying the cases with steam. In the face of each pan, above the line *b*, *b*, the handle of the proof-stick appears, like that of a stopcock. The distribution of the measure cisterns, and some other parts of the pans, is slightly varied in this representation from the former. From the bottom of the liquor cisterns c, c, pipes descend to the charging measures *a*, *a*, below. The cisterns c, c, are made of copper, and contain each about 400 gallons. Six tons of refined sugar can be turned out daily in a three-pan house.

Fig. 1089 represents in section another form of the vacuum-pan. *a* is the spheroidal copper vessel, supported by four iron columns *b*, *b*. It may be discharged by means of

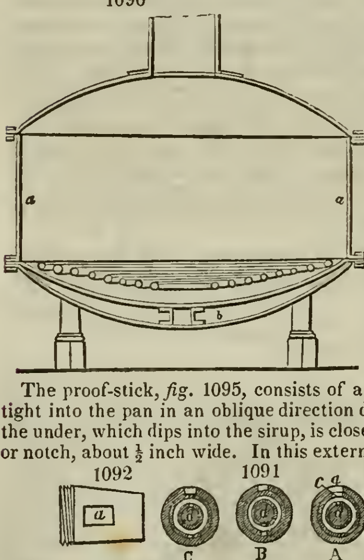
1089



the pipe *c*, which is secured with a conical valve *d*. This may be opened or shut, by acting on the lever *e*. The lower of the two hemispheres of which the pan is composed is double, and the interstitial space *f*, *f*, is filled with steam by the pipe g, as the heating and evaporating agent. *h*, is the steam valve; *i*, the pipe for the efflux of the condensed water. *k*, a tube for the escape of the air at the commencement of the operation. *l*, is an apparatus inserted air-tight into the cover of the vacuum-pan, and which dips down into the sirup; serving to take out a sample of it, without allowing air to enter, and hence called the proof-stick. The construction of this instrument is exhibited in *figs.* 1091, 1092, 1093, 1094, 1095, which will be presently explained. *m*, is the thermometer, which is also plunged into the sugar; behind it, is the barometer. *n*, is the charger or gauge-vessel, filled with the filtered sirup, which it discharges by the pipe *n′*. o, is the cover or capital of the vacuum-pan. o′, is a safety-valve, through which the air may be admitted, after the completion of the process. *p*, is a bent pipe, slanting downwards with a stopcock *q*, at its end, to receive the superfluous sirup. The vapor, which is disengaged from the sirup during its concentration, is extracted from the top of the pan into the pipe *r*, passes from this into the vessel *s*, which is divided by a plate of copper into two compartments. The sirup forced over accidentally in the ebullition, goes into the vessel *s*, and passes by the glass tube *t*, into the pipe *p*. The glass tube serves to show the quantity of the sirup that has boiled over, so that it may be drawn off when necessary. For this purpose, the stopcock *u*, of the vessel *v*, must be closed, and *q* must be opened, in order to fill *v*, while the air contained in it escapes into the pan. The stopcock *q*, being then shut, and *u*, with the little air-cock *x*, opened, the sirup will flow into the large receiver placed beneath it, commonly but erroneously called a cooler; because it is a double copper basin, with steam in the interstitial space. The hot steam rushes from *s*, into the cast-iron vessel *y*, where it is condensed. *z*, is a pipe for introducing the water of condensation through the copper rose *a′*. The condensed water flows through the pipe *b′*, and the valve *e′*, to the air-pump, which receives motion from the shaft of the steam-engine.

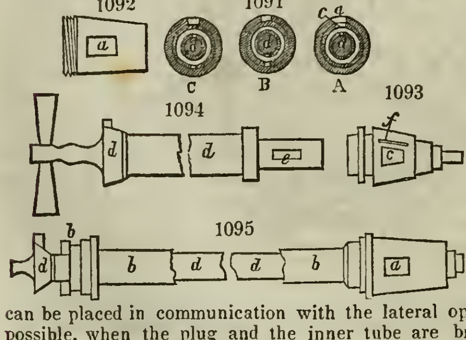
The vacuum-pan was originally heated solely by the admission of steam between the double bottom; but of late years the heat has been also applied to the sirup through several coils of pipe placed within the pan, filled with steam at a temperature many degrees above 212° F., sometimes so high as 250°. By this double application of heat, the evaporating power of a pan has been vastly increased. The latest made pans have a considerably flat bottom, *fig.* 1090; a spiral pipe, laid close upon it; and between the under hemisphere and the upper one, there is a space *a*, *a*, 2½ feet high, to give the sirup room for frothing up without boiling over. The space *b*, of the bottom receives steam of common pressure, and the spiral tubes, of high pressure. A pan like this is now making for a house in London, which is to work off 16 tons of sugar-loaves daily.

1090



The proof-stick, *fig.* 1095, consists of a cylindrical rod, capable of being screwed air-tight into the pan in an oblique direction downwards. The upper or exterior end is open; the under, which dips into the sirup, is closed, and has on one side a slit *a* (*figs.* 1091, 1092) or notch, about ½ inch wide. In this external tube, there is another shorter tube *b*, capable of moving round in it, through an arc of 180°. An opening upon the under end *e*, corresponds with the slit in the outer tube, so that both may be made to coincide, *fig.* 1091, A. A wooden plug *d*, is put in the interior tube, but so as not to shut it entirely. Upon the upper end there is a projection or pin, which catches in a slit of the inner tube, by which this may be turned round at pleasure. In the lower end of the plug there is a hole *e*, which can be placed in communication with the lateral openings in both tubes. Hence it is possible, when the plug and the inner tube are brought into the proper position, A, *fig.* 1091, to fill the cavity of the wooden rod with the sirup, and to take it out without

1092 1091



allowing any air to enter. In order to facilitate the turning of the inner tube within the outer, there is a groove in the under part, into which a little grease may be introduced.

Whenever a proof has been taken, the wooden plug must be placed in reference to the inner tube, as shown in *fig.* 1091, C, and then be turned into the position A; when the cavity of the plug will again be filled with sirup. C must be now turned back to the former position, whereby all intercourse with the vacuum-pan is cut off; the plug being drawn out a little, and placed out of communication with the inner tube. The plug is then turned into the position B, drawn out, and the proof examined by the fingers.

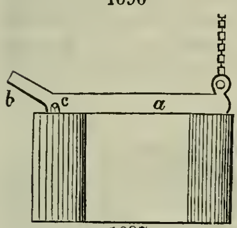
TABLE showing the boiling point of sirup, at the corresponding atmospheric pressure within the vacuum-pan :—

Height of the mercury (inches) in one leg of the syphon, above that in the other—	0·74	0·86	1·01	1·17	1·36	1·57	1·80	2·05	2·36	2·72	3·10	3·52	4·00.
Boiling point, Fahr.—	115°	120°	125°	130°	135°	140°	145°	150°	155°	160°	165°	170°	175°.

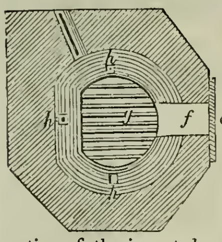
The large double steam-basin, which receives several successive skippings of the concentrated granulating sirup, serves to heat it from the temperature of 160° or 170°, at which it leaves the vacuum-pan, up to 200° or thereby, before it is filled out into the moulds; for were it introduced in the cooler state, it would not concrete into sufficiently compact loaves.

The following apparatus is used in many French sugar-houses, for concentrating sirups, called the *swing pan*, or *chaudière à bascule*. It is represented in *fig.* 1096, in elevation, and in *fig.* 1097, in ground plan. *a*, is the pan; *b*, its spout; *c*, the axis or pivot round which it swings, so as to empty itself, when raised behind by the chain *d*; *e*, is the furnace door; *f*, the passage to the fireplace and grate *g*; *h*, *h*, *h*, side flues for conducting the smoke into the chimney.

1096



1097



The duly clarified, concentrated, granulated, and re-heated sirup, is transferred, by means of copper basins, from the coolers into conical moulds, made either of brown and somewhat porous earthenware, or of sheet iron, strongly painted. The sizes of the moulds vary, from a capacity of 10 pound *loaves*, to that of 56 pound *bastards*—a kind of soft brown sugar obtained by the concentration of the inferior sirups. These moulds have the orifices at their tips closed with bits of twisted paper, and are set up in rows close to each other, in an airy apartment adjoining the coolers. Here they are left several hours, commonly the whole night, after being filled, till their contents become solid, and they are lifted next morning into an upper floor, kept at a temperature of about 80° by means of steam pipes, and placed each over a pot to receive the sirup drainings—the paper plug being first removed, and a steel wire, called a piercer, being thrust up to clear away any concretion from the tip. Instead of setting the lower portion of the inverted cones in pots, some refiners arrange them in wooden racks, with their apices suspended over longitudinal gutters of lead or zinc, laid with a slight slope upon the floor, and terminating in a sunk cistern. The sirup which flows off spontaneously is called green sirup. It is kept separate. In the course of two or three days, when the drainage is nearly complete, some finely clarified sirup, made from loaf sugar, called *liquor* by the refiners, is poured to the depth of about an inch upon the base of each cone, the surface having been previously rendered level and solid by an iron tool, called a bottoming trowel. The liquor, in percolating downwards, being already a saturated sirup, can dissolve none of the crystalline sugar, but only the colored molassy matter; whereby, at each successive liquoring, the loaf becomes whiter, from the base to the apex. A few moulds, taken promiscuously, are emptied from time to time, to inspect the progress of the blanching operation; and when the loaves appear to have acquired as much *color*, according to the language of refiners, as is wanted for the particular market, they are removed from the moulds, turned on a lathe at the tips, if necessary, set for a short time upon their bases, to diffuse their moisture equally through them, and then transferred into a stove heated to 130° or 140° by steam pipes, where they are allowed to remain for two or three days, till they be baked thoroughly dry. They are then taken out of the stove, and put up in blue paper for sale.

In the above description of sugar-refining, I have said nothing of the process of claying the loaves, because it is now nearly obsolete, and abandoned in all well-appointed sugar-houses. Those of my readers who desire to become acquainted with sugar-refining upon the old plan, may consult my Report made upon the subject to the Honorable House of Commons in July, 1833; where they will find every step detailed, and the numerical results stated with minute accuracy. The experiments subservient to that official report were instituted purposely to determine the average yield or product, in double and single refined loaves, lumps, bastards and treacle, which different kinds of sugar would afford per cwt., when refined by decoloring with not more than 5 per cent. of bone black, boiling in an open pan, and clearing the loaves with clay-pap.

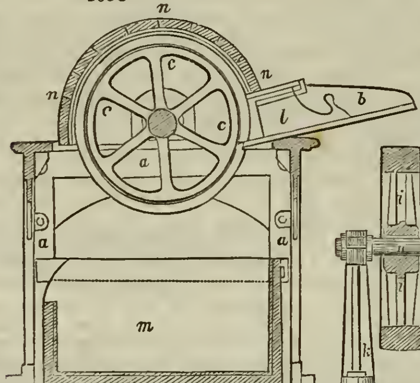
BEET-ROOT SUGAR.

The physical characters which serve to show that a beet-root is of good quality, are its being firm, brittle, emitting a creaking noise when cut, and being perfectly sound within; the degree of sweetness is also a good indication. The 45th degree of latitude appears to be the southern limit of the successful growth of beet in reference to the extraction of sugar.

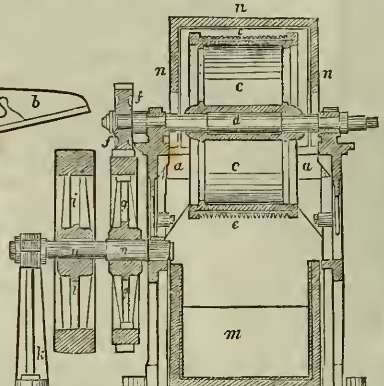
Extraction of Sugar from the Beet.—The first manipulations to which the beets are exposed, are intended to clear them from the adhering earth and stones, as well as the fibrous roots and portions of the neck. It is desirable to expose the roots, after this operation, to the action of a cylinder washing-machine.

The parenchyma of the beet is a spongy mass, whose cells are filled with juice. The cellular tissue itself, which forms usually only a twentieth or twenty-fifth of the whole weight, consists of ligneous fibre. Compression alone, however powerful, is inadequate to force out all the liquor which this tissue contains. To effect this object, the roots must be subjected to the action of an instrument which will tear and open up the greatest possible number of these cells. Experiments have, indeed, proved, that by the most considerable pressure, not more than 40 or 50 per cent. in juice from the beet can be obtained; whilst the pulp procured by the action of a grater produces from 75 to 80 per cent.

1098



1099



The beet-root rasp of Moulfarine is represented in *figs.* 1098, 1099. *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 for securing the saw blades *e, e*, which are packed tight against each other by means of laths of wood; *f*, is a pinion upon the shaft of the drum, into which the wheel *g* works, and which is keyed upon the shaft *h*; *i*, is the driving rigger; *k*, pillar of support; *l*, blocks of wood, with which the workman pushes the beet-roots against the revolving-rasp; *m*, the chest for receiving the beet-pap; *n*, the wooden cover of the drum, lined with sheet iron. The drum should make 500 or 600 turns in the minute.

A few years ago, M. Dombasle introduced a process of extracting the juice from the beet without either rasping or hydraulic pressure. The beets were cut into thin slices, by a proper rotatory blade-machine; these slices were put into a macerating cistern, with about their own bulk of water, at a temperature of 212° F. After half an hour's maceration, the liquor was said to have a density of 2° B., when it was run off into a second similar cistern, upon other beet-roots; from the second it was let into a third, and so on to a fifth; by which time, its density having risen to 5½°, it was ready for the process of defecation. Juice procured 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. The process has been accordingly abandoned in most establishments.

I have seen the following operations successfully executed in a beet-root factory near Lille, and have since verified their propriety in my own laboratory upon white beets, grown near Mitcham in Surrey. My product was nearly 5 per cent.; it was very fair, and large grained, like the vacuum-pan sugar of Demerara, but without its clamminess.

The roots were washed by a rotatory movement upon a grating made like an Archimedes' screw, formed round the axis of a squirrel-cage cylinder, which was laid horizontally beneath the surface of water in an oblong trough. It was turned by hand rapidly, with the intervention of a toothed wheel and pinion. The roots, after being sufficiently agitated in the water, were tossed out by the rotation at the end of the cylinder furthest from the winch. They were next hoisted in a basket up through a trap-hole into the floor above, by means of a cord and pulley moved by mechanical power; a six-horse steam engine, upon Woolfe's expansive principle, being employed to do all the heavy work. They were here subjected to the mechanical grater (*rape mécanique*), see *figs.* 1098, 1099, which had, upon its sloping feed-table, two square holes for receiving at least two beets at a time, which were pushed forwards by a square block of wood held in the workman's hand by means of a strap. The rasp was a drum, having rows of straight saws placed half an inch apart round its periphery, *parallel to the axis*, with teeth projecting about $\frac{1}{8}$ of an inch. The space between each pair of saws was filled with a wedge of wood. The steel slips, or saw plates, were half an inch broad, twelve inches long, and serrated on both their longitudinal edges, so that when the one line of teeth was blunted, the other could be turned out. The drum made 750 turns per minute.

The pulp from the rasp fell into a flat trough placed beneath, whence it was shovelled into small bags. Each bag had its mouth folded over, was laid upon a wicker plate, and spread flat with a rolling-pin. The bags and hurdles were then piled in the hydraulic press. There were three presses, of which the two allotted to the first pressure were charged alternately, and the third was reserved for a final and more durable pressure of the *marc*. See Press, hydraulic, and Stearine Press.

The juice flowed over the edges of the wicker plates, and fell into the sill-plate of the press, which was furnished with upright borders, like a tray, through whose front side a pipe issued, that terminated in a leathern hose, for conducting the juice into an elevated cistern in the boiling-house. Here one pound of slaked lime was mixed with every four hectolitres (about 88 gallons imp.) of juice. The mixture was made to boil for a little while in a round pan alongside, whence it was decanted into oblong flat filters, of blanket stuff. The filtered liquor, which had in general a spec. gravity of 15° Baumé (about double that of the fresh juice), was now briskly concentrated by boiling, in an oblong pan, till it acquired the density of 28° B. The fire being damped with raw coal, the sirup was run off rapidly by a stopcock into a large basin with a swing handle, and immediately replaced by fresh defecated liquor. The basin was carried by two men to the opposite side of the boiling-house, and emptied into a cistern set on a high platform, whose horizontal discharge-pipe was provided with a series (five) of stopcocks, placed respectively over five copper chests (inverted truncated pyramids), containing a thick bed of granular bone black, covered with a perforated copper plate. The hot sirup thus filtered had a pale straw-color, and was subsequently evaporated in swing pans, *figs.* 1096, 1097, over a brisk fire, in quantities equivalent to half a cwt. of sugar, or four hectolitres of average juice.

MAPLE SUGAR.

The manufacture of sugar from the juice of a species of maple tree, which grows 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 forty years.

The extraction of maple sugar is a great resource to the inhabitants of districts far removed from the sea; and the process is very simple. After selecting a spot among surrounding maple trees, a shed is erected, called the *sugar-camp*, to protect the boilers and the operators from the vicissitudes of the weather. One or more augers, three fourths of an inch in diameter; small troughs for receiving the sap; tubes of elder or sumach, 8 or 10 inches long, laid open through two thirds of their length, and corresponding in size to the auger-bits; pails for emptying the troughs, and carrying the sap to the camp; boilers capable of holding 15 or 16 gallons; moulds for receiving the sirup inspissated to the proper consistence for concreting into a loaf of sugar; and, lastly, hatchets to cut and cleave the fuel, are the principal utensils requisite for this manufacture. The whole of February and beginning of March are the sugar season.

The trees are bored obliquely from below upwards, at 18 or 20 inches above the ground, with two holes 4 or 5 inches asunder. Care must be taken that the auger penetrates no more than half an inch into the alburnum, or white bark; as experience has proved that a greater discharge of sap takes place at this depth than at any other. It is also advisable to perforate in the south face of the trunk.

The trough, which contains from two to three gallons, and is made commonly of white pine, is set on the ground at the foot of each tree, to receive the sap which flows through the two tubes inserted into the holes made with the auger; it is collected together daily, and carried to the camp, where it is poured into casks, out of which the boilers are supplied. In every case, it ought to be boiled within the course of two or three days from flowing out of the tree, as it is liable to run quickly into fermentation, if the weather become mild. The evaporation is urged by an active fire, with careful skimming during the boiling; and the pot is continually replenished with more sap, till a large body has at length assumed a sirupy consistence. It is then allowed to cool, and passed through a woollen cloth, to free it from impurities.

The sirup is transferred into a boiler to three fourths of its capacity, and it is urged with a brisk fire, till it acquires the requisite consistence for being poured into the moulds or troughs prepared to receive it. This point is ascertained, as usual, by its exhibiting a granular aspect, when a few drops are drawn out into a thread between the finger and the thumb. If in the course of the last boiling, the liquor froth up considerably, a small bit of butter or fat is thrown into it. After the molasses have been drained from the concreted loaves, the sugar is not at all deliquescent, like equally brown sugar from the cane. Maple sugar is in taste equally agreeable with cane sugar, and it sweetens as well. When refined, it is equally fair with the loaf sugar of Europe.

The period during which the trees discharge their juices is limited to about six weeks. Towards the end of the flow, it is less abundant, less saccharine, and more difficult to be crystallized.

QUANTITY of SUGAR brought into the Markets of the World, in the year 1838.

	Tons.		Tons.
British West Indies	160,000	Bourbon	20,000
Mauritius, 35,000; and British East Indies 20,000	55,000	Cuba	100,000
		Brazils	95,000
Java	36,000	From Beet-root, in France and Belgium	65,000
Manilla and Siam	30,000		
Dutch West Indies	25,000	United States	65,000
St. Thomas and St. Croix	7,000		
Martinique and Guadaloupe	80,000		738,000*

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 acid be saturated. A copper boiler, rendered negatively electrical by soldering a strap of lead within it, is the best adapted to this process on the great scale. 325 parts of finely ground and sifted oxyde of lead, require 575 parts of strong acetic acid, of spec. grav. 7° Baumé, for neutralization, and afford 960 parts of crystallized sugar of lead. The oxyde should be gradually sprinkled into the moderately hot vinegar, with constant stirring, to prevent adhesion to the bottom; and when the proper quantity is dissolved, the solution may be weakened with some of the washings of a preceding process, to dilute the acetate, after which the whole should be heated to the boiling point, and allowed to cool slowly, in order to settle. The limpid solution is to be drawn off by a syphon, concentrated by boiling to the density of 32° B., taking care that there be always a faint excess of acid, to prevent the possibility of any basic salt being formed, which would interfere with the formation of regular crystals. Should the concentrated liquor be colored, it may be whitened by filtration through granular bone black.

Stoneware vessels, with salt glaze, answer best for crystallizers. Their edges should be smeared with candle-grease, to prevent the salt creeping over them by *efflorescent vegetation*. The crystals are to be drained, and dried in a stove-room very slightly heated. It deserves remark, that linen, mats, wood, and paper, imbued with sugar of lead, and strongly dried, readily take fire, and burn away like tinder. When the mother waters cease to afford good crystals, they should be decomposed by carbonate of soda, or by lime skilfully applied, when a carbonate or an oxyde will be obtained, fit for treating with fresh vinegar. The supernatant acetate of soda may be employed for the extraction of pure acetic acid.

* For this important table, I am indebted to James Cook, Esq., of Mincing-lane.

A main point in the preparation of sugar of lead, is to use a strong acid; otherwise much time and acid are wasted in concentrating the solution. This salt crystallizes in colorless, 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 is permanent in the air at ordinary temperatures, but effloresces when heated to 95°, with the loss of its water of crystallization and some acid, falling into a powder, which passes, in the air, slowly into carbonate of lead. The crystals dissolve in 1½ times their weight of water at 60°, but in much less of boiling water, and in 8 parts of alcohol. The solution feebly reddens litmus paper, but has an alkaline reaction upon the colors of violets and turmeric. The constituents of the salt are, 58·71 oxyde of lead, 27·08 acetic acid, and 14·21 water, in 100.

Acetate of lead is much used in calico-printing. It is poisonous, and ought to be prepared and handled with attention to this circumstance.

There are two subacetates of lead; the first of which, the ter-subacetate, has three atoms of base to one of acid, and is the substance long known by the name of Goulard's extract. It may be obtained by digesting with heat a solution of the neutral acetate, upon pure litharge or massicot. The solution affords white crystalline scales, which do not taste so sweet as sugar of lead, dissolve in not less than 30 parts of water, are insoluble in alcohol, and have a decided alkaline reaction upon test paper. Carbonic acid, transmitted through the solution, precipitates the excess of the oxyde of lead, in the state of a carbonate, a process long ago prescribed by Thenard for making white-lead. This subacetate consists of 88·66 of oxyde, and 13·34 acid, in 100 parts. It is employed for making the orange sub-chromate of lead, as also sometimes in surgery.

A *sex-subacetate*, containing 6 atoms of base, may be obtained by adding ammonia in excess to a solution of the preceding salt, and washing the precipitate with dilute water of ammonia. A white powder is thus formed, that dissolves sparingly in cold water, but gives a solution in boiling water, from which white silky needles are deposited. It consists of 92·86 oxyde, and 7·14 acid.

SULPHATES, are saline compounds of sulphuric acid with oxydized bases. The minutest quantity of them present in any solution, may be detected by the precipitate, insoluble in nitric or muriatic acid, which they afford with nitrate or muriate of baryta. They are mostly insoluble in alcohol.

SULPHATE OF ALUMINA AND POTASSA, is alum.

SULPHATE OF AMMONIA, is a salt sometimes formed by saturating the ammonia liquor of the gas-works with sulphuric acid; and it is employed for making carbonate of ammonia. See Ammonia and Sal Ammoniac.

SULPHATE OF BARYTA, is the mineral called heavy-spar, which frequently forms the gangue or vein-stone of lead and other metallic oars.

SULPHATE OF COPPER, *Roman or Blue Vitriol* (*Vitriol de Chypre*, Fr.; *Kupfervitriol*, Germ.), is a salt composed of sulphuric acid and oxyde of copper, and may be formed by boiling the concentrated acid upon the metal, in an iron pot. It is, however, a natural product of many copper mines, from which it flows out in the form of a blue water, being the result of the infiltration of water over copper pyrites, which has become oxygenated by long exposure to the air in subterranean excavations. The liquid is concentrated by heat in copper vessels, then set aside to crystallize. The salt forms in oblique four-sided tables, of a fine blue color; has a spec. gravity of 2·104; an acerb, disagreeable, metallic taste; and, when swallowed, it causes violent vomiting. It becomes of a pale dirty blue, and effloresces slightly, on long exposure to the air; when moderately heated, it loses 36 per cent. of water, and falls into a white powder. It dissolves in 4 parts of water, at 60°, and in 2 of boiling water, but not in alcohol; the solution has an acid reaction upon litmus paper. When strongly ignited, the acid flies off, and the black oxyde of copper remains. The constituents of crystallized sulphate of copper are—oxyde, 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, the farmers sprinkle a weak solution of it upon their grains and seeds before sowing them, to prevent their being attacked by birds and insects.

SULPHATE OF IRON, *Green vitriol, Copperas* (*Couperose verte*, Fr.; *Eisen-vitriol, Schwefelsures Eisenoxydul*, Germ.), is a crystalline compound of sulphuric acid and protoxyde 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 protoxyde, 36, + 1 of acid, 40, + 7 of water, 63, = 139. It may be prepared by dissolving iron to saturation in dilute sulphuric acid, evaporating the solution till a pellicle forms upon its surface, and setting it aside to crystallize. The copperas of commerce is made in a much cheaper way, by stratifying the pyrites found in the coal measures (*Vitriolkies* and *Strahlkies* of the Germans), upon a sloping puddled platform of stone, leaving the sulphuret exposed to the weather, till, by the absorption of oxygen, it effloresces, lixiviating with water the supersulphate of iron thus formed, saturating the excess of acid with plates of old iron, then evaporating and crystallizing. The other pyrites, which occurs often crystallized, called by the Germans *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 bisulphuret 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 crystallization from the alum.

This liquor used formerly to be concentrated directly in leaden vessels; but the first stage of the operation is now carried on in stone canals of considerable length, vaulted over with bricks, into which the liquor is admitted, and subjected at the surface to the action of flame and heated air, from a furnace of the reverberatory kind, constructed at one end, and discharging its smoke by a high chimney raised at the other. See Soda Manufacture. Into this oblong trough, resting on dense clay, and rendered tight in the joints by water-cement, old iron is mixed with the liquor, to neutralize the excess of acid generated from the pyrites, as also to correct the tendency to superoxydizement in copperas, which would injure the fine green color 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 peroxydizement of the iron, and effloresce in a warm atmosphere: they dissolve in 1·43 parts of water at 60°, in 0·27 at 190°, and in their own water of crystallization at a higher heat. This salt is extensively used in dyeing black, especially hats, in making ink and Prussian blue, for reducing indigo in the blue vat, in the China blue dye, for making the German oil of vitriol, and in many chemical and medicinal preparations.

There is a persulphate and 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 oxyde of iron (colcothar) in one and a half of concentrated sulphuric acid, or by adding some nitric acid to a boiling-hot solution of copperas. It forms with galls and logwood a very black ink, which is apt to become brown-black. When evaporated to dryness, it appears as a dirty white pulverulent substance, which is soluble in alcohol. It consists, in 100 parts, of 39·42 of red oxyde of iron, and 60·58 sulphuric acid.

Hydrated peroxyde of iron, prepared by precipitation with alkali from solution of the persulphate, is an excellent antidote against poisoning by arsenic. A French *perruquier*, who had swallowed two drachms of arsenious acid, was, after an interval of twenty minutes, treated with the oxyde precipitated from 6 ounces of that salt by caustic potash. It was diffused in 20 quarts of weak sirup, and administered in successive doses. After repeated vomiting and purging, the patient felt no more pain, and was pronounced by the physician to be quite convalescent.

In the copperas and alum works, a very large quantity of ochrey sediment is obtained; which is a peroxyde of iron, containing a little sulphuric acid and alumina. This deposite, calcined in reverberatory hearths, becomes of a bright-red color; and when ground and elutriated, in the same way as is described under *white lead*, forms a cheap pigment, in very considerable demand, called *English red*, in the French market.

Colcothar of Vitriol, and Crocus of Mars, are old names for red oxyde of iron. This brown-red powder is obtained in its purest state, by calcining dried sulphate of iron in a furnace till all its acid be expelled, and its base become peroxydized. It must be levigated, elutriated, and dried. This powder is employed extensively in the steel manufacture, for giving the finishing lustre to fine articles; it is used by silversmiths under the name of plate powder and *rouge;* and by the opticians for polishing the specula of reflecting telescopes. Much of the *crocus* in the market, is made, however, from the copperas and alum sediments, and is greatly inferior to the article prepared by the last process. The finest *rouge* is made by precipitating the oxyde with soda, then washing and calcining the powder.

An excellent powder for applying to razor-strops, is made by igniting together in a crucible equal parts of well-dried copperas and sea salt. The heat must be slowly raised and well regulated, otherwise the materials will boil over in a pasty state, and the product will be in a great measure lost. When well made, out of contact of air, it has the brilliant aspect of plumbago. It has a satiny feel, and is a true *fer 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 hog's-lard or tallow into a stiff cerate.

SULPHATE OF LIME. See GYPSUM.

SULPHATE OF MAGNESIA, *Epsom Salt* (*Sel amer*, Fr.; *Bittersalz*, Germ.), exists in sea-water, as also in the waters of Saidschütz, Sedlitz, and Püllna; and in many saline springs, besides Epsom in Surrey, whence it has derived its trivial name, and from which it was first extracted, in the year 1695, and continued to be so, till modern chemistry pointed out cheaper and more abundant sources of this useful purgative salt. The sulphate of magnesia, occasionally found effloresced on the surface of minerals in crystalline filaments, was called *haarsalz* (hair salt) by the older writers. The bittern of the Scotch sea-salt works is muriate of magnesia, mixed with a little sulphate of magnesia and chloride of sodium. If the proper decomposing quantity (found by trial) of sulphate of soda be added to it, and the mixed solution be evaporated at the temperature of 122° F., chloride of sodium will form by double affinity, and fall down in cubical crystals; while the solution of sulphate of magnesia which remains, being evaporated to the proper point, will afford regular crystals in four-sided prisms with four-sided acuminations. Or, if bittern be treated in a retort with the equivalent quantity of sulphuric acid, the muriatic acid may be distilled off into a series of Woulfe's bottles, and the sulphate of magnesia, soda, and lime, will remain in the retort, from which mixture the sulphate of magnesia may be separated by filtration and crystallization.

Magnesian limestone being digested with as much muriatic acid as will dissolve out its lime only, will, after washing, afford, with the equivalent quantity of sulphuric acid, a pure sulphate of magnesia; and this is certainly the simplest and most profitable process for manufacturing this salt upon the great scale. Many prepare it directly, by digesting upon magnesian limestone the equivalent saturating quantity of dilute sulphuric acid. The sulphate of lime being separated by subsidence, the supernatant solution of sulphate of magnesia is evaporated and crystallized.

This salt is composed of, magnesia 16·72, sulphuric acid 32·39, and water 50·89. When free from muriate, it tends to effloresce in the air. It dissolves in four parts of water at 32°, in 3 parts at 60°, in 1·4 at 200°, and in its own water of crystallization at a higher heat.

SULPHATE OF MANGANESE is prepared on the great scale for the calico-printers, by exposing the peroxyde of the metal and pitcoal ground together, and made into a paste with sulphuric acid, to a heat of 400° F. On lixiviating the calcined mass, a solution of the salt is obtained, which is to be evaporated and crystallized. It forms pale amethyst-colored prisms, which have an astringent bitter taste, dissolve in $2\frac{1}{2}$ parts of water, and consist of, protoxyde of manganese 31·93, sulphuric acid 35·87, and water 32·20, in 100 parts.

SULPHATE OF MERCURY is a white salt which is used in making corrosive sublimate. See MERCURY. The subsulphate, called *Turbith Mineral*, is a pale yellow pigment, and may be prepared by washing the white sulphated peroxyde with hot water, which resolves it into the soluble supersulphate, and the insoluble subsulphate, or *Turbith*. It is poisonous.

SULPHATE OF POTASSA is obtained by first igniting and then crystallizing the residuum of the distillation of nitric acid from nitre.

SULPHATE OF SODA is commonly called Glauber's salt, from the name of the chemist who first prepared it. It is obtained by igniting and then crystallizing the residuum of the distillation of muriatic acid from common salt. It crystallizes in channelled 6-sided prisms. See SODA MANUFACTURE.

SULPHATE OF ZINC, called also *White Vitriol*, is commonly prepared in the Harz, by washing the calcined and effloresced sulphuret of zinc or blende, on the same principle as green and blue vitriol are obtained from the sulphurets of iron and copper. Pure sulphate of zinc may be made most readily by dissolving the metal in dilute sulphuric acid, evaporating and crystallizing the solution. It forms prismatic crystals, which have an astringent, disagreeable, metallic taste; they effloresce in a dry air, dissolve in 2·3 parts of water at 60°, and consist of—oxyde of zinc, 28·29; acid, 28·18; water, 43·53. Sulphate of zinc is used for preparing drying oils for varnishes, and in the reserve or resist pastes of the calico-printer.

SULPHITES are a class of salts, consisting of sulphurous acid, combined in equivalent proportions with the oxydized bases.

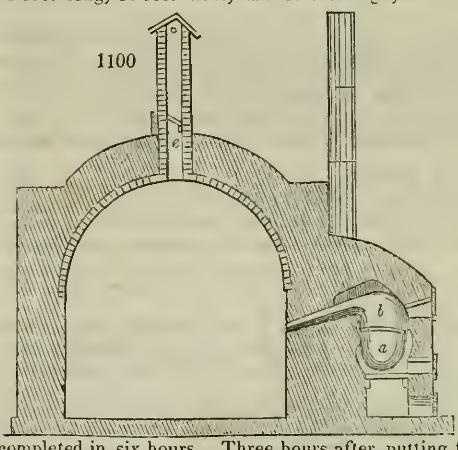
SULPHOSELS is the name given by Berzelius to a class of salts which may be prepared as follows:—1. Dissolve a salt consisting of an oxyde and an acid (an *oxysalt*) in a very small quantity of water, and pass through the solution a stream of sulphureted hydrogen, till the salt be entirely decomposed. In this operation, the *oxysalt* is transformed into a *sulphosalt*, by the sulphur of the compound gas; while its hydrogen forms water with the oxygen of the saline base. This process is applicable only to the metallic salts; and among these, not to the nitrates, carbonates, or phosphates. 2. Another method of preparing *sulphosalts* is, to add to a watery solution of sulphuret of potassium, an electro-negative metallic sulphuret, which will dissolve in the liquid till the sulphuret of potassium be saturated. This saline compound is to be employed to effect double decompositions with the oxysalts; that is, to convert the radical of another base, combined with an *oxacid,* into a sulphosalt. 3. If the electro-negative sulphuret be put in powder into a solution of the hydrosulphuret of potassa, it will dissolve and expel the sulphureted hydrogen with effervescence: just as carbonic acid is displaced by a stronger acid. For his other three methods of preparing *sulphosalts,* see his *Elements,* vol. iii. p. 336, Fr. translation.

SULPHUR, *Brimstone (Soufre,* Fr.; *Schwefel,* Germ.), is a simple combustible, solid, non-metallic, of a peculiar yellow color, very brittle, melting at the temperature of 226° Fahr., and possessing, after it has been fused, a specific gravity of 1·99. When held in a warm hand, a roll of sulphur emits a crackling sound, by the fracture of its interior parts; and when it is rubbed, it emits a peculiar well-known smell, and acquires at the same time negative electricity. When heated to the temperature of 560° F. it takes fire, burns away with a dull blue flame of a suffocating odor, and leaves no residuum. When more strongly heated, sulphur burns with a vivid white flame. It is not affected by air or water.

Sulphur is an abundant product of nature; existing sometimes pure or merely mixed, and at others in intimate chemical combination with oxygen, and various metals, forming sulphates and sulphurets. See ores of COPPER, IRON, LEAD, &c., under these metals.

Fig. 1100 represents one of the cast-iron retorts used at Marseilles for refining sulphur, wherein it is melted and converted into vapors, 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 cwts., and receives a charge of 8 cwts. of crude sulphur. The grate is 8 inches under its bottom, whence the flame rises and plays round its sides. A cast-iron capital *b*, being luted to the pot, and covered with sand, the opening in front is shut with an iron plate. The chamber *d*, is 23 feet long, 11 feet wide, and 13 feet high, with walls 32 inches thick. In the roof, at each gable, valves or flap-doors, *e*, 10 inches square, are placed at the bottom of the chimney *c*. The cords for opening the valves are led down to the side of the furnace. The entrance to the chamber is shut with an iron door. In the wall opposite to the retorts, there are two apertures near the floor, for taking out the sulphur. Each of the two retorts belonging to a chamber is charged with 7½ or 8 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.

1100



When the process of distillation is resumed, after having been some time suspended, explosions may be apprehended, from the presence of atmospherical air; to obviate the danger of which, the flap-doors must be opened every ten minutes; but they should remain closed during the setting of the retorts, and the reflux of sulphurous fumes or acid should be carried off by a draught-hood over the retorts. The distillation is carried on without interruption during the week, the charges being repeated four times in the day. By the third day, the chamber acquires such a degree of heat as to preserve the sulphur in a liquid state; on the sixth, its temperature becoming nearly 300° F., gives the sulphur a dark hue, on which account the furnace is allowed to cool on the Sunday. The fittest distilling temperature is about 248°. The sulphur is drawn off through two iron pipes cast in the iron doors of the orifices on the side of the chamber opposite to the furnace. The iron stoppers being taken out of the mouths of the pipes, the sulphur is allowed to run along an iron spout placed over red-hot charcoal, into the appropriate wooden moulds.

Native sulphur in its pure state is solid, brittle, transparent, yellow, or yellow bordering on green, and of a glassy lustre when newly broken. It occurs frequently in crystalline masses, and sometimes in complete and regular crystals, which are all derivable from the rhomboidal octahedron. The fracture is usually conchoidal and shining. Its specific gravity is 2·072, exceeding somewhat the density of melted sulphur. It possesses a very considerable refractive power; and doubles the images of objects even across two parallel faces. Sulphur, crystallized by artificial means, presents a very remarkable phenomenon; for by varying the processes, crystals are obtained whose forms belong to two different systems of crystallization. The red tint, so common in the crystals of Sicily, and of volcanic districts, has been ascribed by some mineralogists to the presence of realgar, and by others to iron; but Stromeyer has found the sublimed orange-red sulphur of Vulcano, one of the Lipari islands, to result from a natural combination of sulphur and selenium.

It is extracted from the minerals containing it, at Solfatara, by the following process:—

Ten earthen pots, of about a yard in height, and four and a half 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 two inches diameter, which bends down, and enters into another covered pot, with a hole in its bottom, standing over a tub filled with water. On applying heat to the gallery, the sulphur melts, volatilizes, and runs down in a liquid state into the tubs, where it congeals. When one operation is finished, the pots are re-charged, and the process is repeated.

In Saxony and Bohemia, the sulphurets of iron and copper are introduced into large earthenware pipes, which traverse a furnace-gallery; and the sulphur exhaled flows into pipes filled with cold water, on the outside of the furnace. 900 parts of sulphuret afford from 100 to 150 of sulphur, and a residuum of metallic protosulphuret. See Metallurgy and Copper.

Volcanic sulphur is purer than that extracted from pyrites; and as the latter is commonly mixed with arsenic, and some other metallic impregnations, sulphuric acid made of it would not answer for many purposes of the arts; though a tolerably good sulphuric acid may be made directly from the combustion of pyrites, instead of sulphur, in the lead chambers. The present high price of the Sicilian sulphur is a great encouragement to its extraction from pyrites. It is said that the common English brimstone, such as was extracted from the copper pyrites of the Parys mine of Anglesey, contained fully a fifteenth of residuum, insoluble in boiling oil of turpentine, which was chiefly orpiment; while the fine Sicilian sulphur, now imported in vast quantities by the manufacturers of oil of vitriol, contains not more than three per cent. of foreign matter, chiefly earthy, but not at all arsenical.

Sulphur has been known from the most remote antiquity. From its kindling at a moderate temperature, it is employed for readily procuring fire, and lighting by its flame other bodies not so combustible. At Paris, the preparation of sulphur matches constitutes a considerable branch of industry. The sulphurous acid formed by the combustion of sulphur in the atmospheric air, is employed to bleach woollen and silken goods, as also cotton stockings; to disinfect vitiated air, though it is inferior in power to nitric acid vapor and 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 is also employed for cementing iron bars in stone; for taking impressions from seals and cameos, for which purpose it is kept previously melted for some time, to give the casts an appearance of bronze. Its principal uses, however, are for the manufactures of vermilion, or cinnabar, gunpowder, and sulphuric acid.

See Metallurgy, page 829, for the description of Gahn's furnace for extracting sulphur from pyrites.

Pyrites as a bi-sulphuret, consisting of 45·5 parts of iron, and 54·5 of sulphur, may, by proper chemical means, be made to give off one half of its sulphur, or about 27 per cent.; but great care must be taken not to generate sulphurous acid, as is done very wastefully by the Fahlun and the Goslar processes. By the latter, indeed, not more than one or two parts of sulphur are obtained, by roasting 100 parts of the pyritous ores of the Rammelsberg mines. In these cases, the sulphur is burned, instead of being sublimed. The residuum of the operation, when it is well conducted, is black sulphuret of iron, which may be profitably employed for making copperas. The apparatus for extracting sulphur from pyrites should admit no more air than is barely necessary to promote the sublimation. Sicily produced last year 70,000 tons of sulphur, and Tuscany 1200; of which Great Britain consumed 46,000; France, 18,000; other places, 6,000. In 1820, Great Britain consumed only 5,000 tons.

SULPHURATION, is the process by which woollen, silk, and cotton goods are exposed to the vapors of burning sulphur, or to sulphurous acid gas. In the article STRAW-HAT MANUFACTURE, I have described a simple and cheap apparatus, well adapted to this operation.

Sulphuring-rooms are sometimes constructed upon a great scale, in which blankets, shawls, and woollen clothes may be suspended freely upon poles or cords. The floor should be flagged with a sloping pavement, to favor the drainage of the water that drops down from the moistened cloth. The iron or stoneware vessels, in which the sulphur is burned, are set in the corners of the apartment. They should be increased in number according to the dimensions of the place, and distributed uniformly over it. The windows and the entrance door must be made to shut hermetically close. In the lower part of the door there should be a small opening, with a sliding shutter, which may be raised or lowered by the mechanism of a cord passing over a pulley.

The aperture by which the sulphurous acid and azotic gases are let off, in order to carry on the combustion, should be somewhat larger than the opening at the bottom. A lofty chimney carries the noxious gases above the building, and diffuses them over a wide space, their ascension being promoted by means of a draught-pipe of iron, connected with an ordinary stove, provided with a valve to close its orifice when not kindled.

When the chamber is to be used, the goods are hung up, and a small fire is made in the draught-stove. The proper quantity of sulphur being next put into the shallow pans, it is kindled, the entrance door is closed, as well as its shutter, while a vent-hole near the ground is opened by drawing its cord, which passes over a pulley. After a few minutes, when the sulphur is fully kindled, that vent-hole must be almost entirely shut, by relaxing the cord; when the whole apparatus is to be let alone for a sufficient time.

The object of the preceding precautions is to prevent the sulphurous acid gas escaping from the chamber by the seams of the principal doorway. This is secured by closing it imperfectly, so that it may admit of the passage of somewhat more air than can enter by the upper seams, and the smallest quantity of fresh air that can support the combustion. The velocity of the current of air may be increased at pleasure, by enlarging the under vent-hole a little, and quickening the fire of the draught-stove.

Before opening the entrance door of the apartment, for the discharge of the goods, a small fire must be lighted in the draught furnace, the vent-hole must be thrown entirely open, and the sliding shutter of the door must be slid up, gradually more and more every quarter of an hour, and finally left wide open for a proper time. By this means the air of the chamber will become soon respirable.

SULPHURETED HYDROGEN, is a gas, composed of one part of hydrogen and sixteen parts of sulphur, by weight. Its specific gravity is 1·1912, compared to air=1·0000. It is the active constituent of the sulphurous mineral waters. When breathed, it is very deleterious to animal life; and being nearly twice as dense as air, it may be poured from its generating bottle into cavities; a scheme successfully employed by M. Thenard to destroy rats in their holes.

SULPHURIC ACID, *Vitriolic Acid*, or *Oil of Vitriol*, (*Acide sulfurique*, Fr.; *Schwefelsaüre*, Germ.) This important product, the agent of many chemical operations, was formerly procured by the distillation of dried sulphate of iron, called *green* vitriol, whence the corrosive liquid which came over, having an oily consistence, was denominated oil of vitriol. This method has been superseded in Great Britain, France, and most other countries, by the combustion of sulphur along with nitre, in large leaden chambers; but as the former process, which is still practised at Bleyl in Bohemia, and Nordhausen in Saxony, gives birth to some interesting results, I shall describe it briefly.

Into a long horizontal furnace, or gallery of brickwork, a series of earthenware retorts, of a pear shape, is arranged, with curved necks fitted into stoneware bottles or condensers. Each retort is charged with sulphate of iron, which has been previously heated to moderate redness. The first product of the distillation, a slightly acidulous phlegm, is allowed to escape; then the retort and receiver are securely luted together. The fire is now raised, and urged briskly for thirty-six hours, whereby the strong sulphuric acid is expelled, in the form of heavy white vapors, which condense in the cold receiver into an oily-looking liquid. The latter portions, when received in a separate refrigerator, frequently concrete into a crystalline mass, formerly called glacial oil of vitriol. About sixty four pounds of strong acid may be obtained from six hundred pounds of copperas. It is brown-colored; and varies in specific gravity from 1·842 to 1·896. Its boiling point is so low as 120° Fahr. When re-distilled in a glass retort, into a receiver surrounded with ice, a very moderate heat sends over white fumes, which condense into a soft solid, in silky filaments, like asbestos, tough, and difficult to cut. When this is exposed to the air, it emits copious fumes of sulphuric (not sulphurous) acid. It burns holes in paper as rapidly as a red-hot iron. Dropped in small quantities into water, it excites a hissing noise, like ignited metal; and in larger quantities, it occasions an explosion. By dropping a fragment of it into a poised vial containing water, and stoppering instantly, to prevent the ejection of liquid, by the ebullition which always ensues, I got a dilute acid, containing a known portion of the solid acid, from the specific gravity of which, as well as from its saturating power, I ascertained that the above solid sulphuric acid was truly anhydrous (*void of water*), consisting of 1 equivalent proportion of sulphur, and 3 of oxygen; or, by weight, of 16 of the former, and 24 of the latter. This acid makes a red solution of indigo.

The production of sulphuric acid from sulphur and nitre may be elegantly illustrated by means of a glass globe with a stoppered hole at its side, and four bent glass tubes inserted into a leaden cap in its upper orifice. The first tube is to be connected with a heated matrass, disengaging sulphurous acid from copper filings and sulphuric acid; the second with a retort, disengaging more slowly deutoxyde of azote (nitric oxyde) from copper filings and nitric acid; the third with a vessel for furnishing steam in a moderate current towards the end of the process, when no water has been previously admitted into the balloon; the fourth tube may be upright, and terminate in a small funnel. Through the opening in the side of the globe, atmospherical air is to be admitted from time to time, by removing the stopper; after which, the residuary lighter azote may be allowed to escape by the funnel orifice.

The nitric oxyde first absorbs oxygen from the air, becomes, in consequence, nitrous acid vapor, which giving up one third of its oxygen to the sulphurous acid, converts this, with the aid of water, into sulphuric acid, while itself returning to the state of nitric oxyde, is again qualified to take oxygen from the air, and to transfer it to the sulphurous acid gas; and thus in perpetual rotation. These oxygenating and disoxygenating processes continue until nearly the whole oxygen of the atmospheric air contained in the globe is consumed. Were there little aqueous vapor present, those gases would soon cease to operate upon each other; for though the nitric oxyde became nitrous acid, this would oxygenate little of the sulphurous acid, because the three substances would condense into white crystals upon the sides of the balloon, like hoar frost upon a window-pane in winter. These indicate a deficiency of aqueous vapor, and an excess of nitrous acid. On the admission of steam, the crystals disappear, the sulphuric acid is liquefied, the nitrous acid is converted into nitric acid and nitric oxyde; the former of which combines with the water, while the latter is converted by the atmospheric oxygen into nitrous acid vapor. A certain quantity of water is therefore requisite to prevent the formation of that crystalline compound, which condenses the nitrous acid, and renders it inoperative in transforming fresh portions of sulphurous acid into sulphuric. On these principles alone is it possible to oxygenate the sulphurous acid, by the nitrous acid resuming and surrendering a dose of oxygen, in perpetual alternation.

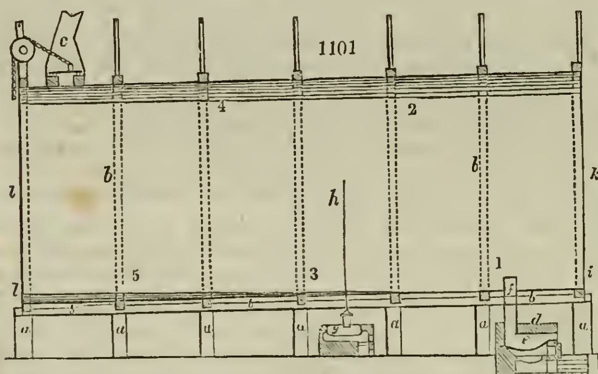
It was MM. Clement and Desormes who first had the sagacity to trace these complicated changes. They showed that nitrous acid gas and sulphurous acid gas mixed, react on each other through the intervention of moisture; that there resulted thence a combination of sulphuric acid, deutoxyde of azote (nitrous gas), and water; that this crystalline compound was instantly destroyed by more water, with the separation of the sulphuric acid in a liquid state, and the disengagement of nitrous gas; that this gas re-constituted nitrous acid at the expense of the atmospheric oxygen of the leaden chamber, and thus brought matters to their primary condition. From this point, starting again, the particles of sulphur in the sulphurous acid, through the agency of water, became fully oxygenated by the nitrous acid, and fell down in heavy drops of sulphuric acid, while the nitrous gas derived from the nitrous acid, had again recourse to the air for its lost dose of oxygen. This beautiful interchange of the oxygenous principle was found to go on, in their experiments, till either the sulphurous acid, or oxygen in the air, was exhausted.

They verified this proposition, with regard to what occurs in sulphuric acid chambers, by mixing in a crystal globe the three substances, deutoxyde of azote, sulphurous acid, and atmospheric air. The immediate production of red vapors indicated the transformation of the deutoxyde into nitrous acid gas; and now the introduction of a very little water caused the proper *reaction*, for opaque vapors rose, which deposited white star-form crystals on the surface of the glass. The gases were once more transparent and colorless; but another addition of water melted these crystals with effervescence, when ruddy vapors appeared. In this manner the phenomena were made to alternate, till the oxygen of the included air was expended, or all the sulphurous acid was converted into sulphuric. The residuary gases were found to be nitrous acid gas and azote, without sulphurous acid gas; while unctuous sulphuric acid bedewed the inner surface of the globe. Hence, they justly concluded their new theory of the manufacture of oil of vitriol to be demonstrated.

In consequence of their discovery, the manufacture of this acid has received such improvements, that a nearly double product of it may now be obtained from the same weight of materials. Indeed, the economy may be reckoned to be much greater; for one half of the more costly ingredient, the nitre, formerly employed with a given weight of sulphur, suffices at present.

In the manufacture of sulphuric acid upon the great scale, two different systems of working were long prevalent; the intermittent or periodical, and the continuous or uniform. Both were carried on in large leaden chambers. In the former, the chambers were closed during the period of combustion and gaseous combination, but were opened from time to time to introduce fresh atmospheric air. This method is, I believe, generally abandoned now, on account of the difficulties and delays attending it, though it afforded large products in skilful hands. In the latter, a continuous current of air is allowed to enter at the oven in front of the chamber for the combustion of the sulphur, and there is a constant escape of nitrogen gas, with a little sulphurous acid gas, at the remote end of the roof.

Fig. 1101 represents a sulphuric acid chamber. *a*, *a*, are the brick or stone pillars upon which it rests; *b*, *b*, are the sustaining wooden beams or joists; *c*, is the chimney for the discharge of the nitrogen; *d*, is the roof, and *e*, the sole of the hearth for the combustion of the sulphur; *f*, is the cylindrical tunnel, or pipe of lead or cast iron, for conducting the gasiform materials into the chamber; *g*, is the steam boiler; and *h*, the steam-pipe. That plan is variously modified, by different oil of vitriol makers in this country and in France. Very frequently, the oven *e*, *d*, is not situated under the chamber, but is built at the end of it, as at *i*, and arched over with brick, the crown being 9 inches thick. The pipe *f*, 18 inches in diameter, is then placed outside of the chamber, being inserted into a brick chimney, and, turning rectangularly, enters it opposite *k*. The sole of the hearth *e*, is a thick plate of cast iron (not hollowed as shown in the figure), 5 or 6 feet long, and 3 or 4 broad, with a small fireplace constructed beneath it, whose smoke-flue runs outwards, under the floor, to the side wall of the building. The oven is in this case about 2 feet in height, from the sole to the roof; and it has an iron door, about 12 inches by 15, which slides up and down in a tightly-fitted iron frame. This door is frequently placed in the side of the oven, parallel to the long side of the leaden chamber. A stout collar of lead is bolted to the chamber, where the pipe enters it. At the middle of the side of the chamber, about 2 feet above the ground, a leaden trough is fixed, which serves as a syphon-funnel and water-trap for introducing water to the acid gases.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Several manufacturers divide the chamber into a series of rectangular compartments, by parallel leaden screens, 10 or 12 feet asunder, and allow these compartments to communicate by a narrow opening, or a hole 1 foot square, in the top and bottom of each screen alternately. Thus the fumes, which enter from the chimney-pipe over *k*, will be forced, by the screen at *b*, to descend to 1, and pass through the opening there, to get into the second compartment, whence they will escape near the top at 2, thus circulating up and down, so as to occasion a complete agitation and intermixture of their heterogeneous particles. Into the side of the chamber, opposite to the centre of each compartment, a lead pipe enters, and proceeds towards the middle of the area, terminating in a narrow orifice, for discharging a jet of high-pressure steam from a boiler loaded with 40 pounds upon the square inch. This boiler should be placed under a shed exterior to the building. It deserves to be noted, that the incessant tremors produced in this pipe by the escape of the steam, cause the orifice to contract, and eventually to close almost entirely, just as the point of a glass tube does when exposed directly to the flame of a blowpipe. Provision should therefore be made against this event, by the chemical engineer.

Equidistant between the middle point and each end of the chamber, two round holes are cut out in its side, about 16 inches in diameter, and 2 feet from the floor; the sheet lead being folded back over the face of the strong deals which strengthen the chamber in that place. The edges of the holes are bevelled outwards, so as to fit a large conical plug of wood faced with lead, called a man-hole door. One or other of these doors is opened from time to time, to allow the superintendent to inspect the process, or workmen to enter, after the chamber is well ventilated, for the purpose of making repairs. The joists or tie-beams, that bind the rafters of the roof of both the leaden chamber and the house, must be at least 7 inches deep, by 3 broad, and of such length as to have their ends supported upon the outer wall, or the columnar supports of the roof, in case a number of chambers are enclosed together in parallel ranges under a vast shed. These beams, which lie two feet apart, suspend the leaden roof, by means of leaden straps soldered to its upper surface and edges. The sides of the chamber are sustained by means of similar leaden straps affixed to the wooden posts (uprights), 4 inches broad by 3 thick, placed two or three feet apart along the sides of the chamber; resting on the ground below, and mortised into the tie-beams above. Some chambers rest upon a sand-floor; but they are preferably placed upon wooden joists, supported by pillars stretching over an open area, as shown in the figure, into which the workmen may descend readily, to examine the bottom.

The outlet *c*, on the top of the chamber, is sometimes joined to a long pipe of lead laid nearly horizontally, with a slight inclination upwards, along the roof, for favoring the condensation and return of acid matter.

At the extremity *l*, of the chamber, which, having a downward slope of 1 inch in every 20 feet, should stand from 3 to 6 inches (according to its length) lower than *i*, one leg of an inverted syphon pipe is fixed by fusion, into which the liquid of the chamber passing, will show by its altitude the depth on the bottom within. From the cup-shaped orifice of that bent-up pipe, the acid of the chamber is drawn off by an ordinary leaden syphon into the concentration pans.

The sheet lead of which the sides and top are made should weigh from 5 to 6 pounds per square foot; that of the bottom should be nearly of double thickness.

Having now detailed, with sufficient minuteness, the construction of the chamber, I shall next describe the mode of operating with it. There are at least two plans at present in use for burning the sulphur continuously in the oven. In the one, the sulphur is laid on the hearth *e*, (or rather on the flat hearth in the separate oven, above described,) and is kindled by a slight fire placed under it; which fire, however, is allowed to go out after the first day, because the oven becomes by that time sufficiently heated by the sulphur flames to carry on the subsequent combustion. Upon the hearth, an iron tripod is set, supporting, a few inches above it, a hemispherical cast-iron bowl (basin) charged with nitre and its decomposing proportion of strong sulphuric acid. In the other plan, 12 parts of bruised sulphur, and 1 of nitre, are mixed in a leaden trough on the floor with 1 of strong sulphuric acid, and the mixture is shovelled through the sliding iron door upon the hot hearth. The successive charges of sulphur are proportioned, of course, to the size of the chamber. In one of the largest, which is 120 feet long, 20 broad, and 16 high, 12 cwts. are burned in the course of 24 hours, divided into 6 charges, every fourth hour, of 2 cwts. each. In chambers of one sixth greater capacity, containing 1400 metres cube, 1 ton of sulphur is burned in 24 hours. This immense production was first introduced at Chaunay and Dieuze, under the management of M. Clement-Desormes. The bottom of the chamber should be covered at first with a thin stratum of sulphuric acid, of spec. grav. 1·07, which decomposes nitrous acid into oxygen and nitrous gas; but not with more water, which would absorb the nitrous acid vapors, and withdraw them from their aerial sphere of action. The vapor of nitric acid, disengaged from the nitre on the hearth of the oven, when brought into intimate contact with the sulphurous acid, either gives up oxygen to it, becomes itself nitrous gas, and converts it into sulphuric acid; or combines with the sulphurous acid into the crystalline compound above described, which, the moment it meets with moisture, is decomposed into sulphuric acid and nitrous gas. The atmospherical oxygen of the chamber immediately reconverts this gas into nitrous or nitric acid fumes, which are again ready, with the co-operation of sulphurous acid gas and aqueous vapor, to produce fresh quantities of hydrous sulphuric acid (oil of vitriol) and nitrous gas. At low temperatures, this curious play of chemical affinities has a great tendency to form the crystalline compound, and to deposite it in a crust of considerable thickness (from one half to one inch) on the sides of the chamber, so as to render the process inoperative. A circumstance of this kind occurred, in a very striking manner, during winter, in a manufacture of oil of vitriol in Russia; and it has sometimes occurred, to a moderate extent, in Scotland. It is called, at Marseilles, the *maladie des chambres*. It may be certainly prevented, by maintaining the interior of the chamber, by a jet of steam, at a temperature of 100° F. When these crystals fall into the dilute acid at the bottom, they are decomposed with a violent effervescence, and a hissing gurgling noise, somewhat like that of a tun of beer in brisk fermentation.

M. Clement-Desormes demonstrated the proposition relative to the influence of temperature by a decisive experiment. He took a glass globe, furnished with three tubulures, and put a bit of ice into it. Through the first opening he then introduced sulphurous acid gas; through the second, oxygen; and through the third, nitrous gas (deutoxyde of azote). While the globe was kept cool, by being plunged in iced water, no sulphuric acid was formed, though all the ingredients essential to its production were present. But on exposing the globe to a temperature of 100° Fahr., the four bodies began immediately to react on each other, and oil of vitriol was condensed in visible *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, nitrous, sulphurous, and dry sulphuric acids. No sooner is this reaction accomplished, than the nitrous gas resumes its oxygen, from the continuous atmospherical current, and becomes again fit to operate a like round of transmutations with sulphurous acid, steam, and oxygen. The nitrogen (azote), which ought to be the only residuum in a *perfectly* regulated vitriol chamber, escapes, by its relative lightness, at the opening *c*, in the roof, or, more properly speaking, is displaced by the influx of the heavier gases at the entrance-pipe.

On the intermittent plan, after the consumption of each charge, and condensation of the product, the chamber was opened, and freely ventilated, so as to expel the residuary azote, and replenish it with fresh atmospheric air. In this system there were four distinct stages or periods:—1. Combustion for two hours; 2. Admission of steam, and settling, for an hour and a half; 3. Conversion, for three hours, during which interval the drops of strong acid were heard falling like heavy hailstones on the bottom; 4. Purging of the chamber, for three quarters of an hour.

By the continuous method, sulphuric acid may be currently obtained in the chambers, of the specific gravity 1·350, or 1·450 at most; for, when stronger, it absorbs and retains permanently much nitrous acid gas; but by the intermittent, so dense as 1·550, or even 1·620; whence in a district where fuel is high priced, as near Paris, this method recommended itself by economy in the concentration of the acid. In Great Britain, and even in most parts of France, however, where time, workmen's wages, and interest of capital, are the paramount considerations, manufacturers do not find it for their interest in general to raise the density of the acid in the chambers above 1·400, or at most 1·500; as the further increase goes on at a retarded rate, and its concentration from 1·400 to 1·600, in leaden pans, costs very little.

At about the specific gravity of 1·35, in Great Britain, the liquid of the chambers is run off, by the syphon above described, into a leaden gutter or spout, which discharges it into a series of rectangular vessels made of large sheets of lead, of 12 or 14 lbs. to the square foot, simply folded up at the angles into pans 8 or 10 inches deep, resting upon a grate made of a pretty close row of wrought-iron bars of considerable strength, under which the flame of a furnace plays. Where coals are very cheap, each pan may have a separate fire; but where they are somewhat dear, the flame, after passing under the lowest pan of the range, which contains the strongest acid (at about 1·600), proceeds upwards with a slight slope to heat the pans of weaker acid, which, as it concentrates, is gradually run down by syphons to replenish the lower pans, in proportion as their aqueous matter is dissipated. The 3 or 4 pans constituting the range are thus placed in a straight line, but each at a different level, terrace like; *en gradins*, as the French say.

When the acid has thereby acquired the density of 1·650, or 1·700 at most, it must be removed from the leaden evaporators, because, when of greater strength, it would begin to corrode them; and it is transferred into leaden coolers, or run through a long refrigeratory worm-pipe surrounded by cold water. In this state it is introduced into glass or platinum retorts, to undergo a final concentration, up to the specific gravity of 1·842, or even occasionally 1·845, in consequence of slight saline impurities. When glass retorts are used, they are set in a long sand-bath over a gallery furnace, resting on fire tiles, under which a powerful flame plays; and as the flue gradually ascends from the fire-place, near to which it is most distant from the tiles, to the remoter end, the heat acts with tolerable equality on the first and last retort in the range. When platinum stills are employed, they are fitted into the inside of cast-iron pots, which protect the thin bottom and sides of the precious metal. The fire being applied directly to the iron, causes a safe, rapid, and economical concentration of the acid. The iron pots, with their platinum interior, filled with concentrated boiling-hot oil of vitriol, are lifted out of the fire-seat by tackle, and let down into a cistern of cold water, to effect the speedy refrigeration of the acid, and facilitate its transvasion into carboys packed in osier baskets lined with straw. Sometimes, however, the acid is cooled by running it slowly off through a long platinum syphon, surrounded by another pipe filled with cold water. *Fig.* 1102 shows my contrivance for this purpose.

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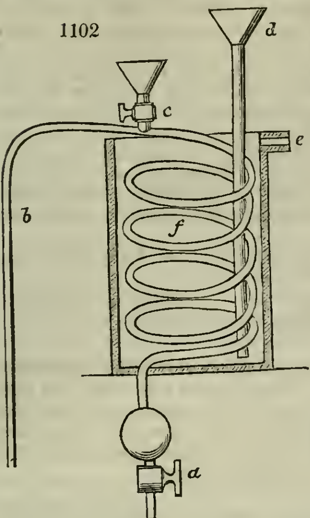


The under stopcock *a*, being shut, and the leg *b*, being plunged to nearly the bottom of the still, the worm is to be filled with concentrated cold acid through the funnel *c*. If that stopcock is now shut, and *a* opened, the acid will flow out in such quantity as to rarefy the small portion of air in the upper part of the pipe *b*, sufficiently to make the hot acid rise up over the bend, and set the syphon in action. The flow of the fluid is to be so regulated by the stopcock *a*, that it may be greatly cooled in its passage by the surrounding cold water in the vessel *f*, which may be replenished by means of the tube and funnel *d*, and overflow at *e*.

A manufacturer of acid in Scotland, who burns in each chamber 210 pounds of sulphur in 24 hours, being at the rate of 420 pounds for 20,000 cubic feet (= nearly 2000 metres cube), has a product of nearly 3 pounds of concentrated oil of vitriol for every pound of sulphur and twelfth of a pound of nitre. The advantage of his process results, I conceive, from the lower concentration of the acid in the chambers, which favors its more rapid production.

The platinum retort admits of from 4 to 6 operations in a day, when it is well mounted and managed. It has a capital of platinum, furnished with a short neck, which conducts the disengaged vapors into a lead worm of condensation; and the liquid thus obtained is returned into the lead pans. Great care must be taken to prevent any particles of lead from getting into the platinum vessel, since at the temperature of boiling sulphuric acid, the lead unites with the precious metal, and thus causes holes in the retort. These must be repaired by soldering-on a plate of platinum with gold.

Before the separate oven or hearth for burning the sulphur in contact with the nitre was adopted, this combustible mixture was introduced into the chamber itself, spread on iron trays or earthen pans, supported above the water on iron stands. But this plan was very laborious and unproductive. It is no longer followed.

One of the characters of the good quality of sulphuric acid, is its dissolving indigo without altering its fine blue color.

Sulphuric acid, when well prepared, is a colorless and inodorous liquid, of an oily aspect, possessing a specific gravity, in its most concentrated state, of 1·842, when redistilled, but as found in commerce, of 1·845. It is eminently acid and corrosive, so that a single drop will communicate the power of reddening litmus to a gallon of water, and will produce an ulcer of the skin when allowed to remain upon it. If swallowed in its strongest state, in even a small quantity, it acts so furiously on the throat and stomach as to cause intolerable agony and speedy death. Watery diluents, mixed with chalk or magnesia, are the readiest antidotes. At a temperature of about 600° F., or a few degrees below the melting point of lead, it boils and distils over like water. This is the best method of procuring sulphuric acid free from the saline and metallic matters with which it is sometimes contaminated.

The affinity of sulphuric acid for water is so strong, that when exposed in an open saucer, it imbibes one-third of its weight from the atmosphere in 24 hours, and fully six times its weight in a few months. Hence it should be kept excluded from the air. If four parts, by weight, of the strongest acid be suddenly mixed with one part of water, both being at 50° F., the temperature of the mixture will rise to 300°; while, on the other hand, if four parts of ice be mixed with one of sulphuric acid, they immediately liquefy and sink the thermometer to 4° below zero. From the great attraction existing between this acid and water, a saucer of it is employed to effect the rapid condensation of aqueous vapor as it exhales from a cup of water placed over it; both standing under the exhausted receiver of an air-pump. By the cold produced by this unchecked evaporation in vacuo, the water is speedily frozen.

To determine the purity of sulphuric acid, let it be slowly heated to the boiling point of water, and if any volatile acid matter be present, it will evaporate, with its characteristic smell. The presence of saline impurity, which is the common one, is discovered by evaporating a given weight of it in a small capsule of platinum placed on red-hot cinders. If more than two grains remain out of 500, the acid may be reckoned to be impure. The best test for sulphuric acid, and the soluble salts into which it enters, is the nitrate of baryta, of which 182 parts are equivalent to 49 of the strongest liquid acid, or to 40 of the dry, as it exists in crystallized sulphate of potassa. One twenty thousandth part of a grain of the acid may be detected by the grayish-white cloud which baryta forms with it. 100 parts of the concentrated acid are neutralized by 143 parts of dry carbonate of potassa, and by 110 of dry carbonate of soda, both perfectly pure.

Of all the acids, the sulphuric is most extensively used in the arts, and is, in fact, the primary agent for obtaining almost all the others, by disengaging them from their saline combinations. In this way, nitric, muriatic, tartaric, acetic, and many other acids, are procured. It is employed in the direct formation of alum, of the sulphates of copper, zinc, potassa, soda; in that of sulphuric ether, of sugar by the saccharification of starch, and in the preparation of phosphorus, &c. It serves also for opening the pores of skins in tanning, for clearing the surfaces of metals, for determining the nature of several salts by the acid characters that are disengaged, &c.

According to the analysis of Dr. Thomson, the crystalline compound deposited occasionally in the leaden chambers above described consists of—

Sulphurous acid,	0·6387, or 3 atoms.		Water - -	0·0733, or 1 atom.
Sulphuric acid,	0·5290	2	Sulphate of lead,	0·0140.
Nitric acid -	0·3450	1 atom.		

He admits that the proportion of water is a little uncertain; and that the presence of sulphurous acid was not proved by direct analysis. When heated with water, the crystalline matter disengages nitrous gas in abundance; lets fall some sulphate of lead; and the liquid is found to be sulphuric acid. When heated without water, it is decomposed with emission of nitrous gas and fuming nitric acid; leaving a liquid which, mixed with water, produces a brisk effervescence, consisting chiefly of nitrous gas.

The following Table shows the quantity of concentrated and dry sulphuric acid in 100 parts of dilute, at different densities, by my experiments, published in the Quarterly Journal of Science, for October, 1817:—

Liquid.	Spec. gravity.	Dry.	Liquid.	Spec. gravity.	Dry.	Liquid.	Spec. gravity.	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	6·52
75	1·6500	61·15	41	1·3080	33·43	7	1·0477	5·71
74	1·6415	60·34	40	1·2999	32·61	6	1·0405	4·89
73	1·6321	59·52	39	1·2913	31·80	5	1·0336	4·08
72	1·6204	58·71	38	1·2826	30·98	4	1·0268	3·26
71	1·6090	57·89	37	1·2740	30·17	3	1·0206	2·446
70	1·5975	57·08	36	1·2654	29·35	2	1·0140	1·63
69	1·5868	56·26	35	1·2572	28·54	1	1·0074	0·8154
68	1·5760	55·45	34	1·2490	27·72			
67	1·5648	54·63	33	1·2409	26·91			

SUMACH (Eng. and Fr.; *Schmack*, Germ.) is the powder of the leaves, peduncles, and young branches of the *Rhus coriaria*, and *Rhus cotinus*, shrubs which grow in Hungary, the Bannat, and the Illyrian provinces. Both kinds contain tannin, with a little yellow coloring matter, and are a good deal employed for tanning light-colored leathers; but the first is the best. With mordants, it dyes nearly the same colors as galls. In calico-printing, sumach affords, with a mordant of tin, a yellow color; with acetate of iron, weak or strong, a gray or black; and with sulphate of zinc, a brownish-yellow. A decoction of sumach reddens litmus paper strongly; gives white flocks with the proto-muriate of tin; pale yellow flocks with alum; blue flocks with red sulphate of iron, with an abundant precipitate. In the south of France, the twigs and leaves of the *Coriaria myrthifolia* are used for dyeing, under the name of *rédoul*, or *rodou*.

SWEEP-WASHER is the person who extracts from the sweepings, potsherds, &c., of refineries of silver and gold, the small residuum of precious metal.

SYNTHESIS is a Greek word, which signifies combination, and is applied to the chemical action which unites dissimilar bodies into a uniform compound; as sulphuric acid and lime, into gypsum; or chlorine and sodium, into culinary salt.

SIRUP is a solution of sugar in water. Cane-juice, concentrated to a density of 1·300, forms a sirup 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 with the calender.

TACAMAHAC is a resin obtained from the *Fagura octandra*, a tree which grows in Mexico and the West Indies. It occurs in yellowish pieces, of a strong smell, and a bitterish aromatic taste. That from the island of Madagascar has a greenish tint.

TAFFETA is a light silk fabric, with a considerable lustre or gloss.

TAFIA is a variety of rum.

TALC is a mineral genus, which is divided into two species, the common and the indurated. The first occurs massive, disseminated in plates, imitative, or crystallized in small six-sided tables. It is 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; oxyde 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-gray color; is massive, with tabular fragments, translucent on the edges, soft, with a white streak; easily cut or broken, but is not flexible; and has a greasy feel. It occurs in the same localities as the preceding. It is employed in the porcelain and crayon manufactures; as also as a crayon itself, by carpenters, tailors, and glaziers.

TALLOW (*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 1836, 1,186,364 cwts. 1 qr. 4 lbs.; in 1837, 1,308,734 cwts. 1 qr. 4 lbs. Retained for home consumption, in 1836, 1,318,678 cwts. 1 qr. 25 lbs.; in 1837, 1,294,009 cwts. 2 qrs. 21 lbs. Duty received, in 1836, £208,284; in 1837, £204,377.

TALLOW, PINEY. See PINEY TALLOW.

TAMPING is a term used by miners to express the filling up of the hole which they have bored in a rock, for the purpose of blasting it with gunpowder. See MINES.

TAN, or TANNIC ACID. (*Tannin*, Fr.; *Gerbstoff*, Germ.) See its preparation and properties described under GALLS.

The barks replete with this principle should be stripped with hatchets and bills, from the trunk and branches of trees, not less than 30 years of age, in spring, when their sap flows most freely. Trees are also sometimes barked in autumn, and left standing, whereby they cease to vegetate, and perish ere long; but afford, it is thought, a more compact timber. This operation is, however, too troublesome to be generally practised, and therefore the bark is commonly obtained from felled trees; and it is richer in tannin the older they are. The bark mill is described in Gregory's *Mechanics*, and other similar works.

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 ounces, 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		
Colored or middle bark of oak	19		
Do. Spanish chestnut	14		
Do. Leicester willow	16		
Entire bark of oak	29		
Do. Spanish chestnut	21		
Do. 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	—	30	
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	
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

TANNING (*Tanner*, Fr.; *Gärberei*, Germ.) is the art of converting skin into Leather, which see. It has been ascertained, beyond a doubt, that "the saturated infusions of astringent barks contain much less extractive matter, in proportion to their tannin, than the weak infusions; and when skin is quickly tanned (in the former), common experience shows that it produces leather less durable than leather slowly formed."* The older tanners, who prided themselves on producing a substantial article, were so much impressed with the advantages of slowly impregnating skin with astringent matter, that they employed no concentrated infusion (ooze) in their pits, but stratified the skins with abundance of ground bark, and covered them with soft water, knowing that its active principles are very soluble, and that, by being gradually extracted, they would penetrate uniformly the whole of the animal fibres, instead of acting chiefly upon the surface, and making brittle leather, as the strong infusions never fail to do. In fact, 100 pounds of skin, quickly tanned in a strong infusion of bark, produce 137 of leather; while 100 pounds, slowly tanned in a weak infusion, produce only 117½. The additional 19½ pounds weight in the former case serve merely to swell the tanner's bill, while they deteriorate his leather, and cause it to contain much less of the textile animal solid. Leather thus highly charged with tannin is, moreover, so spongy as to allow moisture to pass readily through its pores, to the great discomfort and danger of persons who wear shoes made of it. That the saving of time, and the increase of product, are temptations strong enough to induce many modern tanners to steep their skins in a succession of strong infusions of bark, is sufficiently intelligible; but that any shoemaker should be so ignorant or so foolish as to proclaim that his leather is made by a process so injurious to its quality, is unaccountably stupid.

TANTALUM is the rare metal, also called Columbium.

TAPESTRY is an ornamental figured textile fabric of worsted or silk, for lining the walls of apartments; of which the most famous is that of the Gobelins Royal Manufactory, near Paris.

TAPIOCA is a modification of starch, partially converted into gum, by heating and stirring cassava upon iron plates. See Cassava and Starch.

TAR (*Goudron*, Fr.; *Ther*, Germ.) is the viscid, brown-black, resino-oleaginous compound, obtained by distilling wood in close vessels, or in ovens of a peculiar construction. See Charcoal, Pitcoal, coking of, and Pyroligneous Acid. 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.

Tar imported into the United Kingdom, in 1836, 9,797 lsts. 8 barrels; in 1837,

* Sir H. Davy, on the Operation of Astringent Vegetables in Tanning.—*Phil. Trans.* 1803.

11,480lsts. 1 brl. Retained for home consumption, in 1836, 9,639lsts. 8 brls.; in 1837, 11,686lsts. 2 brls. Duty received, in 1836, £7,231; in 1837, £8,775.

TARRAS; see CEMENT, and MORTAR, HYDRAULIC.

TARTAR (*Tartre*, Fr.; *Weinstein*, Germ.), called also argal or argol, is the crude bitartrate of potassa, which exists in the juice of the grape, and is deposited from wines in their fermenting casks, being precipitated in proportion as the alcohol is formed, in consequence of its insolubility in that liquid. There are two sorts of argal known in commerce, the white, and the red; the former, which is of a pale-pinkish color, is the crust let fall by white wines; the latter is a dark-red, from red wines.

The crude tartar is purified, or converted into cream of tartar, at Montpellier, by the following process:—

The argal having been ground under vertical mill-stones, and sifted, one part of it is boiled with 15 of water, in conical copper kettles, tinned on the inside. As soon as it is dissolved, 3½ parts of ground pipe-clay are introduced. The solution being well stirred, and then settled, is drawn off into crystallizing vessels, to cool; the crystals found concreted on the sides and bottom are picked out, washed with water, and dried. The mother water is employed upon a fresh portion of argal. The crystals of the first crop are re-dissolved, re-crystallized, and exposed upon stretched canvass to the sun and air, to be bleached. The clay serves to abstract the coloring matter. The crystals formed upon the surface are the whitest, whence the name cream of tartar is derived.

Purified tartar, the bitartrate of potassa, is thus obtained in hard clusters of small colorless crystals, which, examined by a lens, are seen to be transparent 4-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° F. It is insoluble in alcohol. It consists of 24·956 potassa, 70·276 tartaric acid, and 4·768 water. It affords, by dry distillation, pyrotartaric acid, and an empyreumatic oil; while carbonate of potassa remains associated with much charcoal in the retort, constituting black flux. Tartar is used in dyeing, medicine, and for extracting—

TARTARIC ACID. (*Acide tartarique*, Fr.; *Weinsteinsäure*, Germ.) This is prepared by adding gradually to a boiling-hot solution of 100 parts of tartar, in a large copper boiler, 26 of chalk, made into a smooth pap with water. A brisk effervescence ensues, by the disengagement of the carbonic acid of the chalk, while its base combines with the acid excess in the tartar, and forms an insoluble precipitate of tartrate of lime. The supernatant liquor, which is a solution of neutral tartrate of potassa, must be drawn off by a 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 canvass, and edulcoration 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 crystallize. The crystals, being re-dissolved and re-crystallized, become colorless 6-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 blanch the colored 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.

TARTRATES are salts composed of tartaric acid, and oxydized bases, in equivalent proportions.

TAWING is the process of preparing the white skins of the sheep, doe, &c. See LEATHER.

TEA, *green*, contains 34·6 parts of tannin, 5·9 of gum, 5·7 of vegetable albumine, 51·3 of ligneous fibre, with 2·5 of loss; and *black* tea contains 40·6 of tannin, 6·3 of gum, 6·4 of vegetable albumine, 44·8 of ligneous fibre, with 2 of loss. The ashes contain silica, carbonate of lime, magnesia, and chloride of potassium.—*Frank.* Davy obtained 32·5 of extract from Souchong tea; of which 10 were precipitated by gelatine. He found 8·5 only of tannin in green tea. The latter chemist is most to be depended upon. Chemical analysis has not yet discovered that principle in tea, to which its exciting property is due.

*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 frame-work 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 color and bitter flavor. 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 burnt. When the leaves become inconveniently hot to the hand, they are quickly taken out and delivered to another man with a close-worked bamboo basket ready to receive them. A few leaves that may have been left behind are 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 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 pre-

* By C. A. Bruce, superintendent of tea culture.

vent 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 color.

Next day the leaves are all sorted into large, middling, and small; sometimes there are four sorts. All these, the Chinese informed me, become so many different kinds of teas; the smallest leaves they called Pha-ho, the second, Pow-chong, the third Su-chong, and the fourth, or the largest leaves, Toy-chong. After this assortment they are again put on the sieve in the drying basket (taking great care not to mix the sorts), and on the fire, as on the preceding day; but now very little more than will cover the bottom of the sieve is put in at one time, the same care of the fire is taken as before, and the same precaution of tapping the drying basket every now and then. The tea is taken off the fire with the nicest care, for fear of any particle of the tea falling into it. Whenever the drying basket is taken off, it is put on the receiver, the sieve in the drying basket taken out, the tea turned over, the sieve replaced, the tap given, and the basket placed again over the fire. As the tea becomes crisp, it is taken out and thrown into a large receiving basket, until all the quantity on hand has become alike dried and crisp; from which basket it is again removed into the drying basket, but now in much larger quantities. It is then piled up eight and ten inches high on the sieve in the drying basket; in the centre a small passage is left for the hot air to ascend; the fire that was before bright and clear, has now ashes thrown on it to deaden its effect, and the shakings that have been collected are put on the top of all; the tap is given, and the basket with the greatest care is put over the fire. Another basket is placed over the whole, to throw back any heat that may ascend. Now and then it is taken off, and put on the receiver; the hands, with the fingers wide apart, are run down the sides of the basket to the sieve, and the tea gently turned over, the passage in the centre again made, &c., and the basket again placed on the fire. It is from time to time examined, and when the leaves have become so crisp that they break by the slightest pressure of the fingers, it is taken off, when the tea is ready. All the different kinds of leaves underwent the same operation. The tea is now little by little put into boxes, and first pressed down with the hands and then with the feet (clean stockings having been previously put on).

There is a small room inside of the tea-house, 7 cubits square and 5 high, having bamboos laid across on the top to support a net-work 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 net-work, on an iron pan, the same as is used to heat the leaves; some fire is put into it, either of grass or bamboo, so that the flame may ascend high; the pan is put on a square wooden frame, that has wooden rollers on its legs, and pushed round and round this little room by one man, while another feeds the fire, the leaves on the top being occasionally turned; when they are a little withered, the fire is taken away, and the leaves brought down and manufactured into tea, in the same manner as if it had been dried in the sun. But this is not a good plan, and never had recourse to, if it can possibly be avoided.

Tea imported into the United Kingdom, in 1836, 49,307,701 lbs.; in 1837, 36,765,735 lbs. Retained for home comsumption, in 1836, 49,841,507 lbs.; in 1837, 31,872 lbs. Duty received, in 1836, £4,728,600; in 1837, £3,319,665.

TEASEL, the head of the thistle (*Dipsacus*), is employed to raise the nap of cloth. See Woollen Manufacture.

TEETH. See Bones.

TELLURIUM, is a metal, too rare and high-priced to be used in the arts.

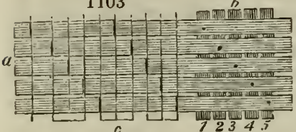
TERRA-COTTA, literally baked clay, is the name given to statues, architectural decorations, figures, vases, &c., modelled or cast in a paste made of pipe or potter's clay and a fine-grained colorless sand, from Ryegate, with pulverized potsherds, slowly dried in the air, and afterwards fired to a stony hardness in a proper kiln. See Stone, artificial.

TERRA DI SIENA, is a brown ferruginous ochre, employed in painting.

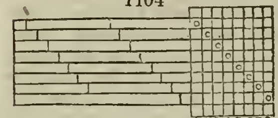
TESTS, are chemical reagents of any kind, which indicate, by special characters, the nature of any substance, simple or compound. See Assay, the several metals, acids, &c.

TEXTILE FABRICS. The first business of the weaver is to adapt those parts of his loom which move the warp, to the formation of the various kinds of ornamental figures which the cloth is intended to exhibit. This subject is called the *draught*, drawing or reading in, and the cording of looms. In every species of weaving, whether direct or cross, the whole difference of pattern or effect is produced, either by the succession in which the threads of warp are introduced into the heddles, or by the succession in which those heddles are moved in the working. The heddles being stretched between two shafts of wood, all the heddles connected by the same shafts are called a leaf; and as the operation of introducing the warp into any number of leaves is called drawing a warp, the plan of succession is called the draught. When this operation has been performed correctly, the next part of the weaver's business is to connect the different leaves with the levers or treddles by which they are to be moved, so that one or more may be raised or sunk by every treddle successively, as may be required to produce the peculiar pattern. These connexions 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.* 1103, 1104, &c.

1103



1104

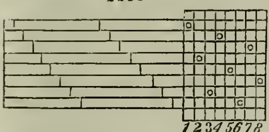


These plans are horizontal sections of a loom, the heddles being represented across the paper at *a*, and the treddles under them, and crossing them at right angles, at *b*. In *figs.* 1103 and 1104, they are represented as if they were distinct pieces of wood, those across being the under shaft of each 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.* 1103, the right-hand thread, next to *a*, passes through the eye of a heddle upon the back leaf, and is disconnected with all the other leaves; the next thread passes through a heddle on the second leaf; the third, through the third leaf; the fourth, through the fourth leaf; and the fifth, through the fifth or front leaf. One set of the draught being now completed, the weaver recommences with the back leaf, and proceeds in the same succession again to the front. Two sets of the draught are represented in this figure, and the same succession, it is understood by weavers (who seldom draw more than one set), must be repeated until all the warp is included. When they proceed to apply the cords, the right-hand part of the plan at *b* serves as a guide. In all the plans shown by these figures, excepting one which shall be noticed, a connexion must be formed, by cording, between every leaf of heddles and every treddle; for all the leaves must either rise or sink. The raising motion is effected by coupling the leaf to one end of its correspondent top lever; the other end of this lever is tied to the long march below, and this to the treddle. The sinking connexion is carried directly from under the leaf to the treddle. To direct a weaver which of these connexions is to be formed with each treddle, a black spot is placed when a leaf is to be raised, where the leaf and treddle intersect each other upon the plan, and the sinking connexions are left blank. For example, to cord the treddle 1, to the back leaf, put a raising cord, and to each of the other four, sinking cords; for the treddle 2, raise the second leaf, and sink the remaining four, and so of the rest; the spot always denoting the leaf or leaves to be raised. The *figs.* 1103, and 1104, 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 1112; but to save room, the latter has been avoided, and the succession marked by the order of the figures under the intervals which denote the treddles.

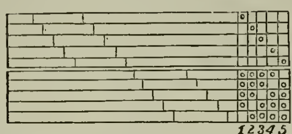
Some explanation of the various kinds of fanciful cloths represented by these plans, may serve further to illustrate this subject, which is, perhaps, the most important of any connected with the manufacture of cloth, and will also enable a person who thoroughly studies them, readily to acquire a competent knowledge of the other varieties in weaving, which are boundless. *Figs.* 1103 and 1104 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.* 1104. 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. 1105 and 1106 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.

1105

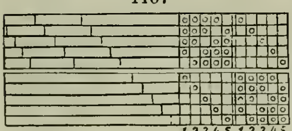


1106

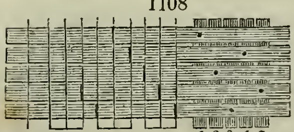


When the broken tweel of eight leaves is used, the effect is much superior to what could be produced by a smaller number; for in this, two leaves are passed in every interval, which gives a much nearer resemblance to plain cloth than the others. For this reason it is preferred in weaving the finest damasks. 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 which mark the raising cords, and comparing them with those of the broken tweel of five leaves. *Fig.* 1107 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.* 1104. 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.* 1108.

1107



1108



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.* 1108, 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:—

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. 1109 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.* 1103, *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.

1109

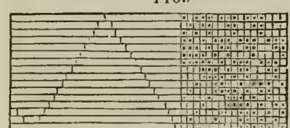


Fig. 1110 represents the draught of the diaper mounting, and the cording of the front leaves, which are moved by treddles. From the plan, it will appear that 5 threads are included in every mail of the harness, and that these are drawn in single threads through the front leaves. The cording forms an exception to the general rules, that when one or more leaves are raised, all the rest must be sunk; for in this instance, one leaf rises, one sinks, and three remain stationary. An additional mark, therefore, is used in this plan. The dots, as formerly, denote raising cords; the blanks, sinking cords; and where the cord is to be totally omitted, the cross marks × are placed.

1110

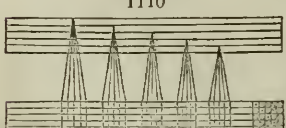
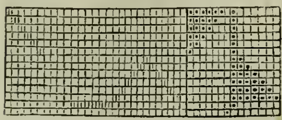


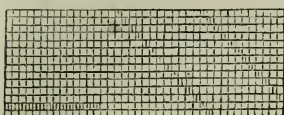
Fig. 1111 is the draught and cording of a spot whose two sides are similar, but reversed. That upon the plan forms a diamond, similar to the one drawn upon the design paper in the diagram, but smaller in size. The draught here is reversed, as in the dimity plan, and the treading is also to be reversed, 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, two 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.

1111



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.

1112



Dissimilar spots, are those whose sides are quite different from each other. The draught only of these is represented by *fig*. 1112. The cording depends entirely upon the figure.

Fig. 1113 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.

1113

1114

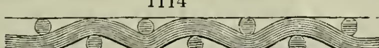
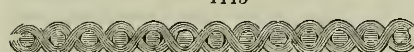


Fig. 1114 is a representation of a section of cloth of an open fabric, where the round dots which represent the warp are placed at a considerable distance from each other.

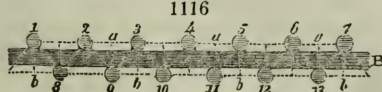
Fig. 1115 may be supposed a plain fabric of that description which approaches the most nearly to any idea we can form of the most dense or close contact of which yarn can be made susceptible. Here the warp is supposed to be so tightly stretched in the loom as to retain entirely the parallel state, without 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.

1115



In *fig*. 1116 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

1116



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 heddles 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 approximation would be inverted. *Fig.* 1117 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.* 1114 and *fig.* 1115.

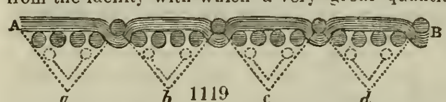
1117

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.* 1118. See CARPET.

1118

Of the simplest kind of tweeled fabrics, a section is given in *fig.* 1119.

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.* 1116, we shall readily discover the very different way in which the tweeled fabric is affected.



1119

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.* 1120. 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.

1120

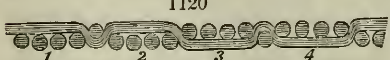


Fig. 1121 represents that kind of tweeled work which produces an ornamental effect, and adds even to the strength of a fabric, in so far as accumulation of matter can be considered in that light. The figure represents a piece of velvet cut in section, and of that kind which, being woven upon a tweeled ground, is known by the name of Genoa velvet. 1st. Because, by combining a great quantity

1121

of material in a small compass, they afford great warmth. 2d. From the great resistance which they oppose to external friction, they are very durable. And 3d. Because, from the very nature of the texture, they afford the finest means of rich ornamental decoration.

The use of velvet cloths in cold weather is a sufficient proof of the truth of the first. The manufacture of plush, corduroy, and other stuffs for the dress of those exposed to the accidents of laborious employment, evinces the second; and the ornamented velvets and Wilton carpeting are demonstrative of the third of these positions.

In the figure, the diagonal form which both the warp and woof of cloth assume, is very apparent from the smallness of the scale. Besides what this adds to the strength of the cloth, the flushed part, which appears interwoven at the darkly shaded intervals, 1, 2, &c., forms, when finished, the whole covering or upper surface. The principle, in so far as regards texture, is entirely the same as any other tweeled fabric.

Fig. 1122, which represents corduroy, or king's cord, is merely striped velvet. The principle is the same, and the figure shows that the one is a copy of the other. The remaining figures represent those kinds of work which are of the most flimsy and open description of texture; those in which neither strength, warmth, nor durability is much required, and of which openness and transparency are the chief recommendations.

1122

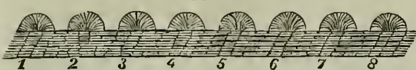
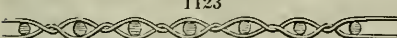


Fig. 1123 represents common gauze, or *linau*, a substance very much used for various purposes. The essential difference between this description of cloth and all others, consists in the warp being turned or twisted like a rope during the operation of weaving, and hence it bears a considerable analogy 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.

1123



1124

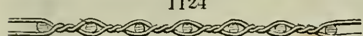


Fig. 1124 represents a section of another species of twisted cloth, which is known by the name of catgut, and which differs from the gauze only by being subjected to a greater degree of twine in weaving; for in place of one revolution between each intersection, a revolution and a half is always given; and thus the warp is alternately above and below, as in other kinds of weaving.

Fig. 1125 is a superficial representation of the most simple kind of ornamental net-work produced in the loom. It is called a whip-net by weavers, who use the term whip for any substance interwoven in cloth for ornamental purposes, when it is distinct from the ground of the fabric. In this, the difference is merely in the crossing of the warp; for it is very evident that the crossings at 1, 2, 3, 4, and 5, are of different threads from those at 6, 7, 8, and 9.

1125

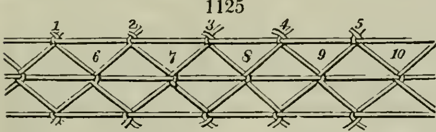
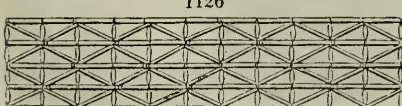


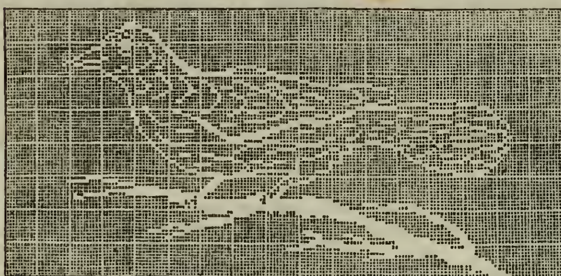
Fig. 1126 represents, superficially, what is called the mail-net, and is merely a combination of common gauze and the whip-net in the same fabric. The gauze here being in the same direction as the dotted line in the former figure, the whole fabric is evidently a continued succession of right-angled triangles, of which the woof forms the basis, the gauze part the perpendiculars, and the whip part the hypotenuses. The contraction here being very different, it is necessary that the gauze and whip parts should be stretched upon separate beams.

1126



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.* 1127, representing a bird perched upon the branch of a tree, it will be proper, in the first place, to count the number of spaces from the point of the bill to the extremity of the tail; and to render this the more easy, it is to be observed that every tenth line is drawn considerably bolder than the others. This number in the design is 135 spaces. Counting again, from the stem of the branch to the upper part of the bird's head, he will find 76 spaces. Between these spaces, 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 dimensions would be proportionally contracted.

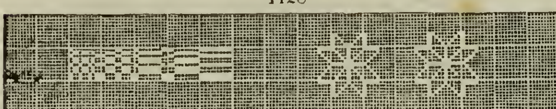
1127



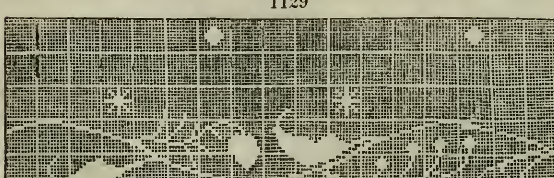
A correct idea being formed of the design, the weaver may proceed to mount his loom according to the pattern; and this is done by two persons, one of whom takes from the design the instructions necessary for the other to follow in tying his cords.

Fig. 1128 is a representation of the most simple species of table-linen, which is 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 uncolored. For such a pattern as this, two sets of common tweel-heddles, moved in the ordinary way, by a double succession of heddles, are sufficient. The other part of *fig.* 1128, 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.* 1129 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.

1128



1129



THENARD'S BLUE, or COBALT BLUE, is prepared by digesting the oxyde of cobalt used in the potteries, with nitric acid, evaporating the nitrate almost to dryness, diluting it with water, and filtering, to separate some arseniate of iron, which usually precipitates. The clear liquor is to be poured into a solution of phosphate of soda, whence an insoluble phosphate of cobalt falls. This being well washed, is to be intimately mixed in its soft state with eight times its weight of well-washed gelatinous alumina, which has been obtained by pouring a solution of alum into water of ammonia in excess. The uniformly colored 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 stopped till used.

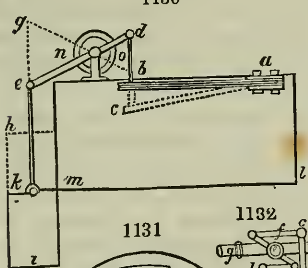
The arseniate of cobalt may be substituted, in the above process, for the phosphate, but it must be mixed with sixteen times its weight of the washed gelatinous alumina. The arseniate is procured by pouring the dilute nitrate of cobalt into a solution of arseniate of potassa. If nitrate of cobalt be mixed with the alumina, and the mixture be treated as above described, a blue pigment will also be obtained, but paler than the preceding, showing that the color consists essentially of alumina stained with oxyde of cobalt.

THERMOMETER, signifies the measure of heat. Its description belongs to a treatise on chemical physics.

THERMOSTAT, is the name of an apparatus for regulating temperature, in vaporization, distillation, heating baths or hot-houses, and ventilating apartments, &c.; for which I obtained a patent in the year 1831. It operates upon the physical principle, that when two thin metallic bars of different expansibilities are 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, stop-cocks, 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:—

Fig. 1130, *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.

1130



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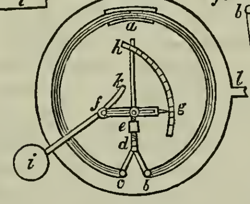


1132

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 hot-house or a water-bath may have its temperature regulated by the contemporaneous admission of warm, and discharge of cold air, or water.

Fig. 1131, *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 overflow pipe, at which the excess of hot water runs off.

Fig. 1132 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 stop-cock *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 stop-cock.

Suppose that for certain purposes in pharmacy, dyeing, or any other chemical art, a water-bath is required to be maintained steadily at a temperature of 150° F.; let the combined thermostatic bars, hinged together at *e*, *f*, *fig.* 1133, 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 stop-cock *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 stop-cock, 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 a stop-cock *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.

1133

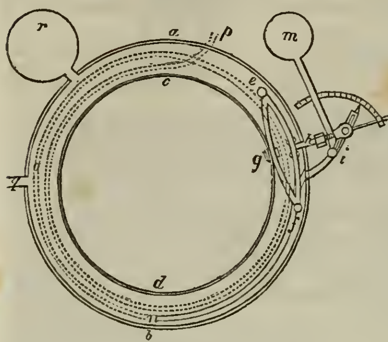
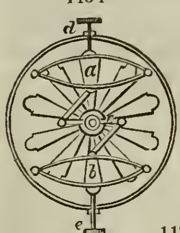
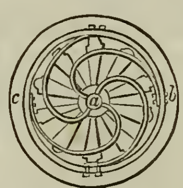


Fig. 1136 is a thermostatic apparatus, composed of three pairs of bars, *d*, *d*, *d*, which are represented in a state of flexure by heat; but they become nearly straight and parallel when cold. *a*, *b*, *c*, is a guide rod, fixed at one end by an adjusting screw *e*, in the strong frame *f*, *e*, having deep guide grooves at the sides. *f*, *g*, is the working-rod, which moves endways when the bars *d*, *d*, *d*, operate by heat or cold. A square register-plate *h*, *g*, may be affixed to the rod *f*, *g*, so as to be moved backwards and 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.

1134



1135



1136

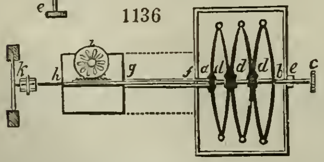


Fig. 1137 represents a chimney, furnished with a *pyrostat*, *a*, *b*, *c*, acting by the links *b*, *d*, *e*, *c*, on a damper *f*, *h*, *g*. The more expansible metal is in the present example supposed to be on the outside. The plane of the damper-plate will, in this case, be turned more directly into the passage of the draught through the chimney by increase of temperature.

Fig. 1135 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 twining 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.

1137

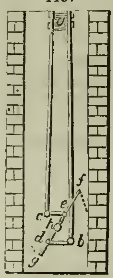


Fig. 1134 represents another arrangement of my thermostatic apparatus applied to a circular turning register, like the preceding, for ventilating apartments. Two pairs of compound bars are applied so as to act in concert, by means of the links *a c*, *b c*, on the opposite ends of a short lever, which 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 flexure of the compound bars will open the apertures.

THIMBLE (*Dé à coudre*, Fr.; *Fingerhut* (*fingerhat*), Germ.), is a small truncated metallic cone, deviating little from a cylinder, smooth within, and 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 intended size of the thimbles. These strips are passed under a punch-press, whereby they are cut into discs of about 2 inches diameter, tagged together by a tail. Each strip contains one dozen of these blanks. A child is employed to make them red-hot, and to lay them on a mandril nicely fitted to their size. The workman now strikes the middle of each with a round-faced punch, about the thickness of his finger, and thus sinks it into the concavity of the first mandril. He then transfers it successively to another mandril, which has five hollows of successively increasing depth; and, by striking it into them, brings it to the proper shape.

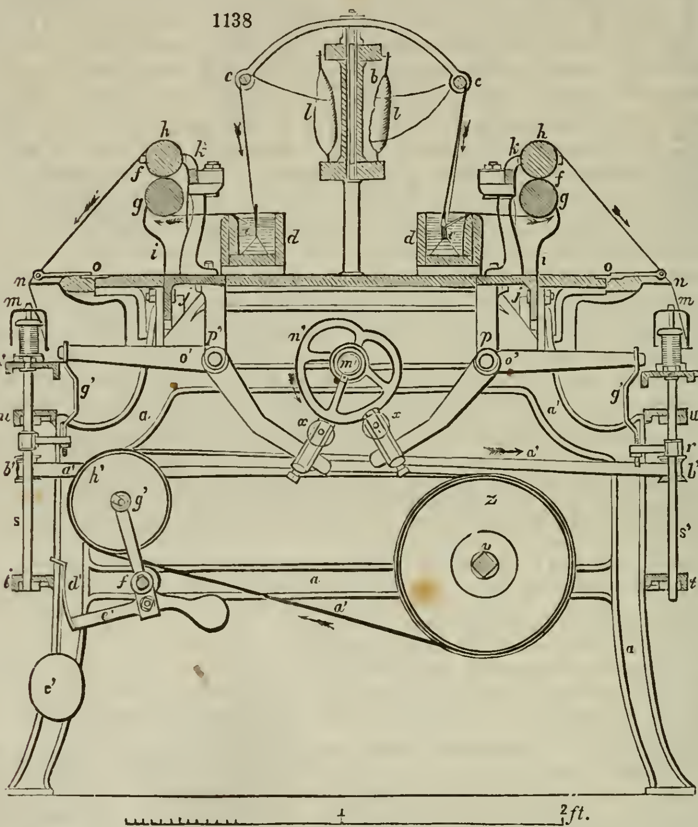
A second workman takes this rude thimble, sticks it in the chuck of his lathe, in order to polish it within, then turns it outside, marks the circles for the gold ornament, and indents the pits most cleverly with a kind of milling tool. The thimbles are next annealed, brightened, and gilt inside, with a very thin cone of gold leaf, which is firmly united to the surface of the iron, simply by the strong pressure of a smooth steel 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 oxydes of iron, lead, manganese, tin, and uranium, besides earths and alkalis, in all 12 substances. Pure thorina is a white powder, without taste, smell, or alkaline reaction on litmus. When dried and calcined, it is not affected by either the nitric or muriatic acid. It may be fused with borax into a transparent glass, but not with potash or soda. Fresh precipitated thorina is a hydrate, which dissolves readily in the above acids, as well as in solutions of the carbonates of potash, soda, and ammonia, but not in these alkalis in a pure state. This earth consists of 74·5 parts of the metal *thorinum*, combined with 100 of oxygen. Its hydrate contains one equivalent prime of water. It is hitherto merely a chemical curiosity, remarkable chiefly for a density of 9·402, far greater than that of all the earths, and even of copper.

THREAD MANUFACTURE. The doubling and twisting of cotton or linen yarn into a compact thread, for weaving bobbinet, or for sewing garments, is performed by a machine resembling the throstle of the cotton-spinner. *Fig.* 1138 shows the thread-frame in a transverse section, perpendicular to its length. *a*, is the strong framing of cast-iron; *b*, is the *creel*, or shelf, in which the bobbins of yarn *l*, *l*, are set loosely upon their respective skewers, along the whole line of the machine, their lower ends turning in oiled steps, and their upper in wire eyes; *c*, is a glass rod, across which the yarn runs as it is unwound; *d*, *d*, are oblong narrow troughs, lined with lead, and filled with water, for moistening the thread during its torsion; the threads being made to pass through eyes at the bottom of the fork *e*, which has an upright stem for lifting it out, without wetting the fingers, when any thing goes amiss; *f*, *f*, are the pressing rollers, the under one *g*, being of smooth iron, and the upper one *h*, of box-wood; the former extends from end to end of the frame, in lengths comprehending 18 threads, which are joined by square pieces, as in the drawing-rollers of the mule-jenny. The necks of the under rollers are supported, at the ends and the middle, by the standards *i*, secured to square bases *j*, both made of cast iron. The upper cylinder has an iron axis, and is formed of as many rollers as there are threads; each roller being kept in its place upon the lower one by the guides *k*, whose vertical slots receive the ends of the axes.

1138



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 rotatory 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 c', 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 n', 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 wheel 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. See Bricks.

TILTING OF STEEL. See Steel. Rees's Cyclopædia contains an excellent article on this subject.

TIN (*Etain*, Fr.; *Zinn*, Germ.), in its pure state, has nearly the color 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 odor; it is flexible in rods or straps of considerable strength, and emits in the act of bending a crackling sound, as if sandy particles were intermixed, called the creaking of tin. A small quantity of lead, or other metal, deprives it of this characteristic quality. Tin melts at 442° Fahr., and is very fixed in the fire at higher heats. Its specific gravity is 7·29. When heated to redness with free access of air, it absorbs oxygen with rapidity, and changes first into a pulverulent gray protoxyde, and by longer ignition, into a yellow-white powder, called *putty* of tin. This is the peroxyde, consisting of 100 of metal + 27·2 of oxygen.

Tin has been known from the most remote antiquity; being mentioned in the books of Moses. The Phœnicians carried on a lucrative trade in it with Spain and Cornwall.

There are only two ores of tin; the peroxyde, or tin-stone, and tin pyrites; the former of which alone has been found in sufficient abundance for metallurgic purposes. The external aspect of tin-stone has nothing very remarkable. It occurs sometimes in twin crystals; its lustre is adamantine; its colors are very various, as white, gray, yellow, red, brown, black; specific gravity 6·9 at least; which is, perhaps, its most striking feature. It does not melt by itself before the blowpipe; but is reducible in the smoky flame or on charcoal. It is insoluble in acids. It has somewhat of a greasy aspect, and strikes fire with steel.

Tin-stone occurs disseminated in the ancient rocks, particularly granite; also in beds and veins, in large irregular masses, called *stockwerks;* and in pebbles, an assemblage of which is called stream-works, where it occasionally takes a ligneous aspect, and is termed *wood-tin.*

This ore has been found in few countries in a workable quantity. Its principal localities are, Cornwall, Bohemia, Saxony, in Europe; and Malacca and Banca, in Asia. The tin-mines of the Malay peninsula lie between the 10th and 6th degree of south latitude; and are most productive in the island of Junck-Ceylon, where they yield sometimes 800 tons per annum, which are sold at the rate of 48*l.* each. The ores are found in large caves near the surface: and though actively mined for many centuries, still there is easy access to the unexhausted parts. The mines in the island of Banca, to the east of Sumatra, discovered in 1710, are said to have furnished, in some years, nearly 3500 tons of tin. Small quantities occur in Gallicia in Spain, in the department of Haute Vienne in France, and in the mountain chains of the Fichtel and Riesengebürge in Germany. The columnar pieces of pyramidal tin-ore from Mexico and Chile, are products of stream-works. Small groups of black twin crystals have been lately discovered in the albite rock of Chesterfield in Massachusetts.

The Cornish ores occur—1. in small strata or veins, or in masses; 2. in stockwerks, or congeries of small veins; 3. in large veins; 4. disseminated in alluvial deposites.

The stanniferous small veins, or thin flat masses, though of small extent, are sometimes very numerous, interposed between certain rocks, parallel to their beds, and are commonly called tin-floors. The same name is occasionally given to stockwerks. In the mine of Bottalack, a *tin-floor* has been found in the killas (primitive schistose rock), thirty-six fathoms below the level of the sea; it is about a foot and a half thick, and occupies the space between a principal vein and its ramification; but there seems to be no connexion between the *floor* and the great vein.

2. Stockwerks occur in granite and in the feldspar porphyry, called in Cornwall, *elvan*. The most remarkable of these in the granite, is at the tin-mine of Carclase, near *St. Austle*. The works are carried on in the open air, in a friable granite, containing feldspar disintegrated into *kaolin*, or china clay, which is traversed by a great many small veins, composed of tourmaline, quartz, and a little tin-stone, that form black delineations on the face of the light-gray granite. The thickness of these little veins rarely exceeds 6 inches, including the adhering solidified granite, and is occasionally much less. Some of them run nearly east and west, with an almost vertical dip; others, with the same direction, incline to the south at an angle with the horizon of 70 degrees.

Stanniferous stockwerks are much more frequent in the elvan (porphyry), of which the mine of Trewidden-ball is a remarkable example. It is worked among flattened masses of *elvan*, separated by strata of *killas*, which dip to the east-north-east at a considerable angle. The tin ore occurs in small veins, varying in thickness from half an inch to 8 or 9 inches, which are irregular, and so much interrupted, that it is difficult to determine either their direction or their inclination.

3. The large and proper metalliferous veins are not equally distributed over the surface of Cornwall and the adjoining part of Devonshire; but are grouped into three districts; namely, 1. In the south-west of Cornwall, beyond Truro; 2. In the neighborhood of St. Austle; and 3. In the neighborhood of Tavistock in Devonshire.

The first group is by far the richest, and the best explored. The formation most abundant in tin mines is principally granitic; whilst that of the copper mines is most frequently schistose or killas; though with numerous exceptions. The great tin veins are the most ancient metalliferous veins in Cornwall; yet they are not all of one formation, but belong to two different systems. Their direction is, however, nearly the same, but some of them dip towards the north, and others towards the south. The first are older than the second; for in all the mines where these two sets of veins are associated, the one which dips to the north, cuts across and throws out the one which dips to the south. See MINES, p. 841.

At Trevannance mines, the two systems of tin veins are both intersected by the oldest of the copper veins; indicating the prior existence of the tin veins. In *fig.* 1139, *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.

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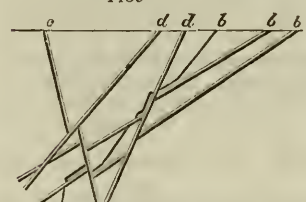
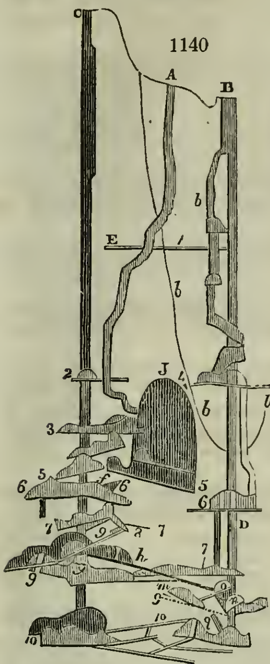


4. *Alluvial tin ore, stream tin.*—Peroxyde of tin occurs disseminated both in the *alluvium* which covers the gentle slopes of the hills adjoining the rich tin-mines, and also in the alluvium which fills the valleys that wind round their base; but in these numerous deposites the tin-stone is rarely distributed in sufficient quantities to make it worth the working. The most important explorations of *alluvial tin ore* are grouped in the environs of St. Just and St. Austle; where they are called *stream-works;* because water is the principal agent employed to separate the metallic oxyde from the sand and gravel.

The tin mine of Altenberg, in Saxony (*fig.* 1140, which is a vertical projection in a plane passing from west to east), is remarkable for a stockwerk, or interlaced mass of ramifying veins, which has been worked ever since the year 1458. The including rock is a primitive porphyry, superposed upon gneiss; becoming very quartzose as it approaches the lode. This is usually disseminated in minute particles, and accompanied with wolfram, copper, and arsenical pyrites, *fer oligiste*, sulphuret of molybdenum, and bismuth, having gangues of lithomarge, fluor spar, mica, and feldspar. The space which the ore occupies in the heart of the quartz, is a kind of dædalus, the former being often so dispersed among the latter as to seem to merge into it; whence it is called by the workmen *zwitter*, or *ambiguous*. In 1620, the mine was worked by 21 independent companies, in a most irregular manner, whereby it was damaged to a depth of 170 fathoms by a dreadful downfall of the roofs. This happened on a Sunday, providentially, when the pious miners were all at church. The depth of this abyss, marked by the curved line *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 deposites 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.

1140

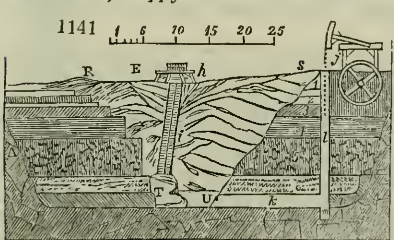


The only rule observed in taking ore from this mine has been to work as much out of each of these levels as is possible, without endangering the superincumbent or collateral galleries; on which account many pillars are constructed to support the roofs. The mine yields annually 1600 quintals (Leipzick) of tin, being four fifths of the whole furnished by the district of Altenberg; to produce which, 400,000 quintals of ore are raised. 1000 parts of the rock yield 8 of concentrated schlich, equivalent to only 4 of metal; being only 1 in 250 parts.

But the most extensive and productive stream-works are those of Pentowan, near St. Austle.

Fig. 1141 represents a vertical section of the Pentowan mine, 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 deposite, 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 deposite of tin-stone occurs, including fragments of various size, of clay slate, flinty slate, quartz, iron ore, jasper; in a word, of all the rocks and gangues to be met with in the surrounding territory, with the exception of granite. Among these fragments there occur, in rounded particles, a coarse quartzose sand, and the tin-stone, commonly in small grains and crystals. Beneath the bed T, the clay slate occurs, called *killas*, (A, X, Y,) which supports all the deposites of more recent formation.

1141



The system of mining is very simple. The successive beds, whose thickness is shown in the figure, are visibly cut out into steps or platforms. By a level or gallery of efflux, *k*, the waters flow into the bottom of the well *l*, *m*, which contains the drainage pumps; and these are put in action by a machine, *j*, moved by a water-wheel. The extraction of the ore is effected by an inclined plane, *i*, cut out of one of the sides of the excavation, at an angle of about 45 degrees. At the lower end of this sloping pathway there is a place of loading; and at its upper end *h*, a horse-gin, for alternately raising and lowering the two baskets of extraction on the pathway *i*.

Mine tin requires peculiar care in its mechanical preparation or dressing, on account of the presence of foreign metals, from which, as we have stated, the stream tin is free.

1. As the mine tin is for the most part extremely dispersed through the gangue, it must be all stamped and reduced to a very fine powder, to allow the metallic particles to be separated from the stony matters.

2. As the density of tin-stone is much greater than that of most other metallic ores, it is less apt to run off in the washing; and may, therefore, be dressed so as to be completely stripped of every matter not chemically combined.

3. As the peroxyde of tin is not affected by a moderate heat, it may be exposed to calcination; whereby the specific gravity of the associated sulphurets and arseniurets is so diminished as to facilitate their separation.

We may therefore conclude, that tin ore should be first of all pounded very fine in the stamp-mill, then subjected to reiterated washings, and afterwards calcined. The order of proceeding in Cornwall is as follows:—

1. *Cleaning the ore.*—This is usually done at the mouth of the gallery of efflux, by agitating the ore in the stream of water as it runs out. Sometimes the ore is laid on a grating, under a fall of water.

2. *Sorting.*—The ore thus cleaned, is sorted on the grate, into four heaps: 1. stones rich in tin; 2. stones containing both tin and copper ore; 3. copper ore; 4. sterile pieces, composed in a great measure of stony gangue, with iron and arsenical pyrites. In those veins where there is no copper ore, the second and third heaps are obviously absent. When present, the compound ore is broken into smaller pieces with a mallet, and the fragments are sorted anew.

3. *Stamping.*—The stanniferous fragments (No. 1) are stamped into a sand, of greater or less fineness, according to the dissemination of the tin-stone in the gangue. The determination of the size of the sand is an object of great importance. It is regulated by a copper plate pierced with small holes, through which every thing from the stamping-mill must run off with the rapid stream introduced for this purpose. This plate forms the front of the stamp cistern.

Several years ago, all the stamp-mills were driven by water-wheels, which limited the quantity of ore that could be worked to the hydraulic power of the stream or waterfall; but since the steam engine has been applied to this purpose, the annual product of tin has been greatly increased. On the mine of Huel Vor, there are three steam engines appropriated to the stamping-mills. Their force is 25 horses at least. One of these machines, called *south stamps*, drives 48 pestles; a second, called *old stamps*, drives 36; and a third, 24. The weight of these pestles varies from 370 to 387 pounds; and they generally rise through a space of 10½ inches. The machine called *south stamps*, the strongest of the three, gives 17½ blows in the minute, each pestle being lifted twice for every stroke of the piston. The steam engine of this mill has a power of 25 horses, and it consumes 1062 bushels of coals in the month. Three pestles constitute a battery, or stamp-box.

Washing and stamping of tin ores at Polgooth, near St. Austle.—The stamps or pestles are of wood, 6 inches by 5½ in the square: they carry lifting bars *b*, secured with a wooden wedge and a bolt of iron, and they terminate below in a lump of cast iron A, called the head, which is fastened to them by a tail, and weighs about 2½ cwts. The shank of the pestle is strengthened with iron hoops. A turning-shaft communicates motion to the stamps by cams stuck round its circumference, so arranged that the second falls while the first and third of each set are uplifted. There are 4 cams on one periphery, and the shaft makes 7 turns in the minute. Each stamp, therefore, gives 28 strokes per minute, and falls through a space of 7½ inches. The stamp chest is open behind, so that the ore slips away under the pestles, by its weight, along the inclined plane with the stream of water. The bottom of the troughs consists of stamped ores. With 6 batteries of 6 pestles each, at Poldice, near Redruth, 120 bags of ore are stamped in 12 hours; each bag containing 18 gallons of 282 cubic inches; measuring altogether 352 cubic feet, and 864 cubic inches.

1142

The openings in the front sides of the troughs are nearly eight inches by seven and a half; they are fitted with an iron frame, which is closed with sheet iron, pierced with about 160 holes in the square inch, bored conically, being narrower within. The ore, on issuing, deposites its *rough* in the first basin, and its slimes in the following basins. The rough is washed in *buddles* (see LEAD, page 757), and in *tossing-tubs;* the slimes in *trunks*, and up on a kind of twin tables, called *racks*. Into the *tossing-tub*, or *dolly, fig.* 1143, the stamped ore is thrown, along with a certain quantity of water, and a workman stirs it about with an iron shovel for three or four minutes. He then removes a little of the water with a handled pitcher, and strikes the sides of the tub for 8 or 10 minutes with a hammer, which hastens the subsidence of the denser parts. The water is next poured off by inclining the tub to one side. In one operation of this kind, four distinct strata of the ores may be procured, as indicated by the lines *a b*, *c d*, *e f g*, *h i k*, in the figure. The portion B is to be washed again in the *trunking-box*, *figs.* 1144, 1145; B is to be washed upon the German chests or racks, *fig.* 1146; C, the most considerable, is put aside, as schlich fit for the market; D, forming a nucleus in the centre of the tub, is to be passed through sieves of copper wire, having 18 meshes in the square inch. This product thus affords a portion D′, which passes through the sieve, and D″ which remains upon it; the latter is sometimes thrown away, and at others is subjected to the operation called the *tie*, viz., a washing upon the sloping bottom of a long trough.

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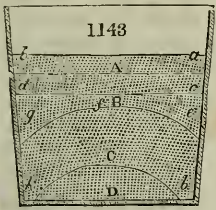

The slimes are freed from the lighter mud in the trunking-box, *figs.* 1144, 1145; which is from 7 to 8 feet long. Being accumulated at M, the workman pushes them back with a shovel from *a* towards *b*. The metallic portion is carried off, and deposited by the stream of water upon the table; but the earthy matters are floated along into a basin beyond it. The product collected in the chest is divided into two portions; the one of which is washed once, and the other twice, upon the *rack*, *fig.* 1146. This is composed of a frame C, which carries a sloping board or table, susceptible of turning round to the right or left upon two pivots, 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 the communication with the lower table C, whose slope is generally 5 inches in its whole length of 9 feet; but this may vary with the nature of the ore, being somewhat less when it is finely pulverized. The ore is thrown upon T, in small portions of 20 or 25 lbs. A woman spreads it with a rake, while a stream of water sweeps a part of it upon the table, where it gets washed. The fine mud falls through a cross slit near the lower end, into a basin B.

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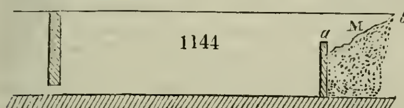

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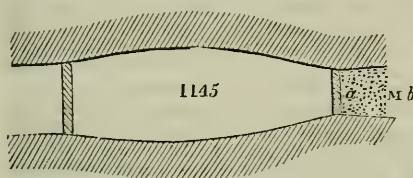

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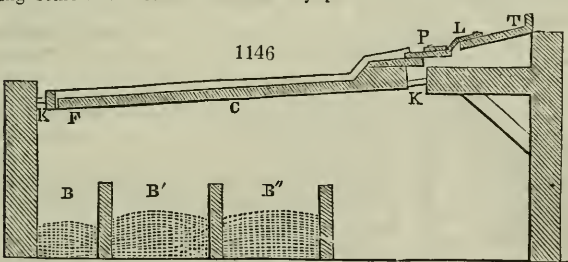


After working for a few minutes, should the schlich seem tolerably rich, the operative turns the table round its axis K, K, so as to tumble it into the boxes below. The mud is in B; an impure schlich in B′, which must be washed again upon the *rack*; and a schlich fit for roasting in B″.

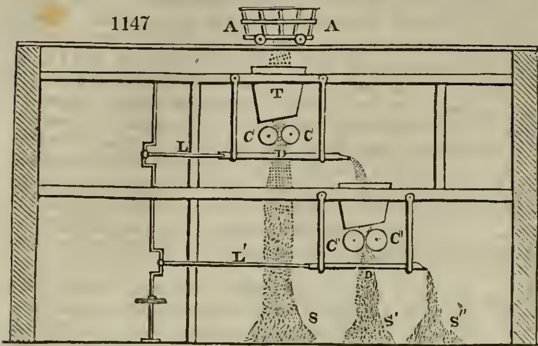
The slope of the rack-table for washing the *roasted* tin ore, is $7\frac{3}{4}$ inches in the nine feet.

Crushing rolls at the Pembroke mines.—Wagons, moved on a railway by an endless rope, bring the ore to be crushed immediately over the rolls, as shown in *fig.* 1147. A trap being opened in the side of the wagon, the ore falls into the hopper T, whence it passes directly between the twin cylinders C, C, and next upon the sieve D, which receives a seesaw motion horizontally, by means of the rod L, and the crank of the upright turning-shaft. The finer portion of ore, which passes through that sieve, forms the heap S. The coarser portion is tossed over the edge of the sieve, and falls between the cylinders C′ C′, upon a lower level, and forms the second heap S′ of sifted, and S″ of unsifted, ore.

The holes of the sieves D, D′, being of the same size, the products S, S′, are of the same fineness. S″ is ground again, being mixed, in the uppermost hopper T, along with the lumps from the wagons.

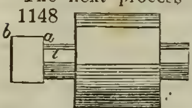
The diameter and length of the under rolls (see *fig.* 1148) are each 16 inches. *a b*, is the square end of the gudgeon *t*, which prevents the shaft shifting laterally out of its place. The diameter of the upper rolls is 18 inches, but their length is the same. Both are made of white cast iron, *chilled* or case-hardened by being cast in iron moulds instead of sand; and they last a month, at least, when of good quality. They make from 10 to 15 turns in a minute, according to the hardness of the ores of tin or copper; and can grind about 50 tons of rich copper ore in 12 hours; but less of the poorer sort.

1147



The next process is the calcination in the *burning-house;* which includes several reverberatory furnaces. At the mine of Poldice, they are 4 or 5 yards long, by from 2½ to 3 yards wide. Their hearth is horizontal; the elevation, about 26 inches high near the fireplace, sinks slightly towards the chimney. There is but one opening, which is in the front; it is closed by a plate-iron door, turning on hinges. Above the door there is a chimney, to let the sulphurous and arsenical vapors fly off, which escape out of the hearth, without annoying the workmen. This chimney leads to horizontal flues, in which the arsenious acid is condensed.

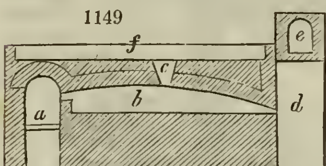
1148



Six hundred weights of ore are introduced; the calcination of which takes from 12 to 18 hours, according to the quantity of pyrites contained in the ore. At the beginning of the operation, a moderate heat is applied; after which it is pushed to a dull red, and kept so during several hours. The door is shut; the materials are stirred from time to time with an iron rake, to expose new surfaces, and prevent them from agglutinating or *kerning*, as the workmen say. The more pyrites is present, the more turning is necessary. Should the ore contain black oxyde of iron, it becomes peroxydized, and is then easily removed by a subsequent washing.

Figs. 1149, 1150 represent the furnace employed at Altenberg, in Saxony, for roasting tin ores. *a* is the grate; *b*, the sole of the roasting hearth; *c*, an opening in the arched roof for introducing the dried schlich (the ground and elutriated ore); *d*, is the smoke-mantle or chimney-hood, at the end of the furnace, under which the workmen turn over the spread schlich, with long iron rods bent at their ends; *e*, is the poison vent, which conducts the arsenical vapors to the poison chamber (*gifthaus*) of condensation.

1149



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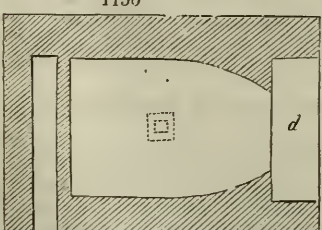


When the ore is sufficiently calcined, as is shown by its ceasing to exhale vapors, it is taken out, and exposed for some days to the action of the air, which decomposes the sulphurets, or changes them into sulphates. The ore is next put into a tub filled with water, stirred up with a wooden rake, and left to settle; by which means the sulphate of copper that may have been formed, is dissolved out. After some time, this water is drawn off into a large tank, and its copper recovered by precipitation with pieces of old iron. In this way, almost all the copper contained in the tin ore is extracted.

The calcined ore is sifted, and treated again on the racks, as above described. The pure schlich, called *black tin,* is sold under this name to the smelters; and that which collects on the middle part of the inclined wash-tables, being much mixed with wolfram, is called *mock lead.* This is passed once more through the stamps, and washed; when it also is sold as *black tin.*

Stream tin is dressed by similar methods; 1. by washing in a trunking-box, of such dimensions that the workman stands upon it in thick boots, and makes a skilful use of the rake; 2, by separating the larger conglomerate pebbles from the smaller pure ones; picking, stamping, and washing, on a kind of *sleeping-tables*. See METALLURGY, *figs*. 677, 678.

The tin ores of Cornwall and Devonshire are all reduced within the counties where they are mined, as the laws prohibit their exportation out of them. Private interests suffer no injury from this prohibition; because the vessels which bring the fuel from Wales, for smelting these ores, return to Swansea and Neath loaded with copper ores.

The smelting-works belong in general to individuals who possess no tin mines, but who purchase at the cheapest rate the ores from the mining proprietors. The ores are appraised according to their contents in metal, and its fineness; conditions which they determine by the following mode of assay:—When a certain number of bags of ore, of nearly the same quality, are brought to the works, a small sample is taken from each bag, and the whole are well blended. Two ounces of this average ore are mixed with about four per cent. of ground coal, put into an open earthen crucible, and heated in an air furnace (in area about ten inches square) till reduction takes place. As the furnace is very hot when the crucible is introduced, the assay is finished in about a quarter of an hour. The metal thus revived is poured into a mould, and what remains in the crucible is pounded in a mortar, that the grains of tin may be added to the ingot.

This method, though imperfect in a chemical point of view, serves the smelter's purpose, as it affords him a similar result to what he would get on the great scale. A more exact assay would be obtained by fusing, in a crucible lined with hard-rammed charcoal, the ore mixed with five 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 four to five per cent. more tin than the other; but it has the inconvenience of reducing the iron, should any be present; which by subsequent solution in nitric acid will be readily shown. This assay would be too tedious for the smelter, who may have occasion to try a great many samples in one day.

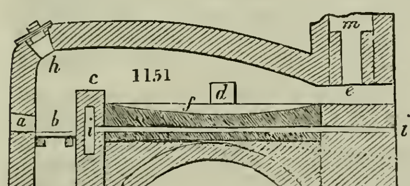
The smelting of tin ores is effected by two different methods:—

In the first, a mixture of the ore with charcoal is exposed to heat on the hearth of a reverberatory furnace fired with coal.

In the second, the tin ore is fused in a blast furnace, called a blowing-house, supplied with wood charcoal. This method is practised in only a few works, in order to obtain a very pure quality of tin, called *grain tin* in England, and *étain en larmes* in France; a metal required for certain arts, as dyeing, &c. This method is applied merely to stream tin.

In the *smelting-houses*, where the tin is worked in reverberatories, two kinds of furnaces are employed; the reduction and the refining furnaces.

Figs. 1151, 1152, represent the furnaces for smelting tin at St. Austle, 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 cwts., and contains from 60 to 70 per cent. of metal.



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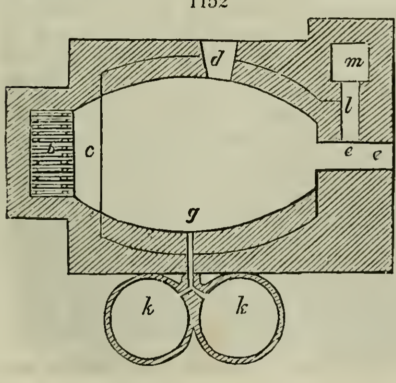
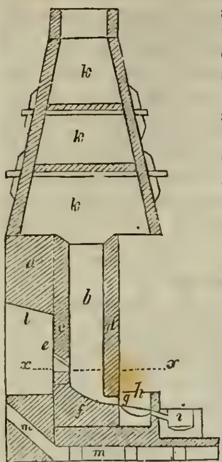


Fig. 1153 represents in a vertical section through the tuyère, and *fig*. 1154, in a horizontal section, in the dotted line *x*, *x*, of *fig*. 1153, the furnace employed for smelting tin at the Erzegebirge mines, in Saxony. *a*, are the furnace pillars, of gneiss; *b*, *b*, are shrouding or casing walls; *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.

1153



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 four feet in diameter, and thirty-two 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.

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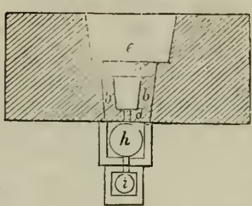


The works in which the blast furnaces are employed, are called *blowing-houses*. The smelting furnaces are six feet high, from the bottom of the crucible (concave hearth) to the throat, which is placed at the origin of a long and narrow chimney, interrupted by a chamber, where the metallic dust, carried off by the blast, is deposited. This chamber is not placed vertically over the furnace; but the lower portion of the chimney has an oblique direction from it. The furnace is lined with an upright cylinder of cast iron, coated internally with loam, with an opening in it for the blast. This opening, which corresponds to the lateral face opposite to the charging side, receives a *tuyère*, in which the nozzles of two cylinder single bellows, driven by a water-wheel, are planted. The *tuyère* opens at a small height above the sole of the furnace. On a level with the sole, the iron cylinder presents a slope, below which is the hemispherical basin of reception, set partly beneath the interior space of the furnace, and partly without. Near the corner of the building there is a second basin of reception, larger than the first, which can discharge itself into the former by a sloping gutter. Near this basin there is another, for the refining operation. These are all made either of brick or cast iron.

The quality of the average ground-tin ore prepared for smelting is such, that 20 parts of it yield from 12½ to 13 of metallic tin, (62½ to 65 per cent.) The treatment consists of two operations, *smelting* and *refining*.

First operation; deoxydization 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 blast from sweeping any of it away at the commencement. From 12 to 16 cwts. 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 oxyde 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 grain tin. These scoriæ are in small quantity. The stamp slag contains fully five 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 sulphurets and arseniurets that have escaped decomposition, a little unreduced oxyde 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.* 1151, 1152.) 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 five 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 oxydes of tin and foreign metals, is successively skimmed off, and thrown back into the furnace. When it is judged that the tin has boiled long enough, the green wood is lifted out, and the bath is allowed to settle. It separates into different zones, the upper being the purest; those of the middle are charged with a little of the foreign metals; and the lower are much contaminated with them. When the tin begins to cool, and when a more complete separation of its different qualities cannot be looked for, it is lifted out in ladles, and poured into cast-iron moulds. It is obvious, that the order in which the successive blocks are obtained, is that of their purity; those formed from the bottom of the basin being usually so impure, that they must be subjected anew to the refining process, as if they had been directly smelted from the ore.

The refining operation takes 5 or 6 hours; namely, an hour to fill the basin, three hours to boil the tin with the green wood, and from one to two hours for the subsidence.

Sometimes a simpler operation, called *tossing*, is substituted for the above artificial ebullition. To effect it, a workman lifts some tin in a ladle, and lets it fall back into the boiler, from a considerable height, so as to agitate the whole mass. He continues this manipulation for a certain time; after which, he skims with care the surface of the bath. The tin is afterwards poured into moulds, unless it be still impure. In this case, the separation of the metals is completed by keeping the tin in a fused state in the boiler for a certain period, without agitation; whereby the upper portion of the bath (at least one half) is pure enough for the market.

The moulds into which the tin blocks are cast, are usually made of granite. Their capacity is such, that each block shall weigh a little more than three hundred weights. 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 no use can be made of it. About three and a half tons of coal are consumed in producing 2 of tin.

Smelting of tin by the blast furnace.—This mode of reduction employs only wood charcoal, and its object is to obtain tin of the maximum purity to which it can be brought by manufacturing processes. The better ores of the stream-works, and the finer tin sands, are selected for this operation. The washings being always well performed, the oxyde of tin is exempt from every arsenical or sulphurous impurity, and is associated with nothing but a little hematite. It is therefore never calcined.

The smelting is effected without addition; only, in a few cases, some of the residuary matters of a former operation are added to the ore. About a ton and six tenths of wood charcoal are burned for one ton of fine smelted tin. The only rule is, to keep the furnace always full of charcoal and ore. The revived tin is received immediately in the first basin; then run off into the second, where it is allowed to settle for some time. The scoriæ that run off into the first basin, are removed as soon as they fix. These scoriæ are divided into two classes; namely, such as still retain tin oxyde, and such as hold none of the metal in that state, but only in granulations. The metallic bath is divided, by repose, into horizontal zones, of different degrees of purity; the more compound and denser matters falling naturally to the bottom of the basin. The tin which forms the superior zones, being judged to be pure enough, is transvased by ladles into the refining basin, previously heated, and under which, if it is of cast-iron, a moderate fire is applied. The tin near the bottom of the receiving basin is always laded out apart, to be again smelted; sometimes, indeed, when the furnace is turning out very impure tin, none of it is transvased into the second basin; but the whole is cast into moulds, to be again treated in the blast furnace.

In general they receive no other preparation, but the green wood ebullition, before passing into the market. Sometimes, however, the block of metal is heated till it becomes brittle, when it is lifted to a considerable height, and let fall, by which it is broken to pieces, and presents an agglomeration of elongated grains or *tears;* whence it is called *grain tin.*

On making a comparative estimate of the expense by the *blowing-house* process, and by the reverberatory furnace, it has been found that the former yields about 66 per cent. of tin, in smelting the stream or alluvial ore, whose absolute contents are from 75 to 78 parts of metal in the hundred. One ton of tin consumes a ton and six tenths of wood charcoal, and suffers a loss of 15 per cent. In working with the reverberatory furnace, it is calculated that ore whose mean contents by an exact analysis are 70 per cent., yields 65 per cent. on the great scale. The average value of tin ore, as sold to the smelter, is 50 pounds sterling per ton; but it fluctuates, of course, with the market prices. In 1824, the ore of inferior quality cost 30*l.*, while the purest sold for 60*l.* One ton of tin, obtained from the reverberatory furnace, cost—

$1\frac{1}{2}$ tons of ore, worth - - - - - - -	£75	0	0
$1\frac{3}{4}$ tons of coals, at 10*s.* per ton - - - -	0	17	6
Wages of labor, interest on capital, &c. - - - -	3	0	0
	78	17	6

On comparing these results with the former, we perceive that in a *blowing-house* the loss of tin is 15 per cent., whereas it is only 5 in the reverberatory furnace. The expense in fuel is likewise much less relatively in the latter process; for only $1\frac{3}{4}$ tons of coals are consumed for one ton of tin; while a ton and six tenths of wood charcoal are burned to obtain the same quantity of tin in the blowing-house; and it is admitted that one ton of wood charcoal is equivalent to two tons of coal, in calorific effect. Hence every thing conspires to turn the balance in favor of the reverberatory plan. The operation is also, in this way, much simpler, and may be carried on by itself. The scoriæ, besides, from the reverberatory hearth, contain less tin than those derived from the same ores treated with charcoal by the blast, as is done at Altenberg. It must be remembered, however, that the grain tin procured by the charcoal process is reckoned to be finer, and fetches a higher price; a superiority partly due to the purity of the ore reduced, and partly to the purity of the fuel.

To test the quality of tin, dissolve a certain weight of it with heat in muriatic acid; should it contain arsenic, brown-black flocks will be separated during the solution, and arseniureted hydrogen gas will be disengaged, which, on being burned at a jet, will deposite the usual gray film of metallic arsenic upon a white saucer held a little way above the flame. Other metals present in the tin are to be sought for, by treating the above solution with nitric acid of spec. grav. 1·16, first in the cold, and at last with heat and a small excess of acid. When the action is over, the supernatant liquid is to be decanted off the peroxydized 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.

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 colors 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 colors to stained glass and artificial gems. (See PURPLE OF CASSIUS.) Enamel is made by fusing oxyde of tin with the materials of flint glass. This oxyde is also an ingredient in the white and yellow glazes of pottery-ware.

An ACCOUNT of TIN coined in Cornwall and Devon, from 1817 to 1829, inclusive:—

Years.	Blocks.	Tons.	Years.	Blocks.	Tons.
1817	25,379	4,120	1824	28,602	4,819
1818	23,048	3,745⅓	1825	24,902	4,170
1819	18,881	3,065	1826	26,299	4,406
1820	17,084	2,773½	1827	31,744	5,316
1821	19,273	3,128	1828	28,179	4,696
1822	18,732	3,137	1829	26,344	4,396
1823	24,077	4,031			

Tin imported. Duty, 50*s.* per cwt.		Tin exported.	Tin imported. Duty, 50*s.* per cwt		Tin exported.
	Cwts.	*Cwts.*		*Cwts.*	*Cwts.*
1827	2,217	2,938	1832	29,203	21,720
1828	3,386	3,258	1833	35,124	39,850
1829	2,674	2,581	1834	46,769	46,685
1830	15,539	10,426	1835	17,705	23,796
1831	8,099	12,226	1836	23,236	17,231

The principal importations are from the East India Company's territories and Ceylon: they amounted in 1832 to 24,585 cwts.; in 1833 to 27,928; in 1834 to 33,611; in 1835 to 10,104; and in 1836 to 17,729. From Sumatra and Java 1961 cwts. were imported in 1832, and 1145 in 1834, but in the other years greatly less.

Declared value of tin and pewter wares and tin-plates exported in—					
	1827.	1829.	1831.	1833.	1835.
	302,255*l.*	235,178*l.*	239,143*l.*	282,176*l.*	381,076*l.*
	1828.	1830.	1832.	1834.	1836.
	266,651*l.*	249,657*l.*	243,259*l.*	337,056*l.*	387,951*l.*

Of these goods, from two fifths to three fifths go to the United States of America.

ABSTRACT of TIN coined in Cornwall and Devon, in the year ending June 30, 1835; from the *Mining Review*, vol. iii.

Smelters.	Blocks of Grain Tin.		Blocks of Common Tin.		Totals.	
	1834.	1835.	1834.	1835.	1834.	1835.
Daubuz and Co.	728	875	6114	4494	6842	5369
Grenfell and Boase	344	196	3776	3097	4120	3293
Bolitho and Sons	229	153	3829	3099	4058	3252
R. and J. Michell	101	75	709	575	810	650
Wheal Vor Adventurers	—	—	3925	4069	3925	4069
Taylor, Sons and Co.	—	112	—	1250	—	1362
John Batten and Son	28	49	2352	2351	2380	2400
Joseph Carne	—	—	896	851	896	851
William Cornish	—	—	622	574	622	574
Gill and Co. (at Morwelham)	—	—	758	—	758	—
Ditto (at Calstock)	60	—	605	—	665	—
Rundle, Paul and Co.	—	12	—	1545	—	1557
Total	1490	1472	23586	21905	25076	23377

Total, in 1834, 4180 tons; in 1835, 3899 tons. (6 blocks = 1 ton.)

TINCAL, crude borax.

TINCTORIAL MATTER. One of the most curious and valuable facts ascertained upon this subject, is, that madder kept in casks, in a warm place, undergoes a species of fermentation, which, by ripening, or rather deoxydizing the coloring-matter, increases its dyeing power by no less than from 20 to 50 per cent. See M. H. Schlumberger's memoir read to the *Société Industrielle de Mulhausen*, 24 November, 1837.

TINCTURE is a title used by apothecaries to designate alcohol, in a somewhat dilute state, impregnated with the active principles of either vegetable or animal substances.

TIN-GLASS is a name of bismuth.

TIN MORDANTS, for dyeing scarlet:—

Mordant A, as commonly made by the dyers, is composed of 8 parts of aquafortis, 1 part of common salt or sal ammoniac, and 1 of granulated tin. This preparation is very uncertain.

Mordant 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 vapors, and put a loose stopper in its mouth. Throw into this nitro-muriatic acid one eighth of its weight of pure tin, in small bits at a time. When the solution is complete, and settled, decant it into bottles, and close them with ground stoppers. It should be diluted only when about to be used.

Mordant C, by Dambourney.—In two drachms Fr. (144 grs.) of pure muriatic acid, dissolve 18 grains of Malacca tin. This is reckoned a good mordant for brightening or fixing the color 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 drachms of nitre. In this acid solution dissolve one ounce of granulated tin of Cornwall, observing not to put in a fresh piece till the preceding be dissolved.

Mordant E, by Scheffer.—Dissolve one part of tin in four of a nitro-muriatic acid, prepared with nitric acid diluted with its own weight of water, and one thirty-secondth of sal ammoniac.

Mordant F, by Poerner.—Mix one pound of nitric acid with one pound of water, and dissolve in it an ounce and a half of sal ammoniac. Stir it well, and add, by very slow degrees, two ounces of tin turned into thin ribands upon the lathe.

Mordant G, by Berthollet.—Dissolve in nitric acid of 30° B. one eighth of its weight of sal ammoniac, then add by degrees one eighth of its weight of tin, and dilute the solution with one fourth of its weight of water.

Mordant K, by Dambourney.—In one drachm (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 colors produced by woods, roots, archil, &c.

TIN-PLATE. The only alloy of iron interesting to the arts is that with tin, in the formation of *tin-plate* or *white-iron*.

The sheet iron intended for this manufacture is refined with charcoal instead of coke, subsequently rolled to various degrees of thinness, and cut into rectangles of different sizes, by means of a shearing-machine driven by a water-wheel, which will turn out 100 boxes a day, or four times the number cut by hand labor. The first step towards tinning is to free the metallic surface from every particle of oxyde or impurity, for any such would inevitably prevent the iron from alloying with the tin. The plates are next bent separately by hand into a saddle or Λ shape, and ranged in a reverberatory oven, so that the flame may play freely among them, and heat them to redness. They are then plunged into a bath, composed of four pounds of muriatic acid diluted with three gallons of water, for a few minutes, taken out and drained on the floor, and once more exposed to ignition in a furnace, whereby they are *scaled*, that is to say, cast their scales. The above bath will suffice for scaling 1800 plates. When taken out, they are beat level and smooth on a cast-iron block, after which they appear mottled blue and white, if the *scaling* has been thoroughly done. They are next passed through *chilled* rolls or cast-iron cylinders, rendered very hard by being cast in thick iron moulds, as has been long practised by the Scotch founders in casting bushes for cart-wheels. After this process of *cold rolling*, the plates are immersed, for ten or twelve hours, in an acidulous ley, made by fermenting bran-water, taking care to set them separately on edge, and to turn them at least once, so that each may receive a due share of the operation. From this ley-steep they are transferred into a leaden trough, divided by partitions, and charged with dilute sulphuric acid. Each compartment is called a *hole* by the workmen, and is calculated to receive about 225 plates, the number afterwards packed up together in a *box*. In this liquid they are agitated about an hour, till they become perfectly bright, and free from such black spots as might stain their surface at the time of immersion. This process, called pickling, is both delicate and disagreeable, requiring a good workman, at high wages. The temperature of the last two steeps should be at least 90° or 100° F., which is kept up by stoves in the apartments. The plates are finally scoured with hemp and sand in a body of water, and then put aside for use in a vessel of pure water, under which they remain bright and free from rust for many months, a very remarkable circumstance.

The *tinning* follows these preparatory steps. A range of rectangular cast-iron pots is set over a fire-flue in an apartment called the *stow*, the workmen stationing themselves opposite to the narrow ends. The first rectangle in the range is the tin-pot; the second is the wash-pot, with a partition in it; the third is the grease-pot; the fourth is the pan, grated at bottom; the fifth is the list-pot, and is greatly narrower than any of the rest: they are all of the same length.

The prepared plates, dried by rubbing bran upon them, are first immersed one by one in a pot filled with melted tallow alone, and are left there for nearly an hour. They are thence removed, with the adhering grease, into pot No. 1, filled with a melted mixture of block and grain tin, covered with about four inches of tallow, slightly carbonized. This pot is heated by a fire, playing under its bottom and round its sides, till the metal becomes so hot as nearly to inflame the grease. Here about 340 plates are exposed, upright, to the action of the tin for an hour and a half, or more, according to their thickness. They are next lifted out, and placed upon an iron grating, to let the superfluous metal drain off; but this is more completely removed in the next process, called *washing*.

Into the wash-pot No. 2, filled with melted *grain* tin, the workman puts the above plates, where the heat detaches the ribs, and drops. There is a longitudinal partition in it, for keeping the drop of tin that rises in washing from entering the vessel where the last dip is given. Indeed, the metal in the wash-pot, after having acted on 60 or 70 boxes, becomes so foul, that the weight of a block (300 cwts.) of it is transferred into the tin-pot, No. 1, and replaced by a fresh block of grain tin. The plates being lifted out of the wash-pot, with tongs held in the left hand of the workman, are scrubbed on each side with a peculiar hempen brush, held in his right hand, then dipped for a moment in the hot tin, and forthwith immersed in the adjoining grease-pot, No. 3. This requires manual dexterity; and though only three-pence be paid for brushing and tin-washing 225 plates, yet a good workman can earn six shillings and three-pence in twelve hours, by putting 5625 plates through his hands. The final tin-dip is useful to remove the marks of the brush, and to make the surface uniformly bright. To regulate the temperature of the tallow-pot, and time during which the plates are left in it, requires great skill and circumspection on the part of the workman. If kept in it too long, they would be deprived, to a certain extent, of their silvery lustre; and if too short, streaks of tin would disfigure their surface. As a thick plate retains more heat after being lifted out of the washing-pot, it requires a proportionally cooler grease-pot. This pot has pins fixed within it, to keep the plates asunder; and whenever the workman has transferred five plates to it, a boy lifts the first out into the cold adjoining pan, No. 4; as soon as the workman transfers a sixth plate, the boy removes the second; and so on. The manufacture is completed by removing the wire of tin left on the under edge of the plates, in consequence of their vertical position in the preceding operations. This is the business of the *list-boy*, who seizes the plates when they are cool enough to handle, and puts the lower edge of each, one by one, into the list-pot, No. 5, which contains a very little melted tin, not exceeding a quarter of an inch in depth. When he observes the wire-edge to be melted, he takes out the plate, and, striking it smartly with a thin stick, detaches the superfluous metal, which leaves merely a faint stripe where it lay. This mark may be perceived on every tin-plate in the market.

The plates are finally prepared for packing up in their boxes, by being well cleansed from the tallow, by friction with bran.

Mr. Thomas Morgan obtained a patent, in September, 1829, for clearing the sheet-iron plates with dilute sulphuric acid in a *hole*, instead of *scaling* them in the usual way, previous to their being cold rolled, annealed, and tinned; whereby, he says, a better article is produced at a cheaper rate.

Crystallized tin-plate, see Moiree Metallique. It would seem that the acid merely lays bare the crystalline structure really present on every sheet, but masked by a film of redundant tin. Though this showy article has become of late years vulgarized by its cheapness, it is still interesting in the eyes of the practical chemist. The English tin-plates marked 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 lacker varnish, otherwise it loses its lustre in the air. If the whole surface is not plunged at once in cold water, but if it be partially cooled by sprinkling water on it, the crystallization will be finely variegated with large and small figures. Similar results will be obtained by blowing cold air through a pipe on the tinned surface, while it is just passing from the fused to the solid state; or a variety of delineations may be traced, by playing over the surface of the plate with the pointed flame of a blowpipe.

The following TABLE shows the several sizes of tin-plates, the marks by which they are distinguished, and their current wholesale prices in London:—

Names.	Sizes.	No. in a box.	Weight of each box.	Marks on the boxes.	Prices per box, in 1823.		Prices per box, in 1838.
	Inches.		*cwt. qrs. lbs.*		*s.*		*s. d.*
Common, No. 1 -	$13\frac{3}{4}$ by 10	225	1 0 0	CI.	47		35
Ditto 2 -	$13\frac{1}{4}$ — $9\frac{1}{4}$	-	0 3 21	CII.	45		33 6
Ditto 3 -	$12\frac{3}{4}$ — $9\frac{1}{2}$	-	0 3 16	CIII.	43		32 9
Cross, No. 1 -	$13\frac{3}{4}$ — 10	-	1 1 0	XI.	53		40 2
Two crosses, 1 -	-	-	1 1 21	XXI.	58		43 2
Three crosses, 1 -	-	-	1 2 14	XXX. I.	63		47
Four crosses, 1 -	-	-	1 3 7	XXXX. I.			
Common doubles -	$16\frac{3}{4}$ — $12\frac{1}{2}$	100	0 3 21	CD.	64–6	150	48 6
Cross doubles -	-	-	1 0 14	XD.	73–6	sheets	56
Two cross do. -	-	-	1 1 7	XXD.	81	in	60 6
Three cross do. -	-	-	1 2 0	XXXD.	88–6	each.	65
Four cross do. -	-	-	1 2 21	XXXXD.			
Com. small doubles -	5 — 11	200	1 2 0	CSD.	69		51 6
Cross do. do. -	-	-	1 2 21	XSD.	75		56 0
Two cross do. -	-	-	1 3 14	XXSD.	80		59 6
Three do. do. -	-	-	2 0 7	XXXSD.			
Four do. do. -	-	-	2 1 0	XXXXSD.			
Waster's com. No. 1	$3\frac{3}{4}$ — 10	225	1 0 0	WCI.	44		32 9
Ditto cross, 1	ditto	-	1 1 0	WXI.	50		47 3

These are the cash prices of one wholesale warehouse in Thames street; an immediately adjoining warehouse charges fully 1*s.* more upon the standard CI, and proportionally upon the others.

TITANIUM is a rare metal, discovered by Klaproth, in menachanite, in 1794. It has been detected since in the form of small cubes of a copper-red color, in some of the blast furnaces in Yorkshire. According to Hassenfratz, its presence in small quantity does not impair the malleability of iron. It is very brittle, so hard as to scratch steel, and very light, having a specific gravity of only 5·3. It will not melt in the heat of any furnace, nor dissolve, when crystallized, even in nitro-muriatic acid; but only when in fine powder. By calcination with nitre, it becomes oxygenated, and forms titanate of potassa. Traces of this metal may be detected in many irons, both wrought and cast. The principal ores of titanium are *sphene*, common and foliated, *rutile*, *iserine*, *menachanite*, and *octahedrite* or *pyramidal titanium ore*. None of them has been hitherto applied to any use.

TOBACCO. It is said that the name tobacco was given by the Spaniards to the plant, because it was first observed by them at Tabasco, or Tabaco, a province of Yucatan in Mexico. In 1560, Nicot, the French ambassador to Portugal, having received some tobacco from a Flemish merchant, showed it, on his arrival in Lisbon, to the grand prior, and, on his return into France, to Catherine of Medicis, whence it has been called Nicotiana by the botanists. Admiral Sir Francis Drake, having, on his way home from the Spanish Main in 1586, touched at Virginia, and brought away some forlorn colonists, is reported to have first imported tobacco into England. But, according to Lobel, this plant was cultivated in Britain before the year 1570; and was consumed by smoking in pipes by Sir Walter Raleigh and companions, so early as the year 1584.

The plants are hung up to dry during four or five weeks; taken down out of the sheds in damp weather, for in dry they would be apt to crumble into pieces; stratified in heaps, covered up, and left to sweat for a week or two, according to their quality and the state of the season; during which time they must be examined frequently, opened up, and turned over, lest they become too hot, take fire, or run into putrefactive fermentation. This process needs to be conducted by skilful and attentive operatives. An experienced negro can form a sufficiently accurate judgment of the temperature, by thrusting his hand down into the heap.

The tobacco thus prepared, or often without fermentation, is sent into the market; but, before being sold, it must undergo the inspection of officers, appointed by the state with very liberal salaries, who determine its quality, and brand an appropriate stamp upon its casks, if it be sound; but if it be bad, it is burned.

Our respectable tobacconists are very careful to separate all the damaged leaves, before they proceed to their preparation, which they do by spreading them in a heap upon a stone pavement, watering each layer in succession with a solution of sea salt, of spec. grav. 1·107, called *sauce*, till a ton or more be laid; and leaving their principles to react on each other for three or four days, according to the temperature, and the nature of the tobacco. It is highly probable that ammonia is the volatilizing agent of many odors, and especially of those of tobacco and musk. If a fresh green leaf of tobacco be crushed between the fingers, it emits merely the herbaceous smell common to many plants; but if it be triturated in a mortar, along with a little quicklime or caustic potash, it will immediately exhale the peculiar odor of snuff. Now analysis shows the presence of muriate of ammonia in this plant, and fermentation serves further to generate free ammonia in it; whence, by means of this process, and lime, the odoriferous vehicle is abundantly developed. If, on the other hand, the excess of alkaline matter in the tobacco of the shops be saturated by a mild dry acid, as the tartaric, its peculiar aroma will entirely disappear.

Tobacco contains a great quantity of an azotized principle, which by fermentation produces abundance of ammonia; the first portions of which saturate the acid juices of the plant, and the rest serve to volatilize its odorous principles. The salt water is useful chiefly in moderating the fermentation, and preventing it from passing into the putrefactive stage; just as salt is sometimes added to saccharine worts in tropical countries, to temper the fermentative action. The sea salt, or concentrated sea water, which contains some muriate of lime, tends to keep the tobacco moist, and is therefore preferable to pure chloride of sodium for this purpose. Some tobacconists mix molasses with the salt *sauce*, and ascribe to this addition the violet color 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 silent spirit of wine being poured in, the mixture is to be equably, but sparingly, sprinkled with the rose of a watering-pot, over the leaves of the tobacco, as they are successively stratified upon the preparation floor.

The fermented leaves, being next stripped of their middle ribs by the hands of children, are sorted anew, and the large ones are set apart for making cigars. Most of the tobaccos on sale in our shops are mixtures of different growths: one kind of smoking tobacco, for example, consists of 70 parts of Maryland, and 30 of meager Virginia; and one kind of snuff consists of 80 parts of Virginia, and 30 parts of either Humesfort 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 Havana is in brownish, light leaves, of an agreeable and rather spicy smell; it forms the best cigars. The Carolina tobacco is less unctuous than the Virginian; but in the United States it ranks next to the Maryland.

The shag tobacco is dried to the proper point upon sheets of copper.

Tobacco is cut into what is called shag tobacco by knife-edged chopping stamps, a machine somewhat similar to that represented under Metallurgy, *fig.* 670. For grinding the tobacco leaves into snuff, conical mortars are employed, somewhat like that used by the Hindoos for grinding sugar-canes, *fig.* 1080; but the sides of the snuff-mill have sharp ridges from the top to near the bottom.

Mr. L. W. Wright obtained a patent in August, 1827, for a tobacco-cutting machine, which bears a close resemblance to the well-known machines with revolving knives, for cutting straw into chaff. The tobacco, after being squeezed into cakes, is placed upon a smooth bed within a horizontal trough, and pressed by a follower and screws to keep it compact. These cakes are progressively advanced upon the bed, or fed in, to meet the revolving blades. The speed of the feeding-screw determines the degree of fineness of the sections or particles into which the tobacco is cut.

I was employed some years ago by the Excise to analyze a quantity of snuff, seized on suspicion of having been adulterated by the manufacturer. I found it to be largely drugged with pearl-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.

According to the recent analysis of Possett 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.

Nicotine is a transparent colorless liquid, of an alkaline nature. It may be distilled in a retort plunged into a bath heated to 290° Fahrenheit. It has a pricking, burning taste, which is very durable; and a pungent, disagreeable smell. It burns by means of a wick, with the diffusion of a vivid light, and much smoke. It may be mixed with water in all proportions. It is soluble also in acetic acid, oil of almonds, alcohol, and ether, but not in oil of turpentine. It acts upon the animal economy with extreme violence; and in the dose of one drop it kills a dog. It forms salts with the acids. About one part of it may be obtained by very skilful treatment from one thousand of good tobacco.

Tobacco imported into the United Kingdom, viz. — unmanufactured, in 1836, 52,232,907 lbs.; in 1837, 27,070,448 lbs.; — manufactured, and snuff, in 1836, 182,248 lbs.; in 1837, 642,287 lbs. Retained for home consumption, unmanufactured, in 1836, 22,309,021 lbs.; in 1837, 22,504,343 lbs.;—manufactured, and snuff, in 1836, 159,226 lbs.; in 1837, 145,045 lbs. Duty received,—on unmanufactured tobacco, in 1836, £3,344,703; in 1837, £3,375,125; on manufactured tobacco, and snuff, in 1836, £71,560; in 1837, £65,220.

TOBACCO-PIPES. The practice of smoking tobacco has become so general in many nations as to render the manufacture of tobacco-pipes a considerable branch of industry. Some seek in the inhalation of tobacco-smoke a pleasurable narcotism; others imagine it to be beneficial to their health; but, in general, smoking is merely a dreamy resource against ennui, which ere long becomes an indispensable stimulus. The filthiness of this habit, the offensive odor which persons under its influence emit from their mouths and clothes, the stupor it too often occasions, as well as the sallow complexion, black or carious teeth, and impaired digestion, all prove the great consumption of tobacco to be akin in evil influence upon mankind to the use of ardent spirits.

Tobacco-pipes are made of a fine-grained plastic white clay, to which they have given the name. It is worked with water into a thin paste, which is allowed to settle in pits, or it may be passed through a sieve, to separate the silicious or other stony impurities; the water is afterwards evaporated till the clay becomes of a doughy consistence, when it must be well kneaded to make it uniform. Pipe-clay is found chiefly in the isle of Purbeck and Dorsetshire. It is distinguished by its perfectly white color, 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.

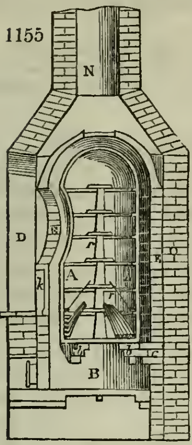
The pipe is finished by means of a folding brass or iron mould, channelled inside of the shape of the stem and the bowl, and capable of being opened at the two ends. It is formed of two pieces, each hollowed out like a half-pipe, cut as it were lengthwise; and these two jaws, when brought together, constitute the exact space for making one pipe. There are small pins in one side of the mould, corresponding to holes in the other, which serve as guides for applying the two together with precision.

The workman takes a long iron wire, with its end oiled, and pushes it through the soft clay in the direction of the stem, to form the bore, and he directs the wire by feeling with his left hand the progress of its point. He lays the pipe in the groove of one of the jaws of the mould, with the wire sticking in it; applies the other jaw, brings them smartly together, and unites them by a clamp or vice, which produces the external form. A lever is now brought down, which presses an oiled stopper into the bowl of the pipe, while it is in the mould, forcing it sufficiently down to form the cavity; the wire being meanwhile thrust backwards and forwards so as to pierce the tube completely through. The wire must become visible at the bottom of the bowl, otherwise the pipe will be imperfect. The wire is now withdrawn, the jaws of the mould opened, the pipe taken out, and the redundant clay removed with a knife. After drying for a day or two, the pipes are scraped, polished with a piece of hard wood, and the stems being bent into the desired form, they are carried to the baking kiln, which is capable of firing fifty gross in from 8 to 12 hours. A workman and a child can easily make five gross of pipes in a day.

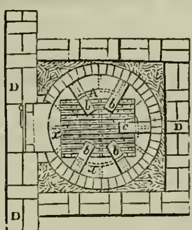
No tobacco-pipes are so highly prized as those made in Natolia, in Turkey, out of meerschaum, a somewhat plastic magnesian stone, of a soft greasy feel, which is formed into pipes after having been softened with water. It becomes white and hard in the kiln.

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.* 1155 and 1156, 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.* 1156 (the dotted circle representing the cylinder). These ribs are perforated with occasional apertures, as shown in *fig.* 1155, 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.

1155



1156



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.* 1155, 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 8 or 9 hours; the fire being gradually raised, or damped if occasion be, by a plate partially slid over the chimney top.

TODDY, *Sura*, *Mee-ra*, sweet juice.—The proprietors of cocoa-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 cocoa-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 cocoa-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 favorably 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 neighborhood of villages, especially where European troops are stationed. When it is drunk before sunrise, it is a cool, delicious, and particularly wholesome beverage; but by eight or nine o'clock fermentation has made some progress, and it is then highly intoxicating.*

TOLU, is a brownish-red balsam, extracted from the stem of the *Myroxilon toluiferum*, a tree which grows in South America. It is composed of resin, oil, and benzoic acid. Having an agreeable odor, it is sometimes used in perfumery. It has a place in the Materia Medica, but for what good reason I know not.

TOMBAC, is a white alloy of copper.

TONKA BEAN, the fruit of the *Dipterix odorata*, affords a concrete crystalline volatile oil (*stearoptène*), called *coumarine* by the French. It is extracted by digestion with alcohol, which dissolves the stearoptène, 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.

TOPAZ. See LAPIDARY.

TORTOISE-SHELL, or rather scales, 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 13 in number, and may be readily separated from the bony part 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 the finger, or breathing upon them, would prevent their coalescence. See HORN.

TOUCH-NEEDLES, and TOUCH-STONE, are means of ascertaining the quality of gold trinkets. See ASSAY.

TOW. See FLAX.

TRAGACANTH, GUM. (*Gomme adracante*, Fr.; *Traganth* Germ.) See GUM.

TRAVERTINO. See TUFA.

TREACLE, is the viscid brown uncrystallizable sirup which drains from the sugar-refining moulds. Its specific gravity is generally 1·4, and it contains upon an average 75 per cent. of solid matter, by my experiments.

TRIPOLI (*Terre pourrie*, Fr.; *Tripel*, Germ.), rotten-stone, is a mineral of an earthy fracture, a yellowish-gray or white color, composition impalpably fine, meager to the touch, does not adhere to the tongue, and burns white. Its analogue, the *Polierschiefer*, occurs in thin flat foliated pieces, of the above colors, occasionally striped; soft, absorbent of water; spec. grav. 1·9 to 2·2.

M. Ehrenberg has shown that both of these friable homogeneous rocks, which consist almost entirely of silica, are actually composed of the exuviæ or rather the skeletons of infusoria (*animalcula*) of the family of *Barcillariæ*, and the genera *Coeconema*, *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 Francisbad, near Eger.

The meadow iron ore (*Fer limoneux des marais*) is composed almost wholly of the *Gaellonella ferruginea*. Most of these infusoria are lacustrine; but others are marine, particularly the *tripolis* of the Isle of France.

According to the chemical analysis of Bucholz, tripoli consists of—silica, 81; alumina, 1·5; oxyde of iron, 8; sulphuric acid, 3·45; water, 4·55. This specimen was probably found in a coal-field. The tripoli of Corfu is reckoned the best for scouring or brightening brass and other metals. Mr. Phillips found in the Derbyshire rotten-stone (near

* Contributions to the History of the Cocoa-nut Tree. By Henry Marshall, Esq., Deputy Inspector of Hospitals.

Bakewell), 86 of alumina, 4 of silica, and 10 of carbon—being a remarkable difference in composition from the Bohemian.

TUFA, or TUF, is a gray deposite of calcareous carbonate, from springs and streams.

TULA METAL, is an alloy of silver, copper, and lead.

TUNGSTEN (Eng. and Fr.; *Wolfram*, Germ.), is a peculiar metal, which occurs in the state of an acid (the *tungstic*), combined with various bases, as with lime, the oxydes of iron, manganese, and lead. The metal is obtained by reduction of the ore, or the deoxydizement of the acid, in the form of a dark steel-gray powder, which assumes under the burnisher a feeble metallic lustre. Its specific gravity is 17·22.

TURBITH MINERAL, is the yellow subsulphate of mercury.

TURF (*Peat*, Scotch; *Tourbe*, Fr.; *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 happily removed by Mr. Williams, managing director of the Dublin Steam Navigation Company, who has recently obtained a patent for a method of converting the lightest and purest beds of peat-moss, or bog, into the four following products: 1. A brown combustible solid, denser than oak; 2. A charcoal, twice as compact as that of hard wood; 3. A factitious coal; and 4. A factitious coke; each of which possesses very valuable properties.

Mr. D'Ernst, artificer of fire-works to Vauxhall, has proved, by the severe test of colored fires, that the turf charcoal of Mr. Williams is 20 per cent. more combustible than that of oak. Mr. Oldham, engineer of the Bank of England, has applied it in softening his steel plates and dies, with remarkable success. But one of the most important results of Mr. Williams's invention is, that with 10 cwts. of pitcoal, and 2½ cwts. of his factitious coal, the same steam power is now obtained, in navigating the Company's ships, as with 17½ cwts. of pitcoal alone; thereby saving 30 per cent. in the stowage of fuel. What a prospect is thus opened up of turning to admirable account the unprofitable bogs of Ireland; and of producing, from their inexhaustible stores, a superior fuel for every purpose of arts and engineering!

The turf is treated as follows:—Immediately after being dug, it is triturated under revolving edge-wheels, faced with iron plates perforated all over their surface, and is forced by the pressure through these apertures, till it becomes a species of pap, which is freed from the greater part of its moisture by squeezing in a hydraulic press between layers of caya cloth, then dried, and coked in suitable ovens.—(See CHARCOAL, and PITCOAL, COKING OF.) Mr. Williams makes his factitious coal by incorporating with pitch or rosin, melted in a caldron, as much of the above charcoal, ground to powder, as will form a doughy mass, which is moulded into bricks in its hot and plastic state. From the experiments of M. Le Sage, detailed in the 5th volume of "The Repertory of Arts," charred ordinary turf seems to be capable of producing a far more intense heat than common charcoal. It has been found preferable to all other fuel for case-hardening iron, tempering steel, forging horse-shoes, and welding gun-barrels. Since turf is partially carbonized in its native state, when it is condensed by the hydraulic press, and fully charred, it must evidently afford a charcoal very superior in calorific power to the porous substance generated from wood by fire.

TURKEY RED, is a brilliant dye produced on cotton goods by MADDER.

TURMERIC, *Curcuma*, *Terra merita*, (*Souchet*, or *Safran des Indes*, Fr.; *Gelbwurzel*, Germ.), is the root of the *Curcuma longa* and *rotunda*, a plant which grows in the East Indies, where it is much employed in dyeing yellow, as also as a condiment in curry sauce or powder. The root is knotty, tubercular, oblong, and wrinkled; pale-yellow without, and brown-yellow within; of a peculiar smell, a taste bitterish and somewhat spicy. It contains a peculiar yellow principle, called *curcumine*, a brown coloring-matter, a volatile oil, starch, &c. The yellow tint of turmeric is changed to brown-red by alkalis, alkaline earths, subacetate of lead, and several metallic oxydes; for which reason, paper stained with it is employed as a chemical test.

Turmeric is employed by the wool-dyers for compound colors 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 color. A yellow lake may be made by boiling turmeric powder with a solution of alum, and pouring the filtered decoction upon pounded chalk.

TURNSOLE. See ARCHIL and LITMUS.

TURQUOIS. See LAPIDARY.

TURPENTINE (*Térébinthine*, Fr.; *Terpenthin*, Germ.), is a substance which flows out of incisions made in the stems of several species of pines. It has the consistence and gray-yellow color of honey. It has a smell which is not disagreeable to many persons, a warm, sharp, bitterish taste; dries into a solid in the air, with the evaporation of its volatile oil. It becomes quite fluid at a moderate elevation of temperature, and burns at a higher heat, with a bright but a very fuliginous flame. There are several varieties of turpentine.

1. *Common turpentine*, is extracted from incisions in the *Pinus abies* and *Pinus silvestris*. It has little smell; but a bitter burning taste. It consists of the volatile oil of turpentine to the amount of from 5 to 25 per cent.; and of rosin or colophony.

2. *Venice turpentine*, is extracted from the *Pinus larix* (larch), and the French turpentine from the *Pinus maritima*. The first comes from Styria, Hungary, the Tyrol, and Switzerland, and contains from 18 to 25 per cent. of oil; the second, from the south of France, and contains no more than 12 per cent. of oil. The oil of all the turpentines is extracted by distilling them along with water. They dissolve in all proportions in alcohol, without leaving any residuum. They also combine with alkaline leys, and in general with the salifiable bases. Venice turpentine contains also succinic acid.

3. Turpentine of Strasbourg is extracted from the *Pinus picea* and *Abies excelsa*. It affords 33·5 per cent. of volatile oil, and some volatile or crystallizable resin, with extractive matter and succinic acid.

4. Turpentine of the Carpathian mountains, and of Hungary; the first of which comes from the *Pinus cembra*, and the second from the *Pinus mugos*. They resemble that of Strasbourg.

5. Turpentine of Canada, called Canada balsam, is extracted from the *Pinus canadensis* and *balsamea*. Its smell is much more agreeable than that of the preceding species.

6. Turpentine of Cyprus or Chio, is extracted from the *Pistacea terebinthus*. It has a yellow, greenish, or blue-green color. Its smell is more agreeable, and taste less acrid, than those of the preceding sorts.

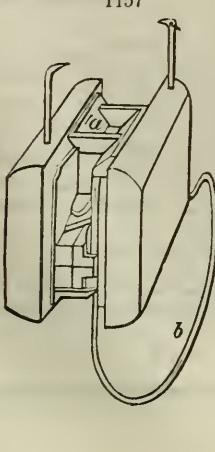
Common turpentine imported into the United Kingdom, in 1836, 370,981 cwts. 1 qr. 26 lbs.; in 1837, 415,023 cwts. 1 qr. 10 lbs. Retained for home consumption, in 1836, 341,693 cwts. 18 lbs.; in 1837, 405,772 cwts. 2 qrs. 14 lbs. Duty received, in 1836, £74,052; in 1837, £87,918.

TURPENTINE, OIL OF, sometimes called essence of turpentine. As found in commerce, it contains more or less rosin, from which it may be freed by re-distillation along with water. It is colorless, limpid, very fluid, and possessed of a very peculiar smell. Its specific gravity, when pure, is 0·870; that of the oil commonly sold in London, is 0·875. It always reddens litmus paper, from containing a little succinic acid. According to Oppermann, the oil which has been repeatedly rectified over chloride of calcium, consists of 84·60 carbon, 11·735 hydrogen, and 3·67 oxygen. When oil of turpentine contains a little alcohol, it burns with a clear flame; but otherwise it affords a very smoky flame. Chlorine inflames this oil; and muriatic acid converts it into a crystalline substance, like camphor. It is employed extensively in varnishes, paints, &c., as also in medicine.

TUTENAG, is an alloy of copper and zinc.

TYPE, (*Caractère*, Fr.; *Druckbuchstabe*, Germ.) The first care of the letter-cutter is to prepare well-tempered steel punches, upon which he draws or marks the exact shape of the letter, with pen and ink if it be large, but with a smooth blunted point of a needle if it be small; and then, with a proper sized and shaped graver and sculptor, 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.*

1157



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.* 1157, in which the types are cast, is composed of two parts. The outer part is made of wood, the inner of steel. At the top it has a hopper-mouth *a*, into which the fused type-metal is poured. The interior cavity is as uniform as if it had been hollowed out of a single piece of steel; because each half, which forms two of the four sides of the letter, is exactly fitted to the other. The matrix is placed at the bottom of the mould, directly under the centre of the orifice, and is held in its position by a spring *b*. Every letter that is cast can be loosened from the matrix only by removing the pressure on the spring.

A good type-foundry is always provided with several furnaces, each surmounted with an iron pot containing the melted alloy, of 3 parts of lead and 1 of antimony. Into this pot the founder dips the very small iron ladle, to lift merely as much metal as will cast a single letter at a time. Having poured in the metal with his right hand, and returned the ladle to the melting-pot, the founder throws up his left hand, which holds the mould, above his head, with a sudden jerk, supporting it with his right hand. It is this movement which forces the metal into all the interstices of the matrix; for without it, the metal, especially in the smaller moulds, would not be able to expel the air and reach the bottom. The pouring in the metal, the throwing up the mould, the unclosing it, removing the pressure of the spring, picking out the cast letter, closing the mould again, and re-applying the spring to be ready for a new operation, are all performed with such astonishing rapidity and precision, that a skilful workman will turn out five hundred good letters in an hour, being at the rate of one every eighth part of a minute. A considerable piece of metal remains attached to the end of the type as it quits the mould. There are nicks upon the lower edge of the types, to enable the compositor to place them upright, without looking at them.

From the table of the *caster*, the heap of types turned out of his mould, is transferred from time to time to another table, by a boy, whose business it is to break off the superfluous metal, and that he does so rapidly as to clear from 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 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 three or four inches high. The names of the different letters and their dimensions, or the number of lines which each occupies in a foot, are stated in the following table:—

Double Pica,	41½	Small Pica,	83	Nonpareil,	143
Paragon,	44½	Long Primer,	89	Agate,	166
Great Primer,	51¼	Bourgeois,	102¼	Pearl,	178
English,	64	Brevier,	112½	Diamond,	205
Pica,	71½	Minion,	128		

T. Aspinwall, Esq., the American Consul, obtained, in May, 1828, a patent for an improved method of casting printing types by means of a mechanical process, being a communication from a foreigner residing abroad. The machine is described, with six explanatory figures, in the second series of Newton's Journal, vol. v. page 212. The patentee does not claim, as his invention, any of the parts separately, but the general process and arrangement of machinery; more particularly the manner of suspending a swing table (upon which the working parts are mounted) out of the horizontal and perpendicular position; the mode of moving the table with the parts of the mould towards the melting pot; the manner of bringing the parts of the mould together, and keeping them closed during the operation of casting the types. Several other mechanical schemes have been proposed for founding types, but I have been informed by very competent judges, Messrs. Clowes, that none of them can compete in practical utility with that dexterity and precision of handiwork, which I have often seen practised in their great printing establishment in Stamford street.

U.

ULTRAMARINE (*Outremer*, Fr.; *Ultramarins*, Germ.), is a beautiful blue pigment obtained from the variegated blue mineral, called lazulite (*lapis lazuli*), by the following process:—Grind the stone to fragments, rejecting all the colorless bits, calcine at a red heat, quench in water, and then grind to an impalpable powder along with water, in a paint-mill (see PAINTS, GRINDING OF), 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 silicious 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 coloring-matter. If it should not separate readily, water heated to about 150° F. should be had recourse to. When the water is sufficiently charged with blue color, it is poured off and replaced by fresh water; and the kneading and change of water are repeated till the whole of the color is extracted. Others knead the mixed resinous mass under a slender stream of water, which runs off with the color into a large earthen pan. The first waters afford, by rest, a deposite of the finest ultramarine; the second, a somewhat inferior article, and so on. Each must be washed afterwards with several more waters, before they acquire the highest quality of tone; then dried separately, and freed from any adhering particles of the pitchy compound by digestion in alcohol. The remainder of the mass being melted with oil, and kneaded in water containing a little soda or potash, yields an inferior pigment, called *ultramarine ashes*. The best *ultramarine* is a splendid blue pigment, which works well with oil, and is not liable to change by time. Its price in Italy was five guineas the ounce, a few years ago, but it is now greatly reduced.

The blue color 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.

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. Of M. Guimet's finest pigment I received a bottle several years ago, from my friend M. Merimée, Secretary of the *Ecole de Beaux Arts*, which has been found by artists little, if any, inferior to the lazulite ultramarine. M. Guimet sells it at sixty francs per pound French,—which is little more than two guineas the English pound. He has kept his process secret. But M. Gmelin, of Tübingen, has published a prescription for making it; which consists in enclosing carefully in a Hessian crucible a mixture of two parts of sulphur, and one of dry carbonate of soda, heating them gradually to redness till the mass fuses, and then sprinkling into it by degrees another mixture, of silicate of soda, and aluminate of soda; the first containing seventy-two parts of silica, and the second seventy 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 sulphuret of sodium; and that to the reaction of the last constituent upon the former two, it owes its color.

UMBER, is a massive mineral; fracture large and flat; conchoidal in the great, very fine earthy in the small; dull; color, liver, chestnut,—dark yellowish brown; opaque; does not soil, but writes; adheres strongly to the tongue, feels a little rough and meager, and is very soft; specific gravity 2·2. It occurs in beds with brown jasper in the Island of Cyprus, and is used by painters as a brown color, and to make varnish dry quickly

URANIUM, is a rare metal, first discovered by Klaproth, in the black mineral called *pechblende*, found in a mine near Johann-Georgen-Stadt, in Saxony, and which is a sulphuret of uranium. A double phosphate of uranium and copper, called *green uranite*, and *uran mica*, occurs in Cornwall. It has been reduced to the metallic state by various devices, but it has hardly the appearance of metal to the naked eye, and from the rarity of its ores is not likely to be of any importance in the arts.

URAO, is the native name of a sesquicarbonate of soda found at the bottom of certain lakes in Mexico, especially to the north of Zacatecas, and in several other provinces; also in South America at Columbia, 48 English miles from Merida.

V.

VALONIA, is a kind of acorn, imported from the Levant and the Morea for the use of tanners, as the husk or cup contains abundance of tannin. The quantity imported for home consumption in 1836, was 80,511 cwts.; of which Turkey furnished 58,724, Italy and the Italian islands, 7209.

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 Jönköping. 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 cinders of the Jaberg iron contain more vanadium than the metal itself. It exists in it as vanadic acid. For the reduction of this acid to vanadium, see Berzelius's *Traité de Chimie*, vol. iv. p. 644. Vanadium is white, and when its surface is polished, it resembles silver or molybdenum more than any other metal. It combines with oxygen into two oxydes and an acid.

The vanadate of ammonia, mixed with infusion of nutgalls, forms a black liquid, which is the best writing-ink hitherto known. The quantity of the salt requisite is so small as to be of no importance when the vanadium comes to be more extensively extracted. The writing is perfectly black. The acids color it blue, but do not remove it, as they do tannate of iron: the alkalis, diluted so far as not to injure the paper, do not dissolve it; and chlorine, which destroys the black color, does not, however, make the traces illegible, even when they are subsequently washed with a stream of water. It is perfectly fluent, and, being a chemical solution, stands in want of no viscid gum to suspend the color, like common ink. The influence of time upon it remains to be tried.

VANILLA, is the oblong narrow pod of the *Epidendron vanilla*, Linn., of the natural family *Orchideæ*, which grows in Mexico, Colombia, 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 mistletoe. The fruit is subcylindric, about 8 inches long, one-celled, siliquose, and pulpy within. It should be gathered before it is fully ripe.

When about 12000 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 color. It contains a pulpy parenchyma, soft, unctuous, very brown, in which are imbedded black, brilliant, very small seeds. Its smell is ambrosiacal and aromatic; its taste hot, and rather sweetish. These properties seem to depend upon an essential oil, and also upon benzoic acid, which forms efflorescences upon the surface of the fruit. The pulpy part possesses alone the aromatic quality; the pericarpium has hardly any smell.

The kind most esteemed in France, is called *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 color, and of a most delicious flavor, 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 one half to three quarters of an inch. It is brown, soft, viscid, almost always open, of a strong smell, but less agreeable than the *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. Their analysis by Bucholz is unsatisfactory, and refers obviously to the coarsest sort. Berzelius says that the efflorescences are not acid.

VAPOR (*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.

VARNISH (*Vernis*, Fr.; *Firniss*, Germ.), is a solution of resinous matter, which is spread over the surface of any body, in order to give it a shining, transparent, and hard coat, capable of resisting, in a greater or less degree, the influences of air and moisture. Such a coat consists of the resinous parts of the solution, which remain in a thin layer upon the surface, after the liquid solvent has either evaporated away, or has dried up. When large quantities of spirit varnish are to be made, a common still, mounted with its capital and worm, is the vessel employed for containing the materials, and it is placed in a steam or water bath. The capital should be provided with a stuffing-box, through which a stirring-rod may pass down to the bottom of the still, with a cross-piece at its lower end, and a handle or winch at its top. After heating the bath till the alcohol boils and begins to distil, the heat ought to be lowered, that the solution may continue to proceed in an equable manner, with as little evaporation of spirit as possible. The operation may be supposed to be complete when the rod can be easily turned round. The varnish must be passed through a silk sieve of proper fineness; then filtered through porous paper, or allowed to clear leisurely in stone jars. The alcohol which has come over should be added to the varnish, if the just proportions of the resins have been introduced at first. The following are reckoned good French recipes for varnishes:—

White spirit varnish.—Sandarach, 250 parts; mastic in tears, 64; elemi resin, 32; turpentine (Venice), 64; alcohol, of 85 per cent., 1000 parts by measure.

The turpentine is to be added after the resins are dissolved. This is a brilliant varnish, but not so hard as to bear polishing.

Varnish for the wood toys of Spa. Tender copal, 75 parts; mastic, 12·5; Venice turpentine, 6·5; alcohol, of 95 per cent., 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 color 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.

Copal varnish.—Hard copal, 300 parts; drying linseed or nut oil, from 125 to 250 parts; oil of turpentine, 500; these three substances are to be put into three separate vessels; the copal is to be fused by a somewhat sudden application of heat; the drying oil is to be heated to a temperature a little under ebullition, and is to be added by small portions at a time to the melted copal. When this combination is made, and the heat a little abated, the essence of turpentine, likewise previously heated, is to be introduced by degrees; some of the volatile oil will be dissipated at first; but more being added, the union will take place. Great care must be taken to prevent the turpentine vapor from catching fire, which might occasion serious accidents to the operator. When the varnish is made, and has cooled down to about the 130th degree of Fahr., it may be strained through a filter, to separate the impurities and undissolved copal.

Almost all varnish-makers think it indispensable to combine the drying oil with the copal, before adding the oil of turpentine; but in this they are mistaken. Boiling oil of turpentine combines very readily with fused copal; and, in some cases, it would probably be preferable to commence the operation with it, adding it in successive small quantities. Indeed, the whitest copal varnish can be made only in this way; for if the drying oil have been heated to nearly its boiling point, it becomes colored, and darkens the varnish.

This varnish improves in clearness by keeping. Its consistence may be varied by varying the proportions of the ingredients, within moderate limits. Good varnish, applied in summer, should become so dry in 24 hours that the dust will not stick to it, nor receive an impression from the fingers. To render it sufficiently dry and hard for polishing, it must be subjected for several days to the heat of a stove.

Milk of wax is a valuable varnish, which may be prepared as follows:—Melt in a porcelain capsule a certain quantity of white wax, and add to it, while in fusion, an equal quantity of spirit of wine, of sp. grav. 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 and Pompeii owe their freshness at the present day.

The most recent practical account of the manufacture of varnishes, is that communicated by Mr. J. Wilson Neil to the Society of Arts, and published in the 49th volume of their "Transactions."

The building or shed wherein varnish is made, ought to be quite detached from any buildings whatever, to avoid accidents by fire. For general purposes, a building about 18 feet by 16 is sufficiently large for manufacturing 4000 gallons and upwards annually, provided there are other convenient buildings for the purpose of holding the utensils, and warehousing the necessary stock.

Procure a copper pan, made like a common washing-copper, which will contain from fifty to eighty gallons, as occasion may require; when wanted, set it upon the boiling furnace, and fill it up with linseed oil within five inches of the brim. Kindle a fire in the furnace underneath, and manage the fire so that the oil shall gradually, but slowly, increase in heat for the first two hours; then increase the heat to a gentle simmer; and if there is any scum on the surface, skim it off with a copper ladle, and put the skimming away. Let the oil boil gently for three hours longer; then introduce, by a little at a time, one quarter of an ounce of the best calcined magnesia for every gallon of oil, occasionally stirring the oil from the bottom. When the magnesia is all in, let the oil boil rather smartly for one hour; it will then be sufficient. Lay a cover over the oil, to keep out the dust while the fire is withdrawn and extinguished by water; next uncover the oil, and leave it till next morning; and then, while it is yet hot, ladle it into the carrying-jack, or let it out through the pipe and cock; carry it away, and deposite it in either a tin or leaden cistern, for wooden vessels will not hold it; let it remain to settle for at least three months. The magnesia will absorb all the acid and mucilage from the oil, and fall to the bottom of the cistern, leaving the oil clear and transparent, and fit for use. Recollect, when the oil is taken out, not to disturb the bottoms, which are only fit for black paint.

GENERAL OBSERVATIONS AND PRECAUTIONS TO BE OBSERVED IN MAKING VARNISHES.

Set on the boiling-pot with 8 gallons of oil; kindle the fire; then lay the fire in the gum-furnace; have as many 8lb. bags of gum-copal all ready weighed up, as will be wanted; put one 8lb. into the pot, put fire to the furnace, set on the gum-pot; in three minutes (if the fire is brisk) the gum will begin to fuse and give out its gas, steam, and acid; stir and divide the gum, and attend to the rising of it, as before directed. Eight pounds 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 pounds 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 pounds of gum in the boiling-pot, under which keep up a brisk strong fire until a scum or froth rises and covers all the surface of the contents, when it will begin to rise rapidly. Observe, when it rises near the rivets of the handles, carry it from the fire, and set it on the ash-bed, stir it down again, and scatter in the driers by a little at a time; keep stirring, and if the frothy head goes down, put it upon the furnace, and introduce *gradually* the remainder of the driers, always carrying out the pot when the froth rises near the rivets. In general, if the fire be good, all the time a pot requires to boil, from the time of the last gum being poured in, is about three and a half or four hours; but *time* is no criterion for a beginner to judge by, as it may vary according to the weather, the quality of the oil, the quality of the gum, the driers, or the heat of the fire, &c.; therefore, about the third hour of boiling, try it on a bit of glass, and keep it boiling until it feels strong and stringy between the fingers; it is then boiled sufficiently to carry it on the ash-bed, and to be stirred down until it is cold enough to mix, which will depend much on the weather, varying from half an hour, in dry frosty weather, to one hour in warm summer weather. Previous to beginning to mix, have a sufficient quantity of turpentine ready, fill the pot, and pour in, stirring all the time at the top or surface, as before directed, until there are fifteen gallons, or five tins of oil of turpentine introduced, which will leave it quite thick enough if the gum is good, and has been well run; but if the gum was of a weak quality, and has not been well fused, there ought to be no more than twelve gallons of turpentine mixed, and even that may be too much. Therefore, when twelve gallons of turpentine have been introduced, have a flat saucer at hand, and pour into it a portion of the varnish, and in two or three minutes it will show whether it is too thick; if not sufficiently thin, add a little more turpentine, and strain it off quickly. As soon as the whole is stored away, pour in the turpentine washings, with which the gum-pots have been washed, into the boiling-pot, and with the swish quickly wash down all the varnish from the pot sides; afterwards, with a large piece of woollen rag dipped in pumice-powder, wash and polish every part of the inside of the boiling-pot, performing the same operation on the ladle and stirrers; rinse them with the turpentine washings, and at last rinse them altogether in clean turpentine, which also put to the washings; wipe dry with a clean soft rag the pot, ladle, stirrer, and funnels, and lay the sieve so as to be completely covered with turpentine, which will always keep it from gumming up. The foregoing directions concerning running the gum, and pouring in the oil, and also boiling off and mixing, are, with very little difference, to be observed in the making of all sorts of copal varnishes, except the differences of the quantities of oil, gum, &c., which will be found under the various descriptions by name, which will be hereafter described.

The choice of linseed oil is of peculiar consequence to the varnish-maker. Oil from fine full-grown ripe seed, when viewed in a vial, 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 color of the varnish when made, but appears limpid and brilliant.

Copal varnishes for fine paintings, &c.—Fuse 8 pounds 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 pounds 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;	$3\frac{1}{2}$ gallons of turpentine.
2 gallons of clarified oil;	To be boiled four hours.

Quick drying body copal varnish, for coaches, &c.

(1.) 8 lbs. of the best African copal;	(2.) 8 lbs. of fine gum animé;
2 gallons of clarified oil;	2 gallons of clarified oil;
$\frac{1}{2}$ lb. of dried sugar of lead;	$\frac{1}{4}$ lb. of white copperas;
$3\frac{1}{2}$ gallons of turpentine.	$3\frac{1}{2}$ gallons of turpentine.
Boiled till stringy, and mixed and strained.	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 colors, &c.

Best pale carriage varnish.

(1.) 8 lbs. 2d sorted African copal;	(2.) 8 lbs. of 2d sorted gum animé;
$2\frac{1}{2}$ gallons of clarified oil.	$2\frac{1}{2}$ gallons of clarified oil;
Boiled till very stringy.	$\frac{1}{4}$ lb. of dried sugar of lead;
$\frac{1}{4}$ lb. of dried copperas;	$\frac{1}{4}$ lb. of litharge;
$\frac{1}{4}$ lb. of litharge;	$5\frac{1}{2}$ gallons of turpentine.
$5\frac{1}{2}$ gallons of turpentine.	Mix this to the first while hot.
Strained, &c.	

This varnish will dry hard, if well boiled, in four hours in summer, and in six in winter. As the name denotes, it is intended for the varnishing of the wheels, springs, and carriage parts of coaches, chaises, &c.; also, it is that description of varnish which is generally sold to and used by house-painters, decorators, &c.; as from its drying quality and strong gloss, it suits their general purposes well.

Second carriage varnish.

8 lbs. of 2d sorted gum animé;
$2\frac{3}{4}$ gallons of fine clarified oil;
$5\frac{1}{4}$ gallons of turpentine;
$\frac{1}{4}$ lb. of litharge;
$\frac{1}{4}$ lb. of dried sugar of lead;
$\frac{1}{4}$ lb. of dried copperas.
Boiled and mixed as before.

Wainscot varnish.

8 lbs. of 2d sorted gum animé;
3 gallons of clarified oil;
$\frac{1}{4}$ lb. of litharge;
$\frac{1}{4}$ lb. of dried sugar of lead;
$5\frac{1}{2}$ 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.

Black japan is made by putting into the set-pot 48 pounds of Naples, or any other of the foreign asphaltums, (except the Egyptian.) As soon as it is melted, pour in 10 gallons of raw linseed oil; keep a moderate fire, and fuse 8 pounds of dark gum animé in the gum-pot; mix it with 2 gallons of hot oil, and pour it into the set-pot. Afterwards fuse 10 pounds of dark or sea amber in the 10 gallon iron pot; keep stirring it while fusing; and whenever it appears to be overheated, and rising too high in the pot, lift it from the fire for a few minutes. When it appears completely fused, mix in 2 gallons of hot oil, and pour the mixture into the set-pot; continue the boiling for 3 hours longer, and during that time introduce the same quantity of driers as before directed; draw out the fire, and let it remain until morning; then boil it until it rolls hard, as before directed; leave it to cool, and afterwards mix with turpentine.

Pale amber varnish.—Fuse 6 pounds of fine picked very pale transparent amber in the gum-pot, and pour in 2 gallons of hot clarified oil. Boil it until it strings very strong. Mix with 4 gallons of turpentine. This will be as fine as body copal, will work very free, and flow well upon any work it is applied to; it becomes very hard, and is the most durable of all varnishes; it is very excellent to mix in copal varnishes, to give them a hard and durable quality. Observe; amber varnish will always require a long time before it is ready for polishing.

Best Brunswick black.—In an iron pot, over a slow fire, boil 45 pounds of foreign asphaltum for at least 6 hours; and during the same time boil in another iron pot 6 gallons of oil which has been previously boiled. During the boiling of the 6 gallons, introduce 6 pounds of litharge gradually, and boil until it feels stringy between the fingers; then ladle or pour it into the pot containing the boiling asphaltum. Let the mixture boil until, upon trial, it will roll into hard pills; then let it cool, and mix it with 25 gallons of turpentine, or until it is of a proper consistence.

Iron-work black.—Put 48 pounds of foreign asphaltum into an iron pot, and boil for 4 hours. During the first 2 hours, introduce 7 pounds of red lead, 7 pounds of litharge, 3 pounds of dried copperas, and 10 gallons of boiled oil; add 1 eight-pound run of dark gum, with 2 gallons of hot oil. After pouring the oil and gum, continue the boiling two hours, or until it will roll into hard pills like japan. When cool, thin it off with thirty gallons of turpentine, or until it is of a proper consistence. This varnish is intended for blacking the iron-work of coaches and other carriages, &c.

A cheap Brunswick black.—Put 28 pounds of common black pitch, and 28 pounds of common asphaltum made from gas tar, into an iron pot; boil both for 8 or 10 hours, which will evaporate the gas and moisture; let it stand all night, and early next morning, as soon as it boils, put in 8 gallons of boiled oil; then introduce, gradually, 10 pounds of red lead, and 10 pounds of litharge, and boil for 3 hours, or until it will roll very hard. When ready for mixing, introduce 20 gallons of turpentine, or more, until of a proper consistence. This is intended for engineers, founders, ironmongers, &c.; it will dry in half an hour, or less, if properly boiled.

Axioms observed in the making of copal varnishes.—The more minutely the gum is run, or fused, the greater the quantity, and the stronger the produce. The more regular and longer the boiling of the oil and gum together is continued, the more fluid or free the varnish will extend on whatever it is applied to. When the mixture of oil and gum is too suddenly brought to 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 driers in varnish render it opaque and unfit for delicate colors. Copperas does not combine with varnish, but only hardens it. Sugar of lead does combine with varnish. Turpentine improves by age; and varnish by being kept in a warm place. All copal or oil varnishes require age before they are used.

Concluding observations.—All body varnishes are intended and ought to have $1\frac{1}{2}$ lbs. of gum to each gallon of varnish, when the varnish is strained off, and cold; but as the *thinning up*, or quantity of turpentine required to bring it to its proper consistence, depends very much upon the degree of boiling the varnish has undergone, therefore, when the gum and oil have not been strongly boiled, it requires less turpentine for that purpose; whereas, when the gum and oil are very strongly boiled together, a pot of 20 gallons will require perhaps 3 gallons above the regular proportionate quantity; and if mixing the turpentine is commenced too soon, and the pot not sufficiently cool, there will be frequently above a gallon and a half of turpentine lost by evaporation.

All carriage, wainscot, and mahogany varnish ought to have fully one pound of gum for each gallon, when strained and cold; and should one pot require more than its proportion of turpentine, the following pot can easily be left not quite so strongly boiled; then it will require less turpentine to thin it up.

Gold sizes, whether pale or dark, ought to have fully half a pound of good gum copal to each gallon, when it is finished; and the best black japan, to have half a pound of good gum, or upwards, besides the quantity of asphaltum.

Fine mastic, or picture varnish.—Put 5 pounds of fine picked gum mastic into a new four-gallon tin bottle; get ready 2 pounds of glass, bruised as small as barley; wash it several times; afterwards dry it perfectly, and put it into the bottle with 2 gallons of turpentine that has settled some time; put a piece of soft leather under the bung; lay the tin on a sack upon the counter, table, or any thing that stands solid; begin to agitate the tin, smartly rolling it backward and forward, causing the gum, glass, and turpentine, to work as if in a barrel-churn for at least 4 hours, when the varnish may be emptied out into any thing sufficiently clean, and large enough to hold it. If the gum is not all dissolved, return the whole into the bottle, and agitate as before, until all the gum is dissolved; then strain it through fine thin muslin into a clean tin bottle: leave it uncorked, so that the air can get in, but no dust; let it stand for 9 months, at least, before it is used; for the longer it is kept, the tougher it will be, and less liable to chill or bloom. To prevent mastic varnish from chilling, boil one quart of river sand with two 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 five 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 vapor 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 parlor. 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 sandarach into a four-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 four-gallon tin, and continue the agitation until it is ready to be strained, when every thing ought to be quite ready, and perfectly clean and dry, as oily tins, funnels, strainers, or any thing damp, or even cold weather, will chill and spoil the varnish. After it is strained off, put into the varnish one 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 sandarach, with 2 pounds of shellac, and 2 gallons of spirits of wine, 60 over proof; proceeding exactly as before directed for the white hard varnish, and agitating it when cold, which requires about 4 hours' time, without any danger of fire; whereas, making any spirit varnish by heat is always attended with danger. No spirit varnish ought to be made either near a fire or by candle light. When this brown hard is strained, add one 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 four-gallon tin, 1 pound of ground turmeric, 1½ ounces of powdered gamboge, 3½ pounds of powdered gum sandarach, 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 sandarach;
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 four-ounce vial 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 fire gradually, and sprinkle in, by a little at a time, 3 lbs. of scale litharge, 3 lbs. of good red lead, and 2 lbs. of Turkey umber, all well dried and free from moisture. If any moist driers are added, they will cause the oil to tumefy; and, at the same time, darken it, causing it to look opaque and thick, ropy and clammy, and hindering it from drying and hardening in proper time; besides, it will lie on the working painting like a piece of bladder skin, and be very apt to rise in blisters. As soon as all the driers are added to the oil, keep quietly stirring the driers from the bottom of the pot; otherwise they will burn, which will cause the oil to blacken and thicken before it is boiled enough. Let the fire be so regulated that the oil shall only boil slowly for three hours from the time all the driers were added; if it then ceases to throw up any scum, and emits little or no smoke, it is necessary to test its temperature by a few quill tops or feathers. Dip a quill top in the oil every two minutes, for when the oil is boiled enough, the quill top will crackle or curl up quite burnt; if so, draw out the fire immediately, and let the oil remain in the pot at least from 10 to 24 hours, or longer if convenient, for the driers settle much sooner when the oil is left to cool in the pot, than when it is immediately taken out.

Poppy oil.—Into four pints of pure soft water, put two ounces of foreign white vitriol; warm the water in a clean copper pan, or glazed earthen jar, until the vitriol is dissolved; pour the mixture into a clean glass or stone bottle, large enough to contain three gallons; then add to the solution of vitriol one gallon and a half of poppy oil, cork and agitate the bottle regularly and smartly for at least two hours; then pour out the contents into a wide earthenware dish: leave it at rest for eight days, when the oil will be clean and brilliant on the surface, and may be taken off with a spoon or flat skimmer, and put up in a glass bottle and exposed to the light, which in a few weeks renders the oil exceedingly limpid and colorless.

Nut-oil, or oil of walnuts, is extracted by expression; and that which is extracted without heat, is certainly the most pale, pure, and nutritive seasoning, and retains an exquisite taste of the fruit. That designed for the arts is of inferior quality, and is plentifully imported to us from France; the heat it undergoes in its torrefaction, previous to its expression, disposes it to dry more quickly than that expressed by the cold process; but, at the same time, the heat, though it frees it from its unctuous quality, gives it more color. When it has been extracted by the cold process, it may be prepared in the same way as directed for the poppy oil.

In the above article I have retained the workmen's names—gum, white vitriol, &c., instead of resin, sulphate of zinc, &c.

VEINS (*Filons*, Fr.; *Gänge*, Germ.), are the fissures or rents in rocks, which are filled with peculiar mineral substances, most commonly metallic ores.

VEIN STONES, or GANGUES, are the mineral substances which accompany, and frequently enclose, the metallic ores.

VELLUM, is a fine sort of PARCHMENT, which see.

VELVET (*Velours*, Fr.; *Sammet*, Germ.), a peculiar stuff, the nature of which is explained under FUSTIAN and TEXTILE FABRICS.

VENETIAN CHALK, is STEATITE.

VENUS, is the mythological name of copper.

VENTILATION, or the renewal of fresh air in stagnant places, is nowhere exhibited to such advantage as in the coal mines of Northumberland and Durham, where Mr. Buddle has carried well nigh to systematic perfection the plan of coursing the air through the winding galleries, originally contrived about the year 1760, by Mr. James Spedding, of Workington, the ablest pitman of his day.* He converted the whole of the passages into air-pipes, so to speak, drew the current of air from the downcast pit, then traversed it up and down, and round about, through the several sheaths of the workings, so that no particular gallery was left without a current of air. He thereby succeeded in actually expelling the noxious gases from the mines; those demons, which in Germany, at no remote era, were wont to be combated by the priests with impotent exorcisms or pious frauds. Before Mr. Buddle introduced his improvements, he has known the air to be led through a series of workings, thirty miles long, before it made its exit. There is in every coal mine an experienced corps, called wastemen, because they travel over the waste, or the exhausted regions, who can tell at once, by the whistling sound which the air makes at the crevices in certain partitions and doors, whether the ventilation be in good condition or not. They hear these stoppings begin to *sing* or *call*, as they say, whenever an interruption takes place in any point of the labyrinthian line. Another indication of something being wrong, is when the doors get so heavy, that the boys in attendance upon them find them difficult to shut or open. The instant such a defect is discovered by any one, he cries aloud, "Holloa, there is something wrong—the doors are calling!"

In Mr. Spedding's system, the whole of the return air came in one current to his rarefying furnace (see letter C, *fig.* 1158), 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 through the active furnace C, *fig.* 1158, and the portion of the air from the *foul* workings of the air which, descending in the downcast pit A, coursed through the *clean* workings, up the dumb furnace 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 divides 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 carbureted 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 fur-

* Mining engineers use the term *good pitman*, as admirals do *good seaman*, to denote a proficient in his calling.

nace. During a practice of twenty years, Mr. Buddle has not met with any accident in consequence of a defect in the stoppings preventing the complete division of the air. The engineer has it thus within his power to detach or insulate those portions of the mine in which there is a great exudation of gas, from the rest; and, indeed, he is continually making changes, borrowing and lending currents, so to speak; sometimes laying one division or panel upon the one air-course, and sometimes upon the other, just to suit the immediate emergency. As soon as any district has ceased to be dangerous, by the exhaustion of the gas-blowers, it is transferred from the foul to the pure air course, where gunpowder may be safely used, as also candles, instead of Davy's lamps, which give less light.

The quantity of air put down into the Wallsend colliery, at the time of the last dreadful accident, 18th June, 1835, was not less than 5000 cubic feet per minute, whence it has been justly inferred that the explosion was caused by the rashness of a wasteman carrying a light through a door into a foul drift.

Till the cutting out of the pillars commences (see the right end of the diagram), the ventilation of the several passages, boards, &c., may be kept perfect, supposing the working extended no further than *a*, or *b*; because, as long as there are pillars standing,

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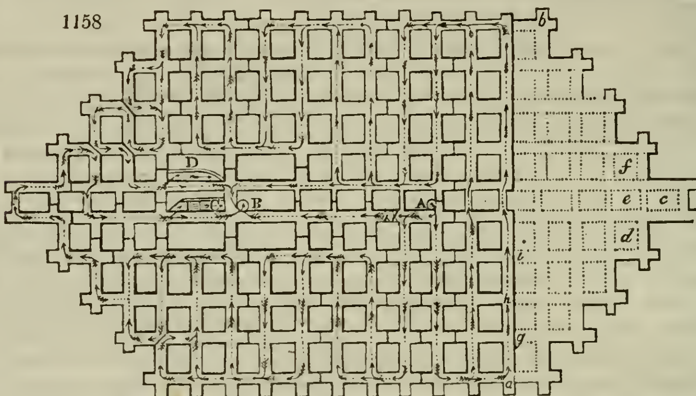

every passage may be converted into an air-conduit, for leading a current of air in any direction, either to C, the burning, or D, the dumb furnace. But the first pillar that is removed deranges the ventilation at that spot, and takes away the means of carrying the air into the further recess towards *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 is a true gas-holder, or reservoir, continually discharging itself at the points *g*, *h*, *i*, into the circulating current, to be carried off by the gas-pipe drift at the dumb furnace, but not to be suffered ever to come in contact with flame of any description. The next range of working, is the line of pillars to the left of *a*, *b*; the coal having been entirely cleared out of the space to the right, where the place of the pillars is marked by dotted lines. The roof in the waste soon falls down, and gets fractured up to the next seam of coal, called the yard-coal seam, which, abounding in gas, sends it down in large quantities, and keeps the immense gasometer, or goaf below, continually replenished. See STOVE.

VERATRINE, is a vegetable alkali, of a poisonous nature, extracted from the seeds of the *Veratrum sabadilla*, the roots of the *Veratrum album*, or white hellebore, and of *Colchicum autumnale*, or meadow saffron, in which plants it exists combined chiefly with gallic acid. It is obtained in the form of a white powder. It has an acrid, burning taste, but without any bitterness; it has no smell; but when snuffed into the nostrils, it excites violent and dangerous sneezing. It melts at a heat of 122° F., and concretes, on cooling, into a transparent yellowish mass. It restores the blue color of reddened litmus paper. It is hardly soluble in water or ether, but abundantly in alcohol. It consists of—carbon 66·75, hydrogen 8·54, nitrogen 5·04, and oxygen 19·60. Its saline compounds have an acrid and burning taste. Veratrine resembles strychnine and brucine, in its effects upon living bodies, producing tetanus and death in a moderate dose; notwithstanding which, it has been prescribed by some of our poison doctors, especially mixed with hog's lard, in the form of frictions on the forehead, for nervous maladies; but seldom, I believe, with any good effects.

VERDIGRIS. (*Vert-de-gris*, Fr.; *Grünspan*, Germ.) The copper used in this manufacture, is formed into round sheets, from 20 to 25 inches diameter, by one twenty-fourth of an inch in thickness. Each sheet is then divided into oblong squares, from 4 to 6 inches in length, by 3 broad; and weighing about 4 ounces. They are separately beaten upon an anvil, to smooth their surfaces, to consolidate the metal, and to free it from scales. The refuse of the grapes, after the extraction of their juice, formerly thrown on to the dunghill, is now preserved for the purpose of making verdigris. It is put loosely into earthen vessels, which are usually 16 inches high, 14 in diameter at the widest part, and about 12 at the mouth. The vessels are then covered with lids, which are surrounded by straw mats. In this situation the materials soon become heated, and exhale an acid odor; the fermentation beginning at the bottom of the cask, and gradually rising till it actuate the whole mass. At the end of two or three days, the manufacturer removes the fermenting materials into other vessels, in order to check the process, lest putrefaction should ensue. The copper plates, if new, are now prepared, by rubbing them over with a linen cloth dipped in a solution of verdigris; and they are laid up alongside of one another to dry. If the plates are not subjected to this kind of preparation, they will become black, instead of green, by the first operation. When the plates are ready, and the materials in a fermenting state, one of them is put into the earthen vessel for 24 hours, in order to ascertain whether it be a proper period to proceed to the remaining part of the process. If, at the end of this period, the plate be covered with a 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 crystallized acetate of copper and the sub-acetate, in varying proportions. According to Vauquelin's researches, there are three compounds of oxyde of copper and acetic acid; 1. a subacetate, insoluble in water, but decomposing in that fluid, at common temperatures changing into peroxyde and acetate; 2. a neutral acetate, the solution of which is not altered at common temperatures, but is decomposed by ebullition, becoming peroxyde 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 oxyde; 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
Peroxyde 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 color, 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 color 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 sirup, and shows a pellicle on its surface; when it is transferred into glazed earthen pans, called *oulas* in the country. In each of these dishes, two or three sticks are placed, about a foot long, cleft till within two inches of their upper end, and having the base of the cleft kept asunder by a bit of wood. This kind of pyramid is suspended by its summit in the liquid. All these vessels are transported into crystallizing rooms, moderately heated with a stove, and left in the same state for 15 days, taking care to maintain a 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 color. Each cluster of crystals weighs from five to six pounds; and, in general, their total weight is equal to about one third of the verdigris employed.

The crystallized binacetate of commerce consists, by my analysis, of—acetic acid, 52; oxyde of copper, 39·6; water, 8·4, in 100. I have prepared crystals which contain no water. There is a triple acetate of copper and lime, which resembles distilled verdigris in color. It was manufactured pretty extensively in Scotland some years ago, and fetched a high price, till I published an analysis of it in the Edinburgh Philosophical Journal. It is much inferior, for all uses in the arts, to the proper binacetate.

VERDITER, or BLUE VERDITER. This is a precipitate of oxyde 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 color. 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 4 open-headed casks; add to each of these 45 pound measures of a boiling-hot solution of muriate of lime, of specific gravity, 1·317, whereby a double decomposition will ensue; with the formation of muriate of copper and sulphate of lime, which precipitates. It is of consequence to work the materials well together at the moment of mixture, to prevent the precipitate agglomerating in unequal masses. After leaving it to settle for 12 hours, a small quantity of the clear liquor may be examined, to see whether the just proportions of the two salts have been employed, which is done by adding either sulphate of copper or muriate of lime. Should either cause much precipitation, some of the other must be poured in till the equivalent decomposition be accomplished; though less harm results from an excess of sulphate of copper than of muriate of lime.

The muriate of copper is to be decanted from the subsided gypsum, which must be drained and washed in a filter; and these blue liquors are to be added to the stronger; and the whole distributed, as before, into 4 casks; composing in all 670 pound measures of a green liquor, of 1·151 specific gravity.

Meanwhile, a magma of lime is to be prepared as follows:—100 pounds of quicklime are to be mixed up with 300 pounds of water, and the mixture is to be passed through a wire-gauze sieve, to separate the sandy and stony 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 color 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 color 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 lrained 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 color-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 deposite may be then drained on a cloth filter. The pigment is sold in the state of a paste; and is used for painting, or printing paper-hangings for the walls of apartments.

The above prescribed proportions furnish the superfine blue paste: for the second quality, one half more quicklime paste is used; and for the third, double of the lime and sal ammoniac; but the mode of preparation is in every case the same.

This paste may be dried into a blue powder, or into crayons for painters, by exposing it on white deals to a very gentle heat in a shady place. This is called *cendres bleues en pierre.*

VERDITER, or BREMEN GREEN. This pigment is a light powder, like magnesia, having a blue or bluish green color. 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 two 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 axes.

c. The bits of copper being placed in oxydation-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 oxyde, 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 oxyde with the help of as little water as possible.

d. This oxydized *schlam,* or mud, is filtered, then thrown, by means of a bucket containing 30 pounds, into a tub, where it is carefully divided or comminuted.

e. For every six pailfuls of *schlam* thus thrown into the large tub, 12 pounds of muriatic acid, at 15° Baumé, are to be added; the mixture is to be stirred, and then left at rest for 24 or 36 hours.

f. Into another tub, called the blue back, there is to be introduced, in like manner, for every six pailfuls of the acidified *schlam*, 15 similar pailfuls of a solution of colorless 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 pail of pure water for every pail of *schlam.*

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 *schlam* rapidly into the latter back; where the second set mix and agitate it all the time requisite to convert the mass into a consistent state, and then leave it at rest from 36 to 48 hours.

The whole mass is to be now washed; with which view it is to be stirred about with the affusion of water, allowed to settle, and the supernatant liquor is drawn off. This process is to be repeated till no more traces of potash remain among the blue. The deposite 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 color acquires its greatest lustre.

VERMICELLI, is a paste of wheat flour, drawn out and dried in slender cylinders, more or less tortuous, like worms, whence the Italian name. The *gruau* of the French is wheat coarsely ground, so as to free it from the husk; the hardest and whitest part, being separated by sifting, is preferred for making the finest bread. When this *gruau* is a little more ground, and the dust separated from it by the bolting-machine, the granular substance called *semoule* is obtained, which is the basis of the best pastes. The softest and purest water is said to be necessary for making the most plastic vermicelli dough; 12 pounds of it being usually added to 50 pounds of *semoule.* It is better to add more *semoule* to the water, than water to the *semoule*, in the act of kneading. The water should be hot, and the dough briskly worked while still warm. The Italians pile one piece of this dough upon another, and then tread it well with their feet for two or three minutes. They afterwards work it for two hours with a powerful rolling-pin, a bar of wood from 10 to 12 feet long, larger at the one end than the other, having a sharp cutting edge at the extremity, attached to the large kneading-trough.

When the dough is properly prepared, it is reduced to thin ribands, cylinders, or tubes, to form vermicelli and macaroni of different kinds. This operation is performed by means of a powerful press. This is vertical, and the iron plate or follower carried by the end of the screw fits exactly into a cast-iron cylinder, called the *bell*, like a sausage-machine, of which the bottom is perforated with small holes, of the shape and size intended for the vermicelli. The *bell* being filled, and warmed with a charcoal fire to thin the dough into a paste, this is forced slowly through the holes, and is immediately cooled and dried by a fanner as it protrudes. When the threads or fillets have acquired the length of a foot, they are grasped by the hand, broken off, and twisted, while still flexible, into any desired shape upon a piece of paper.

The macaroni requires to be made of a less compact dough than the vermicelli. The former is forced through the perforated bottom, usually in fillets, which are afterwards formed into tubes by joining their edges together before they have had time to become dry. The *lazagnes* are macaroni left in the fillet or riband shape.

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 bisulphuret of mercury. This artificial compound being extensively employed, on account of the beauty of its color, 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 color. 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 color. 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 oxydized; but, eventually, Seguin proved that both of these opinions were erroneous; having ascertained, on the one hand, that no hydrogenous matter was given out in the decomposition of cinnabar, and on the other that sulphur and mercury, by combining, were transformed into the red sulphuret in close vessels, without the access of any oxygen whatever. It was likewise supposed that the solution of the problem might be found in the difference of composition between the red and black sulphurets of mercury; and many conjectures were made with this view, the whole of which were refuted by Seguin. He demonstrated, in fact, that a mere change of temperature was sufficient to convert the one sulphuret into the other, without occasioning any variation in the proportion of the two elements. Cinnabar, moderately heated in a glass tube, is convertible into ethiops, which in its turn is changed into cinnabar by exposing the tube to a higher temperature; and thence he was led to conclude that the difference between these two sulphurets was owing principally to the state of the combination of the constituents. It would seem to result, from all these researches, that cinnabar is only an intimate compound of pure sulphur and mercury, in the proportions pointed out by analysis; and it is therefore reasonable to conclude, that in order to make fine vermilion, it should be sufficient to effect the union of its elements at a high enough temperature, and to exclude the influence of all foreign matters; but, notwithstanding these discoveries, the art of making good vermilion is nearly as much a mystery as ever. M. Seguin, indeed, announced in his Memoirs, that he had succeeded in obtaining, in his laboratory, as good a cinnabar as that of Holland, and at a remunerative price; but whatever truth may be in this assertion, or however much the author may have been excited by the love of honor and profit, no manufacture on the great scale sprung up under his auspices. France is still as tributary as ever to foreign nations for this chemical product. At an exposition some years ago, indeed, a sample of good French vermilion was brought forward to prove that the problem was nearly solved; but that it is not so completely, may be inferred from the silence on this subject in M. Dupin's report of the last exposition, in 1834, where we see so many chemical trifles honored with eulogiums and medals by the judges of the show. The English vermilion is now most highly prized by the French manufacturers of sealing-wax.

M. Tuckert, apothecary of the Dutch court, published, long ago, in the *Annales de Chimie*, vol. iv., the best account we yet have of the manufacture of vermilion in Holland; one which has been since verified by M. Paysé, who saw the process practised on the great scale with success.

"The establishment in which I saw, several times, the fabrication of sublimed sulphuret of mercury," says M. Tuckert, "was that of Mr. Brand, at Amsterdam, beyond the gate of Utrecht; it is one of the most considerable in Holland, producing annually, from three furnaces, by means of four workmen, 48,000 pounds of cinnabar, besides other mercurial preparations. The following process is pursued here:—

"The ethiops is first prepared by mixing together 150 pounds of sulphur, with 1080 pounds of pure mercury, and exposing this mixture to a moderate heat in a flat polished iron pot, one foot deep, and two feet and a half in diameter. It never takes fire, provided the workman understands his business. The black sulphuret, thus prepared, is ground, to facilitate the filling with it of small earthen bottles capable of holding about 24 ounces of water; from 30 to 40 of which bottles are filled beforehand, to be ready when wanted.

"Three great subliming pots or vessels, made of very pure clay and sand, have been previously coated over with a proper lute, and allowed to dry slowly. These pots are set upon three furnaces bound with iron hoops, and they are covered with a kind of iron dome. The furnaces are constructed so that the flame may freely circulate and play upon the pots, over two thirds of their height.

"The subliming vessels having been set in their places, a moderate fire is kindled in the evening, which is gradually augmented till the pots become red. A bottle of the black sulphuret is then poured into the first in the series, next into the second and third, in succession; but eventually, two, three, or even more, bottles may be emptied in at once; this circumstance depends on the stronger or weaker combustion of the sulphuret of mercury thus projected. After its introduction, the flame rises 4 and sometimes 6 feet high; when it has diminished a little, the vessels are covered with a plate of iron, a foot square, and an inch and a 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 incrusted within them; and which usually amounts to 400 lbs., being a loss of only 60 on each vessel. The lumps are to be ground along with water between horizontal stones, elutriated, passed through sieves, and dried. It is said that the rich tone of the Chinese vermilion may be imitated by adding to the materials for subliming one per cent. of sulphuret of antimony, and by digesting the ground article first in a solution of sulphuret of potassa, and, finally, in diluted muriatic acid.

The humid process of Kirchoff has of late years been so much improved, as to furnish a vermilion quite equal in brilliancy to the Chinese. The following process has been recommended. Mercury is triturated for several hours with sulphur, in the cold, till a perfect ethiops is formed; potash ley 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 color 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

The first proportions are therefore the most advantageous; the last, which are those of M. Kirchoff himself, are not so good.

Brunner found that 300 parts of quicksilver, 114 of sulphur, 75 of caustic potassa, and from 400 to 450 of water, form very suitable proportions for the moist process; that the best temperature was 113° F.; and that 122° was the highest limit of heat compatible with the production of a fine color.

The theory of this process is by no means clear. We may suppose that a sulphuret of potassium and mercury is first formed, which is eventually destroyed, in proportion as the oxygen of the air acts upon the sulphuret of potassium itself. There may also be produced some hyposulphite of mercury, which, under the same influence, would be transformed into sulphuret of mercury and sulphate of potash.

Sulphuret of potassium and mercury furnish also vermilion, but it is not beautiful. Red oxyde of mercury, calomel, turbith mineral, and the soluble mercury of Hahnemann, treated with the sulphuret of potassium, or the hydrosulphuret of ammonia, are all capable of giving birth to vermilion by the humid way.

The vermilion of commerce is often adulterated with red lead, brickdust, dragon's blood, and realgar. The first two, not being volatile, remain when the vermilion is heated to its subliming point; the third gives a red tincture to alcohol; the fourth exhales its peculiar garlic smell with heat; and when calcined in a crucible with carbonate of soda, and nitre in excess, affords arsenic acid, which may be detected by the usual chemical tests.

VINEGAR MANUFACTORY, BY MALT. Annual produce, 100,000 gallons.

Expenses for one month.	£	s.	d.
Cost of material and fuel for 8,333 gallons, at $8\frac{3}{4}$*d.* - -	303	16	2
Wages to 8 workmen, at 25*s.* per week - - - -	40	0	0
Salaries to clerks, manager, and traveller - - - -	83	6	8
Travelling expenses - - - - - - - - -	30	0	0
Three horses' keep - - - - - - - - -	7	10	0
Rent and taxes - - - - - - - - - -	25	0	0
	£489	12	10
Expenses for 5 months, at 489*l.* 12*s* 10*d.* - - - - -	2448	4	2
Duty on 41,665 gallons, at 2*d.* - - - - - -	347	4	2
Stock of utensils - - - - - - - - -	1500	0	0
	£4295	8	4

Produce of 100,000 gallons, at 1*s.* 8*d.*				£8,333	6	8
Expenses for 12 months, at 489*l.* 12*s.* 10*d.*	£5,875	18	0			
Duty on 100,000 gallons, at 2*d.*	833	6	8			
Interest on capital, 4,295*l.* 8*s.* 4*d.*	214	4	5			
				6,923	9	1
Net profit				£1,409	17	7

See Acetic Acid.

VIOLET DYE, is produced by a mixture of red and blue coloring-matters, which are applied in succession. Silk is dyed a fugitive violet with either archil or Brazil wood; but a fine fast violet, first by a crimson with cochineal, without tartar or tin mordant, and after washing, it is dipped in the indigo vat. A finish is sometimes given with archil. A violet is also given to silk, by passing it through a solution of verdigris, then through a bath of logwood, and, lastly, through alum water. A more beautiful violet may be communicated by passing the alumed silk through a bath of Brazil wood, and after washing it in the river, through a bath of archil.

To produce violets on printed calicoes, a dilute acetate of iron is the mordant, and the dye is madder. The mordanted goods should be well dunged.

A good process for dyeing cottons violet, is—first, to gall, with 18 or 20 pounds of nut-galls for every 100 pounds of cotton; second, to pass the stuff, still hot, through a mordant composed of—alum, 10 pounds; iron-liquor, at $1\frac{1}{2}°$ 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 color 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.

VITRIFIABLE COLORS; see Enamels, Pastes, Pottery, and Stained Glass.

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.

W.

WACKE, is a massive mineral, intermediate between claystone and basalt. It is of a greenish-gray color; 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 peroxyde of that metal, associated with nearly its own weight of oxyde 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.

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 colored with one or other of the matters to be particularly described under the second head; and which are, vermilion, sulphate of indigo, and gamboge. The pap is not allowed to ferment, but must be employed immediately after it is mixed. For this purpose a tool is employed, consisting of two plates of iron, which come together like pincers or a pair of tongs, leaving a certain small definite space betwixt them. These plates are first slightly heated, greased with butter, filled with the pap, closed, and then exposed for a short time to the heat of a charcoal fire. The iron plates being allowed to cool, on opening them, the thin cake appears dry, solid, brittle, and about as thick as a playing-card. By means of annular punches of different sizes, with sharp edges, the cake is cut into wafers. 2. The transparent wafers are made as follows:—

Dissolve fine glue, or ising-glass, 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 coloring-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 color is dear, and can be used only for the finer kinds. Instead of it, a decoction of Brazil wood, brightened with a little alum, may be employed.

For yellow, an infusion of saffron or turmeric has been prescribed; but a decoction of weld, fustic, or Persian berries, might be used.

Sulphate of indigo, partially saturated with potash, is used for the blue wafers; and this mixed with yellow, for the greens. Some recommend the sulphate to be nearly neutralized with chalk, and to treat the liquor with alcohol, in order to obtain the best blue dye for wafers.

Common wafers are, nowever, colored with the substances mentioned at the beginning of the article; and for the cheaper kinds, red lead is used instead of vermilion, and turmeric instead of gamboge.

WALNUT HUSKS, or PEELS (*Brout des noix*, Fr.), are much employed by the French dyers for rooting or giving dun colors.

WARP (*Chaine*, Fr.; *Kette*, *Anschweif*, *Zettel*, Germ.), is the name of the longitudinal threads or yarns, whether of cotton, linen, silk, or wool, which being decussated at right angles by the woof or weft threads, form a piece of cloth. The warp yarns are parallel, and continuous from end to end of the web. See WEAVING, for a description of the *warping-mill.*

WASH, is the fermented wort of the distiller.

WASHING. See BLEACHING, and SCOURING.

WATERING OF STUFFS (*Moirage*, Fr.), is a process to which silk and other textile fabrics are subjected, for causing them to exhibit a variety of undulated reflections, and plays of light. It is produced by sprinkling water upon the goods, and then passing them through a calender, either with cold or hot rollers, plain or variously indented.

WATER-PROOF CLOTH. See CAOUTCHOUC, and GELATINE.

A patent was obtained, in August, 1830, by Mr. Thomas Hancock, for rendering textile fabrics impervious to water and air, by spreading the liquid juice of the caoutchouc tree upon the surfaces of the goods, and then exposing them to the air to dry. It does not appear that this project has been realized in our manufactures.

Mr. William Simpson Potter proposes, in his patent of April, 1835, to render fabrics water-proof by imbuing them with a solution of ising-glass, alum, and soap, by means of a brush applied to the wrong side of the cloth, distended upon a table. After it is dry, it must be brushed on the wrong side, against the grain. Then the brush is to be dipped in clean water, and passed lightly over the cloth. The gloss caused by the above application can be taken off by brushing the goods when they are dry. Cloth so prepared is said to be impervious to water, but not to air.

I have examined woollen cloth now on sale in a shop in the Strand, which may be breathed through with the greatest facility, but which retains water upon its surface, as is evinced by a body of water standing upon a concave piece of it tied over a show-glass in the window.

Mr. Sievier's plan of rendering cloth water-proof, for which he obtained a patent in December, 1835, consists in spreading over it, with a brush, a solution of India rubber in spirits of turpentine, at one or more applications, ana then applying a similar solution mixed with acetate of lead, litharge, sulphate of zinc, gum mastic, or other drying material. He next takes wool, or other textile material, cut into proper lengths, and spreads it upon the surface of the fabric varnished in this manner, for the purpose of forming the nap or pile. He then presses the cloth by means of rollers, or brushes, so as to fix the nap firmly to its surface.

WATERS, MINERAL.—Table I. Analyses of the principal Mineral Waters of Germany.

Grains of Anhydrous Ingredients in One Pound Troy.	Carlsbad.	ms.	Schlesischer. Obersalzbrunnen.	Marienbad. Kreutzbr.	Auschowitz. Ferdinandsbrunnen.	Eger. Franzensbrunnen.	Pyrmont.	Spa. Pouhon.	Fachingen.	Geilnau.	Seltzer.	Seidschutz	Pullna.
Carbonate of Soda	7·2712	8·0625	6·1133	5·3499	4·5976	3·8914	-	0·5531	12·3328	4 9658	4·6162		
Ditto of Lithia	0·0150	0·0405	0·0127	0·0858	0·0507	0·0282							
Ditto of Baryta	-	0·0022	-	-	-	-	-	-	-	-	0·0014		
Ditto of Strontia	0·0055	0·0080	0·0165	0·0028	0·0040	0·0023	-	-	-	-	0·0144		
Ditto of Lime	1·7775	0·8555	1·7497	2·9509	3·0085	1·3501	4·7781	0·7387	1·8667	2·2279	1·4004	5·1045	0·5775
Ditto of Magnesia	1·0275	0·5915	1·4107	2·0390	2·2867	0·5040	-	0·8421	1·2983	1·6282	1·5000	0·8235	4·8045
Ditto (Proto) of Manganese	0·0048	0·0028	-	0·0288	0·0692	0·0322	0·0364	0·0389	-	-	-	0·0032	
Ditto (Proto) of Iron	0·0208	0·0120	0·0480	0·1319	0·2995	0·1762	0·3213	0 2813	-	-	-	0·0095	
Sub-Phosphate of Lime	0·0012	-	-	-	-	0·0172	-	0·0102	0·0061	-	0·0007	0·0117	0·0026
Ditto of Alumina	0·0019	0·0014	0·0045	-	0·0040	0·0092	0·0110	0 0064	-	-	0·0020	0·0088	
Sulphate of Potassa	-	0·4050	0·2220	-	-	-	0·0314	0·0592	-	0·2154	0·2978	3·6705	3·6000
Ditto of Soda	14·9019	-	2·2095	28·5868	16·9022	18·3785	1·6092	0·0281	0·1267	0·0315	-	17·6220	92·8500
Ditto of Lithia	-	-	-	-	-	-	0·0067	-	-	-	-		
Ditto of Lime	-	-	-	-	-	-	5·0265	-	-	-	-	1·1287	1·9500
Ditto of Strontia	-	-	-	-	-	-	0·0154	-	-	-	-	0·0347	
Ditto of Magnesia	-	-	-	-	-	-	2·3684	-	-	-	-	62·3535	69·8145
Nitrate of Magnesia	-	-	-	-	-	-	-	-	-	-	-	5·9302	
Chlor. of Potassium	-	0·0338	-	-	-	-	-	-	-	-	0 2685		
Ditto of Sodium	5·9820	5·7255	0·8752	10·1727	6·7472	6·9229	-	0·3371	3·2337	0·4072	12·9690		
Ditto of Magnesium	-	-	-	-	-	-	0·8450	-	-	-	-	1·2225	14·7495
Fluoride of Calcium	00·184	0 0014	-	-	-	-	-	-	-	-	0 0013		
Alumina	-	-	-	0·0023	-	-	-	-	-	0·0185			
Silica	0·4329	0·3104	0·2531	0·2908	0·5023	0·3548	0·3727	0·3739	0·0657	0·2021	0·2265	0·0900	0·1320
Total	31·4606	16·0525	12·9152	49·6417	34·4719	31·6670	15·4221	3·2691	18·9300	9·6966	21·2982	98·0133	188·4806
Carbonic Acid Gas in 100 cubic inches	58	51	98	105	146	154	160	136	135	163	126	20	7
Temperature (F.)	Sprud. 165° Neub. 138° Mühl. 128° Ther. 122°	Kess. 117° Krän. 84°	58°	53°	46°	53°	56°	50°	50°	51°	58°	58°	58°
Analyzed by	Berzelius.	Struve.	Struve.	Berzelius.	Steinmann.	Berzelius.	Struve.	Struve.	Bischoff.	Struve.	Struve.	Struve.	Struve.

Table II.—The Composition of other celebrated Mineral Waters.

Names of the Springs.	Grains of water.	Cubic Inches of Gases.				Carbonates of				Sulphates of				Muriates of				Silica.	Alumina.	Resins.	Temperature.
		Oxygen.	Carbonic acid.	Sulph. hydrogen.	Azote.	Soda.	Lime.	Magnesia.	Iron.	Soda.	Lime.	Magnesia.	Iron.	Soda.	Lime.	Magnesia.	Potash.				
						grs.	*grs.*	*grs.*	*grs.*	*grs.*	*grs.*	*grs.*	*grs.*	*grs.*	*grs.*	*grs.*	*grs.*	*grs.*	*grs.*	*grs.*	
Kilburn (1)—acidulous.....	138240	-	84·0	36·0	-	-	2·4	1·25	0·3¼	18·2	13·0	91·0	-	6·0	0·6	2·8	-	-	-	6·0	cold
Sulphurous. Harrowgate (2)...........	103643	-	8·0	19·0	7·0	-	18·5	5·5	-	-	-	0·5	-	615·5	3·0	9·1	-	-	-	-	cold
Sulphurous. Moffat (2)................	103643	-	1·0	10·0	4·0	-	-	-	-	-	-	-	-	3·6	-	-	-	-	-	-	cold
Sulphurous. Aix-la-Chapelle (3)........	8940	-	-	13·06	-	-	15·25	5·89	-	-	-	-	-	6·21	-	-	-	-	-	-	143°
Sulphurous. Enghein (4).............	92160	-	18·5	7·0	-	-	21·4	1·35	-	-	33·3	5·8	-	2·4	-	8·0	-	-	-	-	cold
Saline. Seidlitz..................	58309	-	8·0	-	-	-	6·7	21·0	-	-	41·1	14·44	-	-	-	36·5	-	-	-	-	cold
Saline. Cheltenham (5)...........	103643	-	30·3	3·0	12·0	-	-	12·5	5·0	48·0	40·0	-	-	5·0	-	12·5	-	-	-	-	cold
Saline. Plombieres (6)............	14600	-	-	-	-	36·0	0·4	-	-	1·0	-	-	-	2·0	-	-	-	-	-	-	cold
Saline. Dunblane (7) sp. gr. 1·00475	7291	-	-	-	-	-	0·5	-	0·17	3·7	-	-	-	21·0	20·8	-	-	-	-	-	cold
Saline. Pitcaithley (7)...........	7291	-	1·0	-	-	-	0·5	-	-	0·9	-	-	-	12·7	20·2	-	-	-	-	-	cold
Chalybeate. Tunbridge (3)...........	103643	1·4	10·6	-	4·0	-	-	-	1·0	-	1·25	-	-	0·5	-	2·25	-	-	-	-	cold
Chalybeate. Brighton (8).............	58309	-	18·0	-	-	-	-	-	-	-	32·7	-	11·2	12·2	-	6·0	-	1·12	-	-	cold
Chalybeate. Toplitz (9)...............	22540	-	-	-	-	13·5	16·5	-	32·5	-	-	-	-	61·3	28.5	-	-	-	15·1	-	cold
Calcareous, nearly pure. Bath (10)................	15360	-	2·4	-	-	-	1·6	-	0·004	3·0	18·0	-	-	6·6	-	-	-	0·4	-	-	114°
Calcareous, nearly pure. Buxton (11)..............	58309	-	-	-	2·0	-	10·5	-	-	-	2·5	-	-	1·5	-	-	-	-	-	-	82°
Calcareous, nearly pure. Bristol (12)...............	58309	-	30·3	-	-	-	13·5	-	-	11·2	11·7	-	-	4·0	-	7·25	-	-	-	-	74°
Calcareous, nearly pure. Matlock..................	58309	-	-	-	-	-	-	-	-	-	trace	-	-	-	-	-	-	-	-	-	66°
Calcareous, nearly pure. Malvern (13)..............	58309	-	-	-	-	5·33	1 6	0·92	0·625	2·896	- ·054	-	-	1·55	-	-	-	-	-	-	cold
Dead Sea (14) sp. gr. 1·211..	100	-	-	-	-	-	-	-	-	-		-	-	10·676	3·8	10·1					
Do. (15) sp. gr. 1·245..	-	-	-	-	-	-	-	-	-	-	-	-	-	7·8	10·6	24·2					
Do. (16) sp. gr. 1·2283.	-	-	-	-	-	-	-	-	-	-	-	-	-	6·95	4·0	15·31					
Sea water, Forth (7)........	7291		-	-	-	-	-	-	-	25·6	-	-	-	159·3	5·7	35·5	trace†				

(1) Schmesser. (2) Garnet. (3) Babington. (4) Fourcroy. (5) Fothergill. (6) Vauquelin. (7) Dr. Murray. (8) Marcet. (9) John. (10) Phillips. (11) Pearson. (12) Carrick. (13) Dr. Philip. (14) Dr. Marcet. (15) Klaproth. (16) M. Gay Lussac.

† Dr. Wollaston.

Mineral waters may, in most cases, be artificially prepared, by the skilful application of the knowledge derived from analysis, with such precision as to imitate very closely the native springs. When the various earthy or metallic constituents are held in solution by carbonic acid, or sulphureted, they should be placed, along with their due proportions of water, in the receiver of the aerating machine (see SODA WATER), and then the proper quantity of gas should be injected into the water. Sufficient agitation will be given by the action of the forcing-pump to promote their solution.

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 ribands or films thus obtained to the blanching action of air, light, and moisture. For this purpose, the ribands are laid upon long webs of canvass 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 color of the wax seems stationary, it is collected, remelted, and thrown again into ribands upon the wet cylinder, in order to expose new surfaces to the blanching operation. By several repetitions of these processes, if the weather proves favorable, the wax eventually loses its yellow tint entirely, and becomes fit for forming white candles. If it be finished under rain, it will become gray on keeping, and also lose in weight.

In France, where the purification of wax is a considerable object of manufacture, about four ounces of cream of tartar, or alum, are added to the water in the first melting-copper, and the solution is incorporated with the wax by diligent manipulation. The whole is left at rest for some time, and then the supernatant wax is run off into a settling cistern, whence it is discharged by a stopcock or tap, over the wooden cylinder revolving at the surface of a large water-cistern, kept cool by passing a stream continually through it.

The bleached wax is finally melted, strained through silk sieves, and then run into circular cavities in a moistened table, to be cast or moulded into thin disc pieces, weighing from two to three ounces each, and three or four inches in diameter.

Neither chlorine, nor even the chlorides of lime and alkalis, can be employed with any advantage to bleach wax, because they render it brittle, and impair its burning quality.

Wax purified, as above, is white and translucent in thin segments; it has neither taste nor smell; it has a specific gravity of from 0·960 to 0·966; it does not liquefy till it be heated to 154½° F.; but it softens at 86°, becoming so plastic, that it may be moulded by the hand into any form. At 32° it is hard and brittle.

It is not a simple substance, but consists of two species of wax, which may be easily separated by boiling alcohol. The resulting solution deposites, on cooling, the waxy body called *cerine*. The undissolved wax, being once and again treated with boiling alcohol, finally affords from 70 to 90 per cent. of its weight of cerine. The insoluble residuum is the *myricine* of Dr. John, so called because it exists in a much larger proportion in the wax of the *Myrica cerifera*. It is greatly denser than wax, being of the same specific gravity as water; and may be distilled without decomposition, which cerine undergoes. See these two articles.

Wax is adulterated sometimes with starch; a fraud easily detected by oil of turpentine, which dissolves the former, and leaves the latter substance; and more frequently with mutton suet. This fraud may be discovered by dry distillation; for wax does not thereby afford, like tallow, sebacic acid (benzoic), which is known by its occasioning a precipitate in a solution of acetate of lead. It is said that two per cent. of a tallow sophistication may be discovered in this way.

Bees' wax imported for home consumption:—in 1835, unbleached, 4,449 cwts.; bleached, 243 cwts.;—in 1836, unbleached, 4,673 cwts.; bleached, 121 cwts. Duty, when from British possessions, 10*s.*; from foreign, 30*s.*

WAX, MINERAL, or *Ozocerite*, is a solid, of a brown color, of various shades, translucent, and fusible like bees' wax; slightly bituminous to the smell, of a foliated texture, a conchoidal fracture, but wanting tenacity, so that it can be pulverized in a mortar. Its specific gravity varies from 0·900 to 0·953. Candles have been made of it in Moldavia, which give a tolerable light. It occurs at the foot of the Carpathians near Slanik, beneath a bed of bituminous slate-clay, in masses of from 80 to 100 pounds weight. Layers of brown amber are found in the neighborhood. It is associated with variegated sandstone, rock salt, and beds of coal (lignite ?). It is analogous to *hatchetine*. Something similar has been discovered in a *trouble* at Urpeth colliery, near Newcastle, 60 fathoms beneath the surface. *Ozocerite* consists of different hydro-carbureted compounds associated together; the whole being composed, ultimately, of—hydrogen 14, carbon 86, very nearly.

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.* 1159, 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 piece at F, called the *heck* box, which rises and falls by the coiling and uncoiling of the cord G, round the central shaft of the reef H. By this simple contrivance, 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 mills are of a prismatic form; having twelve, eighteen, or more sides. The reel is commonly about six feet in diameter, and seven feet in height, so as to serve for measuring exactly upon its periphery the total length of the warp. All the threads from the frame E, pass through the heck F, which consists of a series of finely-polished hard-tempered steel pins, with a small hole at the upper part of each, to receive and guide one thread. The heck is divided into two parts, either of which may be lifted by a small handle below, while their eyes are placed alternately. Hence, when one of them is raised a little, a vacuity is formed between the two bands of the warp; but when the other is raised, the vacuity is reversed. In this way, the lease is produced at each end of the warp, and it is preserved by appropriate wooden pegs. The lease being carefully tied up, affords a guide to the weaver for inserting his lease-rods. The warping mill is turned alternately from right to left, and from left to right, till a sufficient number of yarns are coiled round it to form the

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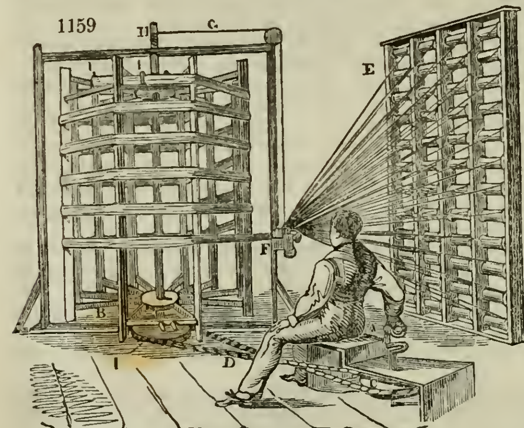
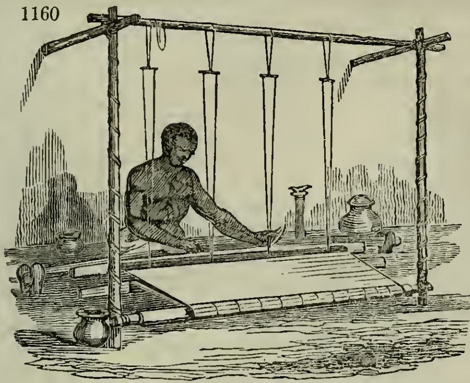


breadth that is wanted; the warper's principal care being to tie immediately every thread as it breaks, otherwise deficiencies would be occasioned in the chain, injurious to the appearance of the web, or productive of much annoyance to the weaver.

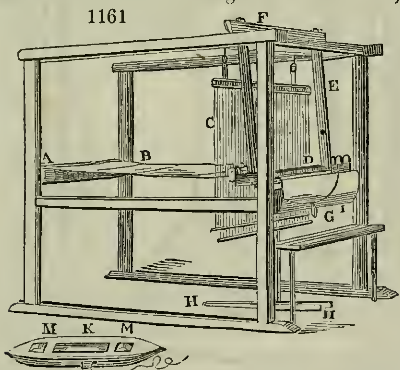
The simplest and probably the most ancient of looms, now to be seen in action, is that of the Hindoo tanty, shown in *fig.* 1160. It consists of two bamboo rollers; one for the warp, and another for the woven cloth; with a pair of heddles, for parting the warp, to permit the weft to be drawn across between its upper and under threads. The shuttle is a slender rod, like a large netting needle, rather longer than the web is broad, and is made use of as a batten or lay, to strike home or condense each successive thread of weft, against the closed fabric. The Hindoo carries this simple implement, with his water pitcher, rice pot, and hooka, to the foot of any tree which can afford him a comfortable shade; he there digs a large hole, to receive his legs, along with the treddles or lower part of the harness; he next extends his warp, by fastening his two bamboo rollers, at a proper distance from each other, with pins, into the sward; he attaches the heddles to a convenient branch of the tree overhead; inserts his great toes into two loops under the gear, to serve him for treddles; lastly, he sheds the warp, draws through the weft, and beats it close up to the web with his rodshuttle or batten.

1160



The European loom is represented in its plainest state, as it has existed for several centuries, in *fig.* 1161. A is the warp-beam, round which the chain has been wound; B represents the flat rods, usually three in number, which pass across between its threads, to preserve the lease, or the plane of decussation for the weft; C shows the heddles or healds, consisting of twines looped in the middle, through which loops the warp yarns are drawn one half through the front heddle, and the other through the back one; by moving which, the decussation is readily effected. The yarns then pass through the dents of the REED under D, which is set in a moveable swing-frame E, called the lathe, lay, and also batten, because it *beats* home the weft to the web. The lay is freely suspended to a cross-bar F, attached by rulers, called the *swords*, to the top of the lateral standards of the loom, so as to oscillate upon it. The weaver, sitting on the bench G, presses down one of the treddles at H, with one of his feet, whereby he raises the corresponding heddle, but sinks the alternate one; thus sheds the warp, by lifting and depressing each alternate thread, through a little space, and opens a pathway or race-course for the shuttle to traverse the middle of the warp, upon its two friction rollers M, M. For this purpose, he lays hold of the picking-peg in his right hand, and, with a smart jerk of his wrist, drives the fly-shuttle swiftly from one side of the loom to the other, between the shed warp yarns. The shoot of weft being thereby left behind from the shuttle pirn or cop, the weaver brings home, by pulling, the lay with its reed towards him by his left hand, with such force as the closeness of the texture requires. The web, as thus woven, is wound up by turning round the cloth beam I, furnished with a ratchet-wheel, which takes into a holding tooth. The plan of throwing the shuttle by the picking-peg and cord, is a great improvement upon the old way of throwing it by hand. It was contrived exactly 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 broadcloth, in the same time.

1161



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

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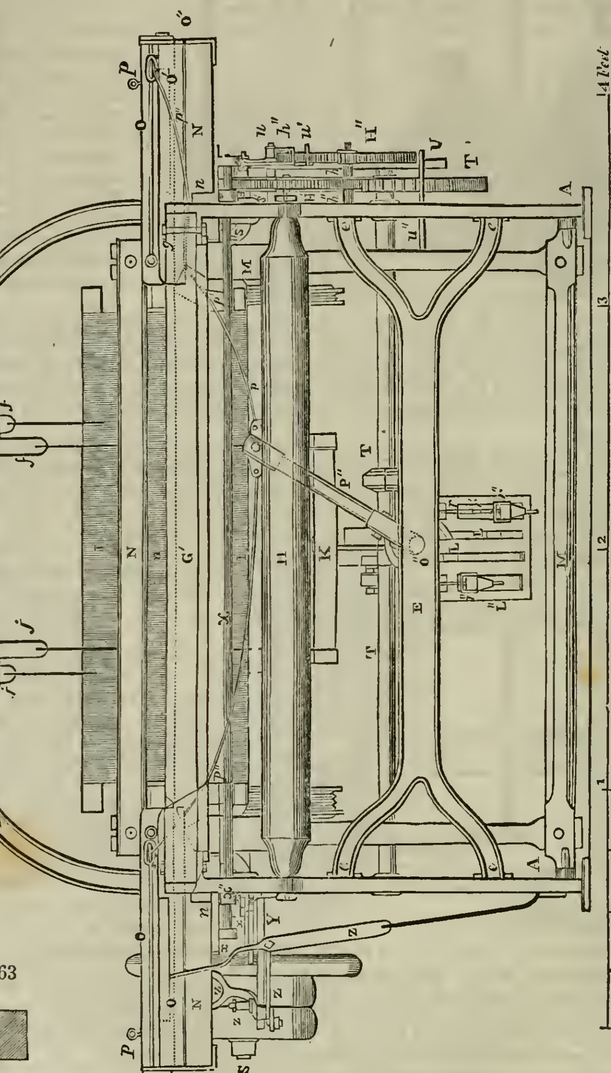
1162



1163

the power loom, called *mêtier mécanique à tisser*, in French. *Fig.* 1162, 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 gear 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.* 1163 and 1164. O″, O″, are iron plates, forming the bottoms of the shuttle-boxes. *p*, small pegs or pins, planted in the posterior faces P (*fig.* 1164) of the boxes, round which the levers P′ turn. These levers are sunk in the substance of the faces P, turn round pegs *p*, being pressed from without inwards, by the springs *p′*. P″, *fig.* 1162, (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.* 1162) is the moving shaft, of wrought iron, resting on the two ends of the frame. S′ (see the right-hand side) is a toothed wheel, mounted exteriorly to the frame, upon the end of the shaft S. S″ (near S′) are two equal elbows, in the same direction, and in the same plane, as the shaft S, opposite to the swords M, M, of the lay.

Z, is the loose, and Z′, the fast pulley, or riggers, which receive motion from the steam-shaft of the factory. Z″, a small fly-wheel, to regulate the movements of the main shaft of the loom.

T, is the shaft of the eccentric tappets, cams, or wipers, which press the treddle levers alternately up and down; on its right end is mounted T′, a toothed wheel in gear with the wheel S′, of one half its diameter. T″, is a cleft clamping collar, which serves to support the shaft T.

U, is a lever, which turns round the bolt *u*, as well as the click *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 fixed 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.* 1161), by means of the whip lever P″, the driver cord *p*, and the pecker 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. For more minute details, the reader may consult *The Cotton Manufacture of Great Britain*, vol. ii. p. 291.

WEFT (*Trame*, Fr.; *Eintrag*, Germ.), is the name of the yarns or threads which run from selvage to selvage in a web.

WELD (*Vouède*, Fr.; *Wau, Gelbkraut*, Germ.), is an annual herbaceous plant, which grows all over Europe, called by botanists *Reseda luteola*. The stems and the leaves dye yellow; and among the dyes of organic nature, they rank next to the Persian berry for the beauty and fastness of color. The whole plant is cropped when in seed, at which period its dyeing power is greatest; and after being simply dried, is brought into the market.

Chevreul has discovered a yellow coloring principle in weld, which he has called *luteoline*. It may be sublimed, and thus obtained in long needle-form, transparent, yellow crystals. Luteoline is but sparingly soluble in water; but it nevertheless dyes alumed silk and wool of a fine jonquil color. It is soluble in alcohol and ether; it combines with acids, and especially with bases.

When weld is to be employed in the dye-bath, it should be boiled for three quarters of an hour; after which the exhausted plant is taken out, because it occupies too much room. The decoction is rapidly decomposed in the air, and ought therefore to be made only when it is wanted. It produces, with

Solution of ising-glass - - - - -	a slight turbidity.	
Litmus paper - - - - - -	a faint reddening.	
Potash ley - - - - - - -	a golden yellow tint.	
Solution of alum - - - - - -	a faint yellow.	
Protoxyde salts of tin - - - - -	a rich yellow	precipitation.
Acetate of lead - - - - - -	ditto	precipitation.
Salts of copper - - - - - -	a dirty yellow-brown	precipitation.
Sulphate of red oxyde of iron - - -	a brown, passing into olive.	

A lack is made from decoction of weld with alum, precipitated by carbonate of soda or potassa. See Yellow Dye.

WELDING (*Souder*, Fr.; *Schweissen*, Germ.), is the property which pieces of wrought iron possess, when heated to whiteness, of uniting intimately and permanently under the hammer, into one body, without any appearance of junction. The welding temperature is usually estimated at from 60° to 90° of Wedgewood. When a skilful blacksmith is about to perform the welding operation, he watches minutely the effect of the heat in his forge-fire upon the two iron bars; and if he perceives them beginning to burn, he pulls them out, rolls them in sand, which forms a glassy silicate of iron upon the surface, so as to prevent further oxydizement; and then laying the one properly upon the other, he incorporates them by his right-hand hammer, being assisted by another workman, who strikes the metal at the same time with a heavy forge-hammer.

Platinum is not susceptible of being welded, as many chemical authors have erroneously asserted.

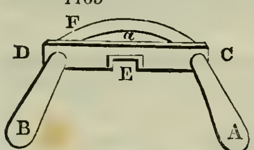
Mr. T. H. Russell, of Handsworth, near Birmingham, obtained a patent, in May, 1836, for manufacturing welded iron tubes, by drawing or passing the skelp, or fillet of sheet iron, five feet long, between dies or holes, formed by a pair of grooved rollers, placed with their sides contiguous; for which process, he does not previously turn up the skelp from end to end, but he does this so as to bring the edges together at the time when the welding is performed. He draws the skelp through two or more pairs of the above pincers or dies, each of less dimension than the preceding. In making tubes of an inch of internal diameter, a skelp four inches and a half broad is employed. The twin rollers revolve on vertical axes, which may be made to approach each other to give pressure; and they are kept cool by a stream of water, while the skelp, ignited to the welding heat, is passed between them. They are affixed at about a foot in front of the mouth of the furnace, on a draw-bench; there being a suitable stop within a few inches of the rollers, against which the workman may place a pair of pincers, having a bell-mouthed hole or die, for welding and shaping the tube. In the first passage between the rollers, a circular revolving plate of iron is let down vertically between them, to prevent the edges of the skelp from overlapping, or even meeting. The welding is performed at the last passage.

WELLS, ARTESIAN. See also Artesian Wells. The following account of a successful operation of this kind, lately performed at Mortlake, in Surrey, deserves to be recorded. The spot at which this undertaking was begun, is within 100 feet of the Thames. In the first instance, an auger, seven inches in diameter, was used in penetrating 20 feet of superficial detritus, and 200 feet of London clay. An iron tube, 8 inches in diameter, was then driven into the opening, to dam out the land-springs and the percolation from the river. A 4-inch auger was next introduced through the iron tube, and the boring was continued until, the London clay having been perforated to the depth of 240 feet, the sands of the plastic clay were reached, and water of the softest and purest nature was obtained; but the supply was not sufficient, and it did not reach the surface. The work was proceeded with accordingly; and after 55 feet of alternating beds of sand and clay had been penetrated, the chalk was touched upon. A second tube, 4½ inches in diameter, was then driven into the chalk, to stop out the water of the plastic sands; and through this tube an auger, 3½ inches in diameter, was introduced, and worked down through 35 feet of hard chalk, abounding with flints. To this succeeded a bed of soft chalk, into which the instrument suddenly penetrated to the depth of 15 feet. On the auger being withdrawn, water gradually rose to the surface, and overflowed. The expense of the work did not exceed 300*l.* The general summary of the strata penetrated is as follows:—Gravel, 20 feet; London clay, 250; plastic sands and clays, 55; hard chalk with flints, 35; soft chalk, 15;=375 feet.

WHALEBONE (*Baleine*, Fr.; *Fischbeine*, Germ.), is the name of the horny laminæ, consisting of fibres laid lengthwise, found in the mouth of the whale, which, by the fringes upon their edges, enable the animal to allow the water to flow out, as through rows of teeth (which it wants), from between its capacious jaws, but to catch and detain the minute creatures upon which it feeds. The fibres of whalebone have little lateral cohesion, as they are not transversely decussated, and may, therefore, be readily detached in the form of long filaments or bristles. The *blades*, or scythe-shaped plates, are externally compact, smooth, and susceptible of a good polish. They are connected, in a parallel series, by what is called the *gum* of the animal, and are arranged along each side of its mouth, to the number of about 300. The length of the longest *blade*, which is usually found near the middle of the series, is the gauge adopted by the fishermen to designate the size of the fish. The greatest length hitherto known has been 15 feet, but it rarely exceeds 12 or 13. The breadth, at the root end, is from 10 to 12 inches; and the average thickness, from four to five tenths of an inch. The series, viewed altogether in the mouth of the whale, resemble, in general form, the roof of a house. They are cleansed and softened before cutting, by boiling for two hours in a long copper.

Whalebone, as brought from Greenland, is commonly divided into portable junks or pieces, comprising ten or twelve blades in each; but it is occasionally subdivided into separate blades, the gum and the hairy fringes having been removed by the sailors during the voyage. The price of whalebone fluctuates from 50*l.* to 150*l.* per ton. The blade is cut into parallel prismatic slips, as follows:—It is clamped horizontally, with its edge up and down, in the large wooden vice of a carpenter's bench, and is then planed by the following tool: *fig.* 1165, 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.

1165



From its flexibility, strength, elasticity, and lightness, whalebone is employed for many purposes: for ribs to umbrellas or parasols; for stiffening stays; for the frame-work 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.

WHEAT. (*Triticum vulgare*, Linn.; *Froment*, Fr.; *Waizen*, Germ.) See BREAD, GLUTEN, and STARCH.

WHEEL CARRIAGES. Though this manufacture belongs most properly to a treatise upon mechanical engineering, I shall endeavor 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. 1166, 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. 1167, 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.* 1171.

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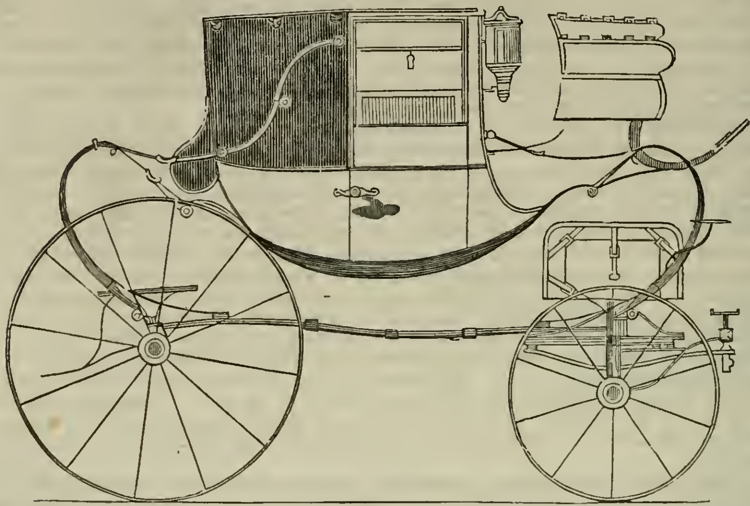

Fig. 1168, is the longitudinal section of a metal nave, which also forms the bush, for the better fitting of which to the axletree, it is bored out of the solid, and made quite air-tight upon the pin; and for retaining the oil, it is left close at the out-head D.

Fig. 1169, 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.* 1167, and its greatest diameter the same with that of the solid collar G, *fig.* 1167. This collet is made with a joint at S, and opens at *p*. Two grooves are represented at *qq*, *qq*, which are seen at the same letters in *fig.* 1170, as also the dovetail *r*, in both figures.

Fig. 1170, is an edge view of the collet, *fig.* 1169.

Fig. 1171, 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

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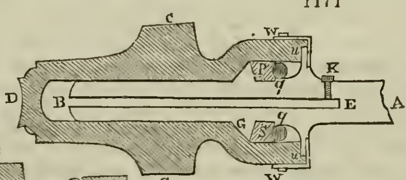

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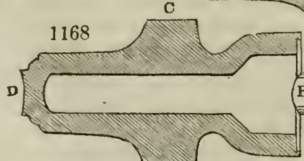

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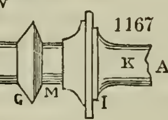


answers also for the bush. P, S, the collet (see *figs.* 1169 and 1170), put into its place. *q*, *q*, two steel pins, passing through the in-head of the bush, and filling up the grooves in the collet. W, W, a caped hoop, sufficiently broad to cover the ends of said pins, and made fast to the bush by 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.* 1167. 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 one inch shorter than the bore of the bush, and the screw, being afterwards replaced, keeps all tight. In putting on the wheel, a little oil ought to be put into the space betwixt the collet P, S, and the larger collar. The collar P, S, being moveable 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.* 1170, 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.

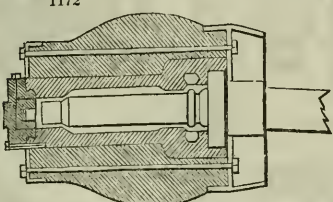
The spokes of the wheel, made of malleable iron, are screwed into the bush or nave at c, c, *figs.* 1168, 1171, all round. The felloes, composed merely of two bars of iron, bent into a circle edgeways, are put on, the one on the front, the other on the back, of the spokes, which have shoulders on both 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. 1172, 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.* 1173.

1172



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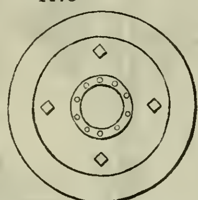


In the cap *a*, there is also a groove for conducting the oil to the interior of the box, with a screw at the opening, to prevent it running out as the wheel goes round.

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.

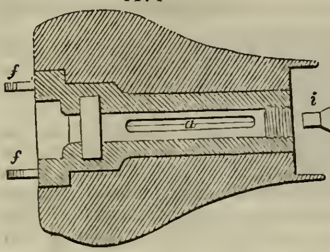
Mr. Mason's patent, of August, 1830, applies also to the boxes and axles of that construction of carriage wheels which are fitted with the so called mail-boxes; but part of the invention applies to other axles.

Fig. 1174, represents the nave of a wheel, with the box for the axle within it, both shown in section longitudinally; *fig.* 1175, is a section of the axle, taken in the same direction; and *fig.* 1176, 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.

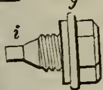
The cylindrical recess *a*, in the box of the nave, is designed to fit the cylindrical part of the axle *b*; and the conical part *c*, of the axle, to shoulder up against a corresponding conical cavity in the box, with a washer of leather to prevent its shaking. A collar *d*, formed by a metallic ring, 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.

1174



1176



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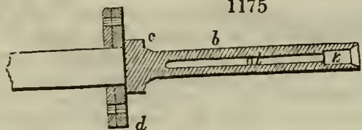
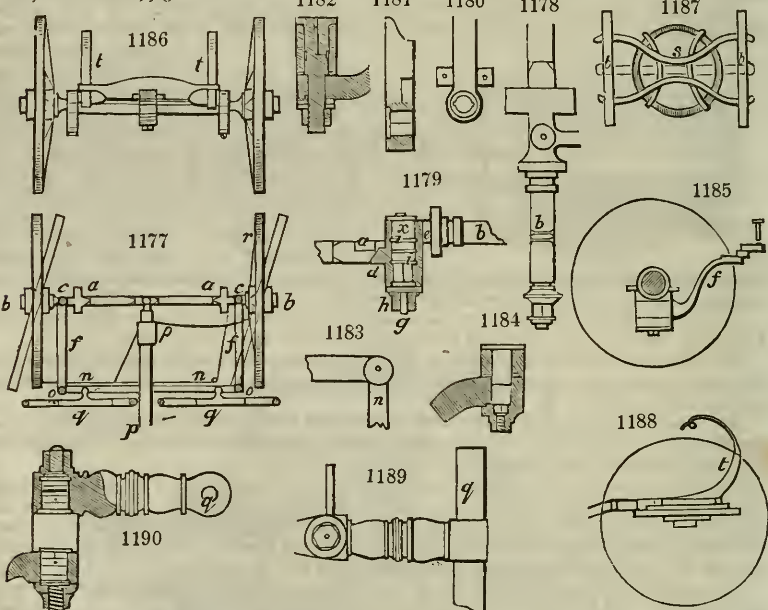


Mr. William Mason's patent invention for wheel carriages, of August, 1831, will be understood by reference to the annexed figures. *Fig.* 1177, is a plan showing the fore-axletree bed *a*, *a*, of a four-wheeled carriage, to which the axletrees *b*, *b*, are jointed at each end; *fig.* 1178 is an enlarged plan; and *fig.* 1179 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 *c*, which passes through and turns in a cylindrical hole *d*, formed at the end of the axletree bed, shown also in the plan view, *fig.* 1180, and section, *fig.* 1181.



The axletree *b*, is firmly united with the upper end *e*, of the pin or bolt *c*; and to the lower end of it, which is squared, the guide piece *f*, is also fitted, and secured by the screw g, and cap or nut *h*, seen in *fig.* 1179, and in section in *fig.* 1182. 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.* 1182, 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.* 1180, and 1181. The guide piece *f*, is affixed at right angles with the axletree *b*, as shown in *fig.* 1178, 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.* 1177, is jointed to the other end of the iron fore-axletree bed.

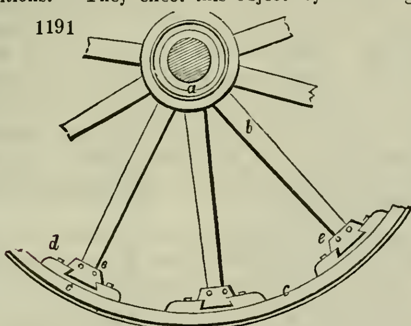
The outer ends of the guide pieces *f*, *f*, are jointed to the splinter-bar *n*, *fig.* 1181, as follows:—*Fig.* 1183, is a plan, and *fig.* 1184, a section of the joint *o*, in *fig.* 1177, shown on an enlarged scale; a cylindrical pin or bolt *c*, is firmly secured in the splinter-bar, and round the 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.* 1177, are likewise jointed in the same way to the splinter-bar. *Fig.* 1185, is a side view of these parts. The fore wheels of the carriage, *fig.* 1177, are furnished with cast-iron boxes, as usual. The dotted lines show the action of the pole *p*, *p*, upon the splinter-bar *n*, and as communicated through the latter to the guide pieces *f*, *f*, connected with the axletrees *b*, *b*, so as to lock the wheels *r*, *r*, as shown in that figure.

The axletree may be incased in the woodwork of the fore-bed of the carriage, as usual, and as shown by dotted lines in the back end view thereof, *fig.* 1186; and the framing *s*, *fig.* 1187, 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.* 1186 and 1187, and likewise in the side view, *fig.* 1188. 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.* 1189 and 1190; the swingletrees *q*, *q*, and guide pieces *f*, *f*, turning freely above and below upon the said pin or bolt, and secured in their places thereon by screws and screwed nuts, oil being also supplied through holes formed in both ends of the said pin or bolt, and leather washers provided, as in the above-described instances.

Mr. Gibbs, engineer, and Mr. Chaplin, coach-maker, obtained a patent, in 1832, for the construction of a four-wheeled carriage which shall be enabled to turn within a small compass, by throwing the axles of all the four wheels simultaneously into different positions. They effect this object by mounting each wheel upon a separate jointed axle, and by connecting the free ends of the four axles by jointed rods or chains, with the pole and splinter-bar in front of the carriage.

1191



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.* 1191 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.* 1192, by which it will be perceived that the end

1192

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.* 1193, 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

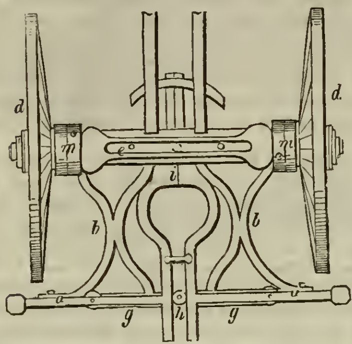
1193

wedges being cut off, the caps are then attached on the face of the block, as at *e*, *e*, by pins riveted at their ends, which secures the spokes, and renders it impossible for them to be loosened by the vibrations as the wheel passes over the ground. One important use of the wedges, is to correct the eccentric figure of the wheel, which may be readily forced out in any part that may be out of the true form, by driving the wedge up further; and this, it is considered, will be a very important advantage, as the nearer a wheel can be brought to a true circle, the easier it will run upon the road. The periphery of the wheel is to be protected by a tire, which may be put on in pieces, and bolted through the felloe; or it may be made in one ring, and attached, while hot, in the usual way.

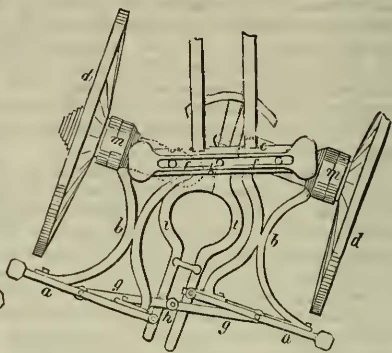
Mr. Reedhead's patent improvements in the construction of carriages, are represented in the following figures. They were specified in July, 1833.

Fig. 1194, 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.* 1195, is a similar view, showing the wheels as locked, when in the act of

1194



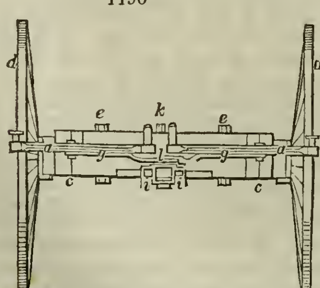
1195



turning; *fig.* 1196, is a front end elevation of the same; *fig.* 1197, is a section taken through the centre of the fore axletree; and *fig.* 1198, is a side elevation of the general appearance of a stage-coach, with the improvements appended: *a*, *a*, are two splinter-bars, with their roller-bolts, for connecting the traces of the harness; these splinter-bars are attached, by the bent irons *b*, *b*, to two short axletrees or axle-boxes *c*, *c*, which carry the axles of the fore wheels *d*, *d*, and turn upon vertical pins or bolts *e*, *e*, passed through the fore axletree *f*, the splinter-bars and axle-boxes being mounted so as to move parallel to each other, the latter partaking of any motion given to the splinter-bars by the horses in drawing the carriage forward, and thereby producing the locking of the wheels, as shown in *fig.* 1195; 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 naves of the wheels, as represented in the side view of a wheel detached, at *fig.* 1200, 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.* 1200 and 1199; upon this bottom plate is formed the chamber *m*, *m*, carrying the two anti-friction rollers *n*, *n*, which turn on short axles passed through the sides and partition at the upper part of the chambers. These anti-friction rollers bear upon the cylindrical parts of the axle *o*, of each wheel, and support the weight of the coach; *p*, is a bearing firmly secured in the axle-box to the plate *l*, for the end of the axle *o* to run

1196



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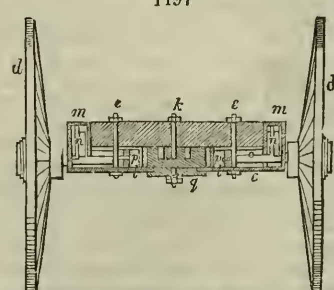
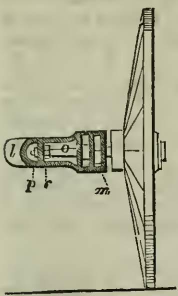


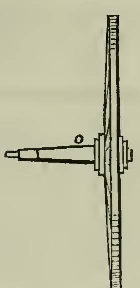
in, the axle being confined in its proper situation by a collar and screw-nut on its end; *e*, is the vertical pin or bolt before mentioned, upon which the axle-bar turns when the

1200

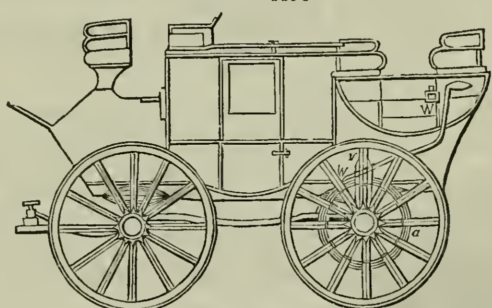


wheels are locking, which bolt is enlarged within the box, and has an eye for the axle to pass through, being firmly secured to the plate *l*, and also to the sides of the box. *Fig.* 1200, is a plan or horizontal view of an axle and its box, belonging to one of the fore wheels; a piece *q*, is fixed to the under side of the main axletree, which supports the ends of the plates *l*, and thereby relieves the pins *e*, *e*, of the strain they would otherwise have to withstand. The axles of the hind wheels are mounted upon similar plates *l*, *l*, with bearings and chambers with anti-friction rollers; but as these are not required to lock, the plates *l*, *l*, are fixed on to the under side of the hind 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.* 1198, 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.* 1198, it may be adapted to the fore

1199



1198



wheels, and the end of the lever brought up to the side of the foot-board, or under it, and within command of the coachman, the standard which carries the fulcrum being made to move upon a pivot, to accommodate the locking of the wheels. It will be observed, that by these improved constructions of the carriage, and mode of locking, the patentee is enabled to use much larger fore wheels than in common, and that the splinter-bars will always be in the position of right angles with the track or way of the horses in drawing the carriage, by which they are much relieved, and always pull in a direct and equal manner.

A manifest defect in all four-wheeled carriages, involving vast superfluous friction, is the small size of the front wheels; a defect which has existed ever since Walter Rippon made "the first hollow *turning* coach with pillars and arches for her majesty Queen Mary, being then her servant," until the railroad era, when our engineers remedied the defect by equalizing the wheels, at the expense of another defect—sacrificing the power of turning, and thus producing great lateral friction; whence a train of evil consequences result:—necessarily increased strength, and consequently increased weight of the carriages; increased power and weight of the engine to draw them, and overcome the friction; and, of course, increased strength of rails, and greater solidity of railway.

These defects are at last remedied by an invention patented by Mr. William Adams, author of a work entitled "English Pleasure Carriages." Instead of placing the perch-bolt, or turning centre, as is commonly done, over the front axle, he places it at a convenient distance *between* the front and hind axles; so that when turning the carriage the front wheels, instead of turning *beneath* the body, as is common, turn outside of it, and the driver's seat turns with them; thus giving him a perfect command over his horses in all positions, instead of the usual dangerous plan, which renders a driver liable to be pulled off his box by a restiff horse, when in the act of turning. A carriage constructed on Mr. Adams's plan may also be driven round a corner at full speed, without any risk of overturning, as the weight is equally poised on the axles in all positions. It is well known that the oversetting of stage coaches usually takes place when turning a corner, the momentum urging the vehicle in a right line, while the horses are pulling at an angle. By the new arrangement the front wheels may be made equal to the hind ones, or of any desirable height, and at the same time the body may be kept as low as may be thought convenient, even almost close to the ground, if desired. Thus two important objects, hitherto deemed incompatible, are combined—high wheels and a low centre of gravity. These carriages are therefore essentially safety carriages, while the friction is reduced to a minimum. The principle, in its various modifications, is applicable to every variety of carriage, both those of the simply useful kind, and those where beauty of form and color are prime requisites.

Another most important part of Mr. Adams's invention, is his new mode of spring suspension; applying the principle of the bow and string, for the first time, to obviate the effects of concussion in wheel carriages. All the springs hitherto in use for wheel carriages, have been friction springs, composed of long sliding surfaces, uncertain in their action, and liable to quick destruction by rust. But Mr. Adams's springs are essentially elastic, being formed of single plates abutting endways, so that all friction is removed, and they can be hermetically sealed within paint to prevent their corrosion. He has various modes of applying the bow, either single or double, above or below the axle; but one most important feature is, that the axle being attached to the flexible cords or braces, the concussion which affects the wheels, either laterally, vertically, or in the line of progress, is perfectly intercepted, without the unpleasant oscillation experienced in carriages where the same purpose is accomplished by the use of the curved or C spring. Mr. Adams's brace being, at the same time, a non-conductor of sound, the rattling of the wheels does not annoy the rider as in ordinary carriages. His springs are equally applicable to vehicles with two and four wheels.

The advantages of these carriages may be thus summed up:—A great diminution of the total weight; a diminution of resistance in draught equal to about one third; increase of safety to the riders; increased durability of the vehicle; absence of noise and vibration; absence of oscillation.

To these qualities, so desirable to all, and especially those of delicate nervous temperament, may be added—greater economy, both in the first cost and maintenance.

The *whirling* public so blindly follows fashionable caprice in the choice of a carriage, as to have hitherto paid too little attention to this fundamental improvement; but many intelligent individuals have fully verified its practical reality. Having inspected various forms of two-wheeled and four-wheeled carriages, in the patentee's premises in Drury Lane, I feel justified in recommending them as being constructed on the soundest mechanical principles; and have no doubt, that if reason be allowed to decide upon their merits, they will ere long be universally preferred by all who seek for easy-moving, safe, and comfortable vehicles.

WHETSLATE, is a massive mineral of a greenish-gray color; 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 *hone-stones*, which are in much esteem for sharpening steel instruments.

WHEY (*Petit lait*, Fr.; *Molken*, Germ.), is the greenish-gray liquor which exudes from the curd of milk. Scheele states, that when a pound of milk is mixed with a spoonful of proof spirit, and allowed to become sour, the whey filtered off, at the end of a month or a little more, is a good vinegar, devoid of lactic acid.

WHISKEY, is dilute alcohol, distilled from the fermented worts of malt or grains.

WHITE LEAD, *Carbonate of lead, or Ceruse.* (*Blanc de plomb*, Fr.; *Bleiweiss*, Germ.) This preparation is the only one in general use for painting wood and the plaster walls of apartments white. It mixes well with oil, without having its bright color impaired, spreads easily under the brush, and gives a uniform coat to wood, stone, metal, &c. It is employed either alone, or with other pigments, to serve as their basis, and to give them body. This article has been long manufactured with much success at Klagenfurth in Carinthia, and its mode of preparation has been lately described with precision by Marcel de Serres. The great white-lead establishments at Krems, whence, though incorrectly, the terms *white of Kremnitz* became current on the continent, have been abandoned.

1. The lead comes from Bleyberg; it is very pure, and particularly free from contamination with iron, a point essential to the beauty of its factitious carbonate. It is melted

in ordinary pots of cast iron, and cast into sheets of varying thickness, according to the pleasure of the manufacturer. These sheets are made by pouring the melted lead upon an iron plate placed over the boiler; and whenever the surface of the metal begins to consolidate, the plate is slightly sloped to one side, so as to run off the still liquid metal, and leave a lead sheet of the desired thinness. It is then lifted off like a sheet of paper; and as the iron plate is cooled in water, several hundred weights of lead can be readily cast in a day. In certain white-lead works these sheets are one twenty-fourth of an inch thick; in others, half that quantity; in some, one of these sheets takes up the whole width of the conversion-box; in others, four sheets are employed. It is of consequence not to smooth down the faces of the leaden sheets; because a rough surface presents more points of contact, and is more readily attacked by acid vapors, 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 sulphureted and phosphureted 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 vapors, 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 vapors in the first case, or of injuring the color 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 twenty pounds of wine-lees, with eight and a half 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 vapors, 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 fifteen days, in which time the operation is, for the most part, completed. If the heat be too high, and the vapors too copious, the carbonic acid escapes in a great measure, and the metallic lead, less acted upon, affords a much smaller product.

When the process is well managed, as much carbonate of lead is obtained, as there was employed of metal; or, for 300 pounds of lead, 300 of ceruse are procured, besides a certain quantity of metal after the crusts are removed, which is returned to the melting-pot. The mixture introduced into the boxes serves only once; and if carbonate of potash has been used, the residuary matter is sold to the hatters.

4. When the preceding operation is supposed to be complete, the sheets, being removed from the boxes, are found to have grown a quarter of an inch thick, though previously not above a twelfth of that thickness. A few pretty large crystals of acetate of lead are sometimes observed on their edges. The plates are now shaken smartly, to cause the crust of carbonate of lead formed on their surfaces to fall off. This carbonate is put into large cisterns, and washed very clean. The cistern is of wood, most commonly of a square shape, and divided into from seven to nine compartments. These are of equal capacity, but unequal height, so that the liquid may be made to overflow from one to the other. Thereby, if the first chest is too full, it decants its excess into the second, and so on in succession. See Rinsing Machine.

The water poured into the first chest passes successively into the others, a slight agitation being meanwhile kept up, and there deposites the white lead diffused in it proportionally, so that the deposite 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 color, and protects the lead from being speedily darkened by sulphureous smoke or vapors.

The high reputation of the white lead of Krems was by no means due to the barytes, for the first and whitest quality was mere carbonate of lead. The freedom from silver of the lead of Villach, a very rare circumstance, is one cause of the superiority of its carbonate; as well as the skilful and laborious manner in which it is washed, and separated from any adhering particle of metal or sulphuret.

In England, lead is converted into carbonate in the following way:—The metal is cast into the form of a net-work grating, in moulds about fifteen inches long, and four or five broad. Several rows of these are placed over cylindrical glazed earthen pots, about four or five inches in diameter, containing some treacle-vinegar, which are then covered with straw; above these pots another range is piled, and so in succession, to a convenient height. The whole are imbedded in spent bark from the tan-pit, brought into a fermenting state by being mixed with some bark used in a previous process. The pots are left undisturbed under the influence of a fermenting temperature for eight or nine weeks. In the course of this time the lead gratings become, generally speaking, converted throughout into a solid carbonate, which when removed is levigated in a proper mill, and elutriated with abundance of pure water. The plan of inserting coils of sheet lead into earthenware pipkins containing vinegar, and imbedding the pile of pipkins in fermenting horse-dung and litter, is now little used; because the coil is not uniformly acted on by the acid vapors, and the sulphureted hydrogen evolved from the dung is apt to darken the white lead.

In the above processes, the conversion of lead into carbonate seems to be effected by keeping the metal immersed in a warm, humid atmosphere, loaded with carbonic and acetic acids; and hence a pure vinegar does not answer well; but one which is susceptible, by its spontaneous decomposition in these circumstances, of yielding carbonic acid. Such are tartar, wine-lees, molasses, &c.

Another process has lately been practised to a considerable extent in France, though it does not afford a white lead equal in body and opacity to the products of the preceding operations. M. Thenard first established the principle, and MM. 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 uncrystallized 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 oxyde 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 sulphureted 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 deposite being first rinsed with a little water, this washing is added to the acetate; after which the white lead is thoroughly elutriated. This repetition of the process may be indefinitely made; but there is always a small loss of acetate, which must be repaired, either directly or by adding some vinegar.

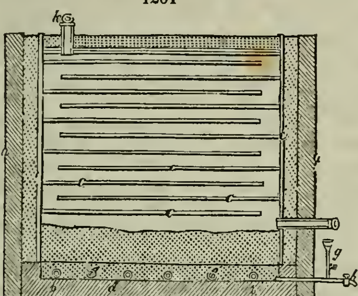
In order to obtain the finest white lead by the process with earthen pots containing vinegar buried in fermenting tan, and covered by a grating of lead, the metal should be so thin as to be entirely convertible into carbonate; for whenever any of it remains, it is apt to give a gray tint to the product; if the temperature of the fermenting mass is less than 90° Fahr., some particles of the metal will resist the action of the vinegar, and degrade the color; and if it exceeds 122°, the white verges into yellow, in consequence of some carbonaceous compound being developed from the principles of the acetic acid. The dung and tan have been generally supposed to act in this process by supplying carbonic acid, the result of their fermentation; but it is now said that this explanation is inexact, because the best white lead can be obtained by the entire exclusion of air from the pots in which the carbonization of the metal is carried on. We are thence led to conclude that the lead is oxydized at the expense of the oxygen of the vinegar, and carbonated by the agency of its oxygen and carbon; the hydrogen of the acid being left to associate itself with the remaining oxygen and carbon, so as to constitute an ethereous compound: thus, supposing the three atoms of oxygen to form, with one of lead and one of carbon, an atom of carbonate, then the remaining three atoms of carbon and three of hydrogen would compose olefiant gas.

It is customary on the continent to mould the white lead into conical loaves, before sending them into the market. This is done by stuffing well-drained white lead into unglazed earthen pots, of the requisite size and shape, and drying it to a solid mass, by exposing these pots in stove-rooms. The moulds being now inverted on tables, discharge their contents, which then receive a final desiccation; and are afterwards put up in pale-blue paper, to set off the white color by contrast. Nothing in all the white-lead process is so injurious as this pot operation; a useless step, fortunately unknown in Great Britain. Neither greasing the skin, nor wearing thick gloves, can protect the operators from the diseases induced by the poisonous action of the white lead; and hence they must be soon sent off to some other department of the work.

It has been supposed that the differences observed between the ceruse of Clichy and the common kinds, depend on the greater compactness of the particles of the latter, produced by their slower aggregation; as also, according to M. Robiquet, on the former containing considerably less carbonic acid. See *infrà*.

Mr. Ham proposed, in a patent dated June, 1826, to produce white lead with the aid of the following apparatus. *a*, *a* (*fig.* 1201) 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 vapors; 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 vapors raised by the heat, pass up through the spent bark, and on coming into contact with the sheets of lead, corrode them. The quantity of acid liquor should not be in excess; a point to be ascertained by means of the small tube *i*, at top, which is intended for testing it by the tongue. *k*, is a tube for inserting a thermometer, to watch the temperature, which should not exceed 170° Fahr. I am not aware of what success has attended this patented arrangement. The heat prescribed is far too great.

1201



A magnificent factory has been recently erected at West Bromwich, near Birmingham, to work a patent lately granted to Messrs. Gossage and Benson, for making white lead by mixing a small quantity of acetate of lead in solution with slightly damped litharge, contained in a long stone trough, and passing over the surface of the trough currents of hot carbonic acid, while its contents are powerfully stirred up by a travelling-wheel mechanism. The product is afterwards ground and elutriated, as usual. The carbonic acid gas is produced from the combustion of coke. I am told that 40 tons of excellent white lead are made weekly by these chemico-mechanical operations.

Messrs. Button and Dyer obtained a patent about a year and a half ago, for making white lead by transmitting a current of purified carbonic acid gas, from the combustion of coke, through a mixture of litharge and nitrate of lead, diffused and dissolved in water, which is kept in constant agitation and ebullition by steam introduced through a perforated coil of pipes at the bottom of the tub. The carbonate of lead is formed here upon the principle of Thenard's old process with the subacetate; for the nitrate of lead forms with the litharge a subnitrate, which is forthwith transformed into carbonate and neutral nitrate, by the agency of the carbonic acid gas. I have discovered that all sorts of white lead produced by precipitation from a liquid, are in a semi-crystalline condition; they 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 oxydized and carbonated. It is said that upwards of 100,000*l*. have been expended at Chelsea, by a joint stock company, in a factory constructed for executing the preceding most operose and defective process; which has been, many years ago, tried without success in Germany. I am convinced that the whole of these recent projects for preparing white lead, are inferior in economy, and quality of produce, to the old Dutch process, which may be so arranged as to convert sheets of blue lead thoroughly into the best white lead, within the space of 12 days, at less expense of labor than by any other plan.

White lead, as obtained by precipitation from the acetate, subacetate, and subnitrate, is a true carbonate of the metal, consisting of one prime equivalent of lead 104, one of oxygen 8, and one of carbonic acid 22; whose sum is 134, the atomic weight of the compound; or, of lead, 77·6; oxygen, 6; carbonic acid, 16·4; in 100 parts. It has been supposed, by some authors, that the denser and better-covering white lead of Krems and Holland is a kind of subcarbonate, containing only 9 per cent. of carbonic acid; but this view of the subject does not accord with my researches.

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 upon 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. In the more southern states of Europe, the grapes, being more saccharine, afford a more abundant production of alcohol, and stronger wines, as exemplified in the best port, sherry, and madeira. The influence of solar heat upon the vines may, however, be mitigated by growing them to moderate heights on level ground, and by training them in festoons under the shelter of trees. In the more temperate climates, such as the district of Burgundy, the finer flavored 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 vapors 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 flavor. 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 favorable 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 granite debris forms the foundations of the lands where the Hermitage wines are grown; silicious 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 soil, afford inferior wine to the middle southern slopes.

Amelioration of the soil.—When the vine lands are too light or too dense, they may be modified, within certain limits, by introducing into them either argillaceous or silicious matter. Marl is excellent for almost all grounds which are not previously too calcareous, being alike useful to open dense soils, and to render porous ones more retentive.

Manure.—For the vine, as well as all cultivated plants, a manure supplying azotized or animal nutriment may be used with great advantage, provided care be taken to ripen it by previous fermentation, so that it may not, by absorption in too crude a state, impart any disagreeable odor to the grape; as sometimes happens to the vines grown in the vicinity of great towns, like Paris, and near Argenteuil. There is a compost used in France, called *animalized black*, of which from one fifth to one half of a litre (old English quart) serves sufficiently to fertilize the root of one vine, when applied every year, or two years. An excess of manure, in rainy seasons especially, has the effect of rendering the grapes large and insipid.

The ground is tilled at the same time as the manure is applied, towards the month of March; the plants are then dressed, and the props are inserted. The weakness of the plants renders this practice useful; but in some southern districts, the stem of the vine, when supported at a proper height, acquires after a while sufficient size and strength to stand alone. The ends of the props or poles are either dipped in tar, or charred, to prevent their rotting. The bottom of the stem must be covered over with soil, after the spring rains have washed it down. The principal husbandry of the vineyard consists in digging or ploughing to destroy the weeds, and to expose the soil to the influence of the air, during the months of May, June, and occasionally in August.

The vintage, in the temperate provinces, generally takes place about the end of September; and it is always deteriorated whenever the fruit is not ripe enough before the 15th or 20th of October; for, in this case, not only is the must more acid, and less saccharine, but the atmospherical temperature is apt to fall so low during the nights, as to obstruct more or less its fermentation into wine. The grapes should be plucked in dry weather, at the interval of a few days after they are ripe; being usually gathered in baskets, and transported to the vats in dorsels, sufficiently tight to prevent the juice from running out. Whenever a layer about 14 or 15 inches thick has been spread on the bottom of the vat, the treading operation begins, which is usually repeated after macerating the grapes for some time, when an incipient fermentation has softened the texture of the skin and the interior cells. When the whole bruised grapes are collected in the vat, the juice, by means of a slight fermentation, reacts, through the acidity thus generated, upon the coloring 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 Auger introduced with success his elastic bung in the manufacture of wine in the department of the Maine-et-Loire.

With whatever kind of apparatus the fermentation may have been regulated, as soon as it ceases to be tumultuous, and the wine is not sensibly saccharine or muddy, it must be racked off from the lees, by means of a spigot, and run into the ripening tuns. The marc being then gently squeezed in a press, affords a tolerably clear wine, which is distributed among the tuns in equal proportions; but the liquor obtained by stronger pressure is reserved for the casks of inferior wine.

In the south of France the fermentation sometimes proceeds too slowly, on account of the must being too saccharine; an accident which is best counteracted by maintaining a temperature of about 65° or 68° F., in the tun-room. When the must, on the other hand, is too thin, and deficient in sugar, it must be partially concentrated by rapid boiling, before the whole can be made to ferment into a good wine. By boiling up a part of the must for this purpose, the excess of ferment is at the same time destroyed. Should this concentration be inconvenient, a certain proportion of sugar must be introduced, immediately after racking it off.

The specific gravity of must varies with the richness and ripeness of the grapes which afford it; being in some cases so low as 1·0627, and in others so high as 1·1283. This happens particularly in the south of France. In the district of the Necker in Germany, the specific gravity varies from 1·050 to 1·090; in Heidelberg, from 1·039, to 1·091; but it varies much in different years.

After the fermentation is complete, the vinous part consists of water, alcohol, a coloring-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 proportions.

It is known that a few green grapes are capable of spoiling a whole cask of wine, and therefore they are always allowed to become completely ripe, and even sometimes to undergo a species of slight fermentation, before being plucked, which completes the development of the saccharine principle. At other times the grapes are gathered whenever they are ripe, but are left for a few days on wicker-floors, to sweeten, before being pressed.

In general the whole vintage of the day is pressed in the evening, and the resulting must is received in separate vats. At the end usually of 6 or 8 hours, if the temperature be above 50° F., and if the grapes have not been too cold when plucked, a froth or scum is formed at the surface, which rapidly increases in thickness. After it acquires such a consistence as to crack in several places, it is taken off with a skimmer, and drained; and the thin liquor is returned to the vat. A few hours afterwards another coat of froth is formed, which is removed in like manner, and sometimes a third may be produced. The regular vinous fermentation now begins, characterized 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 ising-glass.

The white wines should be racked off as soon as the first frosts have made them clear, and at the latest by the end of the February moon. By thus separating the wine from the lees, we avoid, or render of little consequence, the fermentation which takes place on the return of spring, and which, if too brisk, would destroy all its sweetness, by decomposing the remaining portion of sugar.

The characteristic odor 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 forty thousandth part of the wine; and consists of a peculiar new acid, and ether, each of which has been called the *œnanthic.* The acid is analogous to the fatty acids, and the ether is liquid, but insoluble in water. The acid is perfectly white when pure, of the consistence of butter at 60°, melts with a moderate heat, reddens litmus, and dissolves in caustic and carbonated alkalis, as well as in alcohol and ether. Œnanthic ether is colorless, has an extremely strong smell of wine, which is almost intoxicating when inhaled, and a powerful disagreeable taste. *Liebig and Pelouze.*

Sparkling wines.—In the manufacture of these, black grapes of the first quality are usually employed, especially those gathered upon the vine called by the French *noirien,* cultivated on the best exposures. As it is important, however, to prevent the coloring-matter of the skin from entering into the wine, the juice should be squeezed as gently and rapidly as possible. The liquor obtained by a second and third pressing is reserved for inferior wines, on account of the reddish tint which it acquires. The marc is then mixed with the grapes of the red-wine vats.

The above nearly colorless must is immediately poured into tuns or casks, till about three fourths of their capacity are filled, when fermentation soon begins. This is allowed to continue under the control of the elastic bung, above mentioned, for about 15 days, and then three fourths of the casks are filled up with wine from the rest. The casks are now closed by a bung secured with a piece of hoop iron nailed to two contiguous staves. The casks should be made of new wood, but not of oak—though old white wine casks are occasionally used.

In the month of January the clear wine is racked off, and is fined by a small quantity of ising-glass dissolved in old wine of the same kind. Forty days afterwards a second fining is required. Sometimes a third may be useful, if the lees be considerable. In the month of May the clear wine is drawn off into bottles, taking care to add to each of them a small measure of what is called *liquor,* which is merely about 3 per cent. of a sirup made by dissolving sugar-candy in white wine. The bottles being filled, and their corks secured by packthread and wire, they are laid on their sides, in this month, with their mouths sloping downwards at an angle of about twenty 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 2 or 3 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 flavored wines have been hitherto made. The breakage of the bottles in these sparkling wines amounts frequently to thirty per cent., a circumstance which adds greatly to their cost of production.

Weak wines of bad growths ought to be consumed within 12 or 15 months after being manufactured; and should be kept meanwhile in cool cellars. White wines of middling strength ought to be kept in casks constantly full, and carefully excluded from contact of air, and the racking off should be done as quickly as possible. As the most of them are injured by too much fermentation, this process should be so regulated as always to leave a little sugar undecomposed. It is useful to counteract the absorption of oxygen, and the consequent tendency to acidity, by burning a sulphur match in the casks into which they are about to be run. This is done by hooking the match to a bent wire, kindling and suspending it within the cask through the bung-hole. Immediately on withdrawing the match, the cask should be corked, if the wine be not ready for transfer. If the burning sulphur be extinguished on plunging it into the cask, it is a proof of the cask being unsound, and unfit for receiving the wine; in which case it should be well cleansed, first with lime-water, then with very dilute sulphuric acid, and lastly with boiling water.

Wine-cellars ought to be dry at bottom, floored with flags, have windows opening to the north, be so much sunk below the level of the adjoining ground as to possess a nearly uniform temperature in summer and winter; and be at such a distance from a frequented highway or street as not to suffer vibration from the motion of carriages.

Wines should be racked off in cool weather; the end of February being the fittest time for light wines. Strong wines are not racked off till they have stood a year or eighteen months upon the lees, to promote their slow or insensible fermentation. A syphon well managed serves better than a faucet to draw off wine clear from the sediment. White wines, before being bottled, should be fined with ising-glass; red wines are usually fined with whites of eggs beat up into a froth, and mixed with two or three times their bulk of water. But some strong wines, which are a little harsh from excess of tannin, are fined with a little sheep or bullock's blood. Occasionally a small quantity of sweet glue is used for this purpose.

The following maladies of wines, are certain accidental deteriorations, to which remedies should be speedily applied.

La-pousse (pushing out of the cask), is the name given to a violent fermentative movement, which occasionally supervenes after the wine has been run off into the casks. If these have been tightly closed, the interior pressure may increase to such a degree as to burst the hoops, or cause the seams of the staves or ends to open. The elastic bungs already described will prevent the bursting of the casks; but something must be done to repress the fermentation, lest it should destroy the whole of the sugar, and make the wine unpalatably harsh. One remedy is, to transfer the wine into a cask previously fumigated with burning sulphur; another is, to add to it about one thousandth part of sulphite of lime; and a third, and perhaps the safest, is to introduce half a pound of mustard-seed into each barrel. At any rate, the wines should be fined whenever the movements are allayed, to remove the floating ferment which has been the cause of the mischief.

Turning sour.—The production of too much acid in a wine, is a proof of its containing originally too little alcohol, of its being exposed too largely to the air, or to vibrations, or to too high a temperature in the cellar. The best thing to be done in this case is, to mix it with its bulk of a stronger wine in a less advanced state, to fine the mixture, to bottle it, and to consume it as soon as possible, for it will never prove a good keeping wine. This *distemper* in wines formerly gave rise to the very dangerous practice of adding litharge as a sweetener; whereby a quantity of acetate or sugar of lead was formed in the liquor, productive of the most deleterious consequences to those who drank of it. In France, the regulations of police, and the enlightened *surveillance* of the council of salubrity, have completely put down this gross abuse. The saturation of the acid by lime and other alkaline bases has generally a prejudicial effect, and injures more or less the vinous flavor 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 azotized matter, analogous to *gliadine* (gluten); and in fact it is the white wines, especially those which contain the least tannin, which are subject to this malady. He also pointed out the proper remedy, in the addition of tannin under a rather agreeable form, namely, the bruised berries of the mountain-ash (*sorbier*), in a somewhat unripe state; of which one pound, well stirred in, is sufficient for a barrel. After agitation, the wine is to be left in repose for a day or two, and then racked off. The tannin by this time will have separated the azotized matter from the liquor, and removed the ropiness. The wine is to be fined and bottled off.

The taste of the cask, which sometimes happens to wine put into casks which had remained long empty, is best remedied by agitating the wine for some time with a spoonful of olive oil. An essential oil, the chief cause of the bad taste, combines with the fixed oil, and rises with it to the surface.

According to a statement in the *Dictionnaire Technologique*, the annual produce of a hectare of vineyard, upon the average of 113 years, in the district of Volnay, is 1779 litres, which fetch 0·877 francs each, or 200 francs the piece of 228 litres, amounting in all to 1672 francs. Deducting for expenses and taxes (*contributions*) 572 francs, there remain 1,100 francs of net proceeds; and as the value of the capital may be estimated at 23,000 francs, the profit turns out to be no more than 5 per cent. The net proceeds in the growths of Beaune, Nuits, &c., does not exceed 600 francs per hectare (2·4 acres), and therefore is equivalent to only $2\frac{1}{2}$ per cent. upon the capital.

The quantity of alcohol contained in different wines, has been made the subject of elaborate experiments by Brande and Fontenelle; but as it must evidently vary with different seasons, the results can be received merely as approximative. The only apparatus required for this research, is a small still and refrigeratory, so well fitted up as to permit none of the spirituous vapors to be dissipated. The distilled liquor should be received in a glass tube, graduated into one hundred measures, of such capacity as to contain the whole of the alcohol which the given measure of wine employed is capable of yielding. In the successive experiments, the quantity of wine used, and of spirit distilled over, being the same in volume, the relative densities of the latter will show at once the relative strengths of the wines. A very neat small apparatus has been contrived for the purpose of analyzing 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 I.

W

Name of the wine.	Sp. grav.	100 measures contain at 60° F.		Name of the wine.	Sp. grav.	100 measures contain at 60° F.	
		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
Port Wine,...........	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
Madeira,..............	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
Sherry,................	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	14·35
Bordeaux, Claret,.....	0·97092	16·32	15·11	Syracuse,.............	0·98200	15·28	14·15
Calcavella,............	0·97920	18·10	16·76	Nice,..................	0·98263	14·63	13·64
Lisbon,................	0·97846	18·94	17·45	Tokay,................	0·98760	9·88	9·15
Malaga,................	0·98000	17·26	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
Marsala,...............	0·98000	17·26	15·98	Elder Wine,.. ..... }			
Champagne, [rose],....	0·98608	11·30	10·46	Cider,............... }	0·98760	9·87	9·14
Champagne, [white],..	0·98450	12·80	11·84	Perry,.............. }			
Burgundy,.............	0·98300	14·53	13·34	Brown Stout,.........	0·99116	6·80	6·30
Burgundy,.............	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 Hermitage,.......	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
Hock,..................	0·98873	8·88	8·00	Scotch Whiskey,......	—	54·32	50·20
Vin de Grave..........	0·98450	12·80	11·84	Irish Whiskey,........	—	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	Carcasonne 8 "	7·190	White do. -	7·056
Salces 10 "	8·580			Burgundy 4 "	6·195
		Department of l'He-		Grave 3 "	5·838
Department of the		*rault.*		Champagne (sparkling)	5·880
Aude.		Nissau 9 "	7·896	Do. white do.	5·145
Fitou and Leu-		Beziers 8 "	7·728	Do. rose -	4·956
caté 10 yrs. old	8·568	Montagnac 10 "	8·108	Bordeaux -	6·186
Lapalme 10 "	8·790	Mèze 10 "	7·812	Toulouse -	5·027

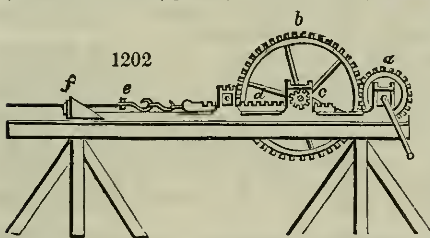
WINE, FAMILY, may be made by the following recipe:—Take black, red, white currants, ripe cherries (black hearts are the best), and raspberries, of each an equal quantity. To 4 pounds of the mixed fruit, well bruised, put 1 gallon of clear soft water; steep three days and nights, in open vessels, frequently stirring up the magma; then strain through a hair sieve; press the residuary pulp to dryness, and add its juice to the former. In each gallon of the mixed liquors dissolve 3 pounds of good yellow muscovado sugar; let the solution stand other three days and nights, frequently skimming and stirring it up; then tun it into casks, which should remain full, and purging at the bung-hole, about two weeks. Lastly, to every 9 gallons put 1 quart of good Cognac brandy (but not the drugged imitations made in London with grain whiskey), and bung down. If it does not soon become fine, a steeping of ising-glass may be stirred into the liquid, in the proportion of about half an ounce to 9 gallons. I have found that the addition of an ounce of cream of tartar to each gallon of the fermentable liquor, improves the quality of the wine, and makes it resemble more nearly the produce of the grape.

WINE-STONE is the deposite of crude tartar, called argal, which settles on the sides and bottoms of wine casks.

WIRE-DRAWING. (*Tréfilerie*, Fr.; *Draht-ziehen*, *Drahtzug*, Germ.) When an oblong lump of metal is forced through a series of progressively diminishing apertures in a steel plate, so as to assume in its cross section the form and dimensions of the last hole, and to be augmented in length at the expense of its thickness, it is said to be wire-drawn. The piece of steel called the *draw-plate* is pierced with a regular gradation of holes, from the largest to the smallest; and the machine for overcoming the lateral adhesion of the metallic particles to one another, is called the *draw-bench*. The pincers which lay hold of the extremity of the wire, to pull it through the successive holes, are adapted to bite it firmly, by having the inside of the jaws cut like a file. For drawing thick rods of gilt silver down into stout wire, the hydraulic press has been had recourse to with advantage.

Fig. 1202 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 oxyde formed in the annealing, before the wire enters the draw-plate.

1202



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 the 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. In the act of drawing, they must be well supplied with grease for the larger kinds of wire, and with wax for the smaller.

WOAD (*Vouëde, Pastel*, Fr.; *Waid*, Germ.; *Isatis tinctoria*, Linn.), the *glastum* of the ancient Gauls and Germans, is an herbaceous plant which was formerly much cultivated, as affording a permanent blue dye, but it has been in modern times well nigh superseded by *indigo*. Pliny says, "A certain plant which resembles *plantago*, called *glastum*, is employed by the women and girls in Great Britain for dyeing their bodies all over, when they assist at certain religious ceremonies; they have then the color of Ethiopians."—*Hist. Nat.* cap. xxii. § 2.

When the arts, which had perished with the Roman empire, were revived, in the middle ages, woad began to be generally used for dyeing blue, and became an object of most extensive cultivation in many countries of Europe. The environs of Toulouse and Mirepoix, in Upper Languedoc, produced annually 40,000,000 pounds of the prepared woad, or pastel, of which 200,000 bales were consumed at Bordeaux. Beruni, a rich manufacturer of this drug, became surety for the payment of the ransom of his king, Francis I., then the prisoner of Charles V. in Spain.

The leaves of woad are fermented in heaps, to destroy certain vegetable principles injurious to the beauty of the dye, as also to elaborate the indigoferous matter present, before they are brought into the market; but they should be carefully watched during this process. Whenever the leaves have arrived at maturity, a point judged of very differently in different countries, they are stripped off the plant, a cropping which is repeated as often as they shoot, being three or four times in Germany, and eight or ten times in Italy. The leaves are dried as quickly as possible, but not so much as to become black; and they are ground before they get quite dry. The resulting paste is laid upon a sloping pavement, with gutters for conducting the juice, which exudes into a tank; the heap being tramped from time to time, to promote the discharge of the juice. The woad ferments, swells, and cracks in many places, which fissures must be closed; the whole being occasionally watered. The fermentation is continued for twenty or thirty days, in cold weather; and if the leaves have been gathered dry, as in Italy, for four months. When the fermented heap has become moderately dry, it is ground again, and put up in cakes of from one to three pounds; which are then fully dried, and packed up in bundles for the market. Many dyers subject the pastel to a second fermentation.

1,600 square toises (fathoms) of land afford in two cuttings at least 19,000 pounds of leaves, of which weight four fifths are lost in the fermentation, leaving 3,880 pounds of pastel, in loaves or cakes. When good, it has rather a yellow, or greenish-yellow, than a blue color; it is light, and slightly humid; it gives to paper a pale-green trace; and improves by age, in consequence of an obscure fermentation; for if kept four years, it dyes twice as much as after two years. According to Hellot, 4 pounds of Guatimala indigo produce the same effect as 210 pounds of the pastel of Albi. At Quins, in Piedmont, the dyers estimate that 6 pounds of indigo are equivalent to 300 of pastel; but Chaptal thinks the indigo underrated.

Pastel will dye blue of itself, but it is commonly employed as a fermentative addition to the proper blue vat, as described under Indigo.

Fresh woad, analyzed by Chevreul, afforded, in 100 parts, 65·4 of juice. After being steeped in water, the remaining mass yielded, on expression, 29·65 of liquid; being in whole, 95·05 parts, leaving 4·95 of ligneous fibre. The juice, by filtration, gave 1·95 of green fecula. 100 parts of fresh woad, when dried, are reduced to 13·76 parts. Alcohol, boiled upon dry woad, deposites, after cooling, indigo in microscopic needles; but these cannot be separated from the vegetable albumine, which retains a greenish-gray color.

WOLFRAM is the native tungstate of iron and manganese, a mineral which occurs in primitive formations, along with the ores of tin, antimony, and lead, in the Bohemian Erzegebirge, in Cornwall, Switzerland, North America, &c. It is used by chemists for obtaining tungstic acid and tungsten.

WOOD (*Bois*, Fr.; *Holz*, Germ.), is the hard but porous tissue between the pith and the bark of trees and shrubs, through which the chief part of the juices is conducted from the root towards the branches and leaves, during the life of the vegetable. The ligneous fibre is the substance which remains, after the plant has been subjected to the solvent action of ether, alcohol, water, dilute acids, and caustic alkaline leys. It is considered by chemists that dry timber consists, on an average, of 96 parts of fibrous, and 4 of soluble matter, in 100; but that these proportions vary somewhat with the seasons, the soil, and the plant. All kinds of wood sink in water, when placed in a basin of it under the exhausted receiver of an air-pump; showing their specific gravity to be greater than 1·000. That of fir and maple is stated, by chemical authors, to be 1·46; and that of oak and beech, at 1·53; but I believe them to have all the same spec. grav. as the fibre of flax; namely, 1·50, as determined by me some years ago.*

Wood becomes snow-white, when exposed to the action of chlorine; digested with sulphuric acid, it is transformed first into gum, and, by ebullition with water, afterwards into grape-sugar; with concentrated nitric acid, it grows yellow, loses its coherence, falls into a pulverulent mass, but eventually dissolves, and is converted into oxalic acid; with strong caustic alkaline leys, in a hot state, it swells up excessively, dissolves into a homogeneous liquid, and changes into a blackish-brown mass, containing oxalic and acetic acids.

The composition of wood has been examined by Gay Lussac and Thenard, and Dr. Prout. The first two chemists found it to consist, in 100 parts, of—

	Oak.	Beech.
Carbon - - - -	52·53	51·45
Hydrogen - - -	5·69	5·82
Oxygen - - - -	41·78	42·73

According to Dr. Prout, the oxygen and hydrogen are in the exact proportions to form water. Willow contains 50, and box 49·8 per cent. of carbon; each containing, therefore, very nearly 44·444 of oxygen, and 5·555 of hydrogen. In the analyses of Gay Lussac and Thenard, there is a great excess of hydrogen above what the oxygen requires to form water. Authenrieth stated, some years ago, that he found that fine sawdust, mixed with a sufficient quantity of wheat flour, made a coherent dough with water, which formed an excellent food for pigs; apparently showing that the digestive organs of this animal could operate the same sort of change upon wood as sulphuric acid does.

Table of the Distillation of One Pound of Wood, dried, at 86° Fahr.

Name of the wood.	Weight of wood acid.	One ounce of the acid saturates of carbonate of potash.	Weight of the combustible oil.	Weight of the charcoal.
	Ounces.	*Grains.*	*Ounces.*	*Ounces.*
White birch - - - -	7	44	1¼	3¾
Red beech - - -	7	44	1½	3¾
Prick wood (spindle tree) -	7½	40	1¾	3½
Large leaved linden - -	6¾	41	2	3¾
Red or scarlet oak - -	7	40	1½	4¼
White beech - - -	6½	40	1¾	3¾
Common ash - - -	7½	34	1½	3½
Horse chestnut - - -	7½	31	1½	3½
Italian poplar - - -	7¼	30	1½	3¾
Silver poplar - - -	7¼	30	1¼	3¾
White willow - - -	7¼	28	1½	3½
Root of the sassafras laurel	6¾	29	1¾	4¼
Wild service tree - - -	7	28	1¾	3½
Basket willow - - -	8	27	1½	3½
Dogberry tree - - -	7	27	2	3½
Buckthorn - - -	7½	26	1½	3½
Logwood - - - - -	7¾	26	1½	4
Alder - - - - -	7¼	22	1½	3½
Juniper - - - - -	7¼	23	1¾	3½
White fir (deal) - -	6½	23	2¼	3½
Common pine wood - -	6¾	22	1¾	3½
Savine tree - - -	7	20	1¾	3¾
Red deal (pine) - - -	6	18	2¼	3¾
Guiac wood - - - - -	6	16	2½	4

* "From the small difference found by experiment between the specific gravity of flax (1·50) and of cotton (1·47), I am inclined to think that the density of both may be considered to be equal," or 1·50.—*Philosophy of Manufactures*, 2d edition, pp. 97, 98, 99.

WOOF is the same as WEFT.

WOOLLEN MANUFACTURE. In reference to textile fabrics, sheep's wool is of two different sorts, the short and the long stapled; each of which requires different modes of manufacture in the preparation and spinning processes, as also in the treatment of the cloth after it is woven, to fit it for the market. Each of these is, moreover, distinguished in commerce by the names of fleece wools and dead wools, according as they have been shorn at the usual annual period from the living animal, or are cut from its skin after death. The latter are comparatively harsh, weak, and incapable of imbibing the dyeing principles, more especially if the sheep has died of some malignant distemper. The annular pores, leading into the tubular cavities of the filaments, seem, in this case, to have shrunk and become obstructed. The time of year for sheep-shearing most favorable 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 the 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 broadcloth is made should be not only shorter, but, generally speaking, finer and softer than the worsted wools, in order to fit them for the fulling process. Some wool-sorters and wool-staplers acquire by practice great nicety of discernment in judging of wools by the touch and traction of the fingers. Two years ago, I made a series of observations upon different wools, and published the results. The filaments of the finer qualities varied in thickness from $\frac{1}{1100}$ 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. See *Philosophy of Manufactures*, gs. 11, 12, page 91, second edition.

There are four distinct qualities of wool upon every sheep; the finest being upon the spine, from the neck to within 6 inches of the tail, including one third of the breadth of the back; the second covers the flanks between the thighs and the shoulders; the third clothes the neck and the rump; and the fourth extends upon the lower part of the neck and breast down to the feet, as also upon a part of the shoulders and the thighs, to the bottom of the hind quarter. These should be torn asunder, and sorted, immediately after the shearing.

The harshness of wools is dependant not solely upon the breed of the animal, or the climate, but is owing to certain peculiarities in the pasture, derived from the soil. It is known, that in sheep fed upon chalky districts, wool is apt to get coarse; but in those upon a rich loamy soil, it becomes soft and silky. The ardent sun of Spain renders the fleece of the Merino breed harsher than it is in the milder climate of Saxony. Smearing sheep with a mixture of tar and butter is deemed favorable 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 favorable 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. England grows annually about 1,000,000 packs of wool, and imports 100,000 bags.

Wool imported into the United Kingdom, in 1836, 64,239,977 lbs.; in 1837, 48,356,121 lbs. Retained for home consumption, in 1836, 60,724,795 lbs.; in 1837, 43,148,297 lbs. Duty received, in 1836, £190,075; in 1837, £118,519.

Having premised these general observations on wool, I shall now proceed to treat of its manufacture, beginning with that of wool-combing, or

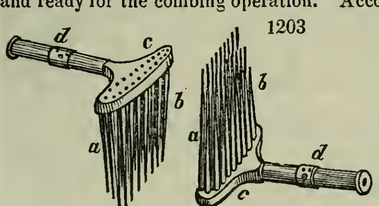
THE WORSTED MANUFACTURE.

In this branch of business, a long stapled and firm fibre is required to form a smooth level yarn, little liable to shrink, curl, or felt in weaving and finishing the cloth. It must not be entangled by carding, but stretched in lines as parallel as possible, by a suitable system of *combing*, manual or mechanical.

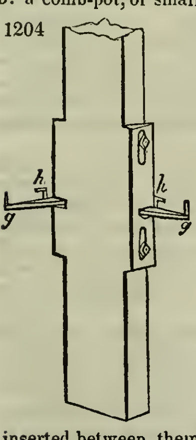
When the long wool is brought into the worsted factory, it is first of all washed by men with soap and water, who are paid for their labor by the piece, and are each assisted by a boy, who receives the wool as it issues from between the drying *squeezers*, (see BLEACHING.) The boy carries off the wool in baskets, and spreads it evenly upon the floor of the drying-room, usually an apartment over the boilers of the steam-engine, which is thus economically heated to the proper temperature. The health of the boys employed in this business is found to be not at all injured.

The wool, when properly dried, is transferred to a machine called the *plucker*, which is always superintended by a boy of 12 or 14 years of age, being very light work. He lays the tresses of wool pretty evenly upon the feed-apron, or table covered with an endless moving web of canvass, 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 labor 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.* 1203, disposed in two or three parallel planes, each row being a little longer than the preceding. They are made fast at the roots to a wooden stock or head *c*, which is covered with horn, and has a handle *d*, fixed into it at right angles to the lines of the teeth. The spaces between these two or three planes of teeth, is about one third of an inch at their bottoms, but somewhat more at their tips. The first combing, when the fibres are most entangled, is performed with the two-row toothed combs; the second, or finishing combing, with the three-row toothed.

1203



1204



In the workshop a post is planted (*fig.* 1204), upright, for resting the combs occasionally upon, during the operation. An iron stem g, projects from it horizontally, having its end turned up, so as to pass through a hole in the handle of the comb. Near its point of insertion into the post, there is another staple point *h*, which enters into the hollow end of the handle; which, between these two catches, is firmly secured to the post. The stove is a very simple affair, consisting merely of a flat iron plate, heated by fire or steam, and surmounted with a similar plate, at an interval sufficient to allow the teeth to be inserted between them at one side, which is left open, while the space between their edges, on the other sides, is closed to confine the heat.

In combing the wool, the workman takes it up in tresses of about four ounces each, sprinkles it with oil, and rolls it about in his hands, to render all the filaments equally unctuous. Some harsh dry wools require one sixteenth their weight of oil, others no more than a fortieth. He next attaches a heated comb to the post, with its teeth pointed upwards, seizes one half of the tress of wool in his hands, throws it over the teeth, then draws it through them, and thus repeatedly, leaving a few straight filaments each time upon the comb. When the comb has in this way collected all the wool, it is placed with its points inserted into the cell of the stove, with the wool hanging down outside, exposed to the influence of the heat. The other comb, just removed in a heated state from the stove, is planted upon the post, and furnished in its turn with the remaining two-ounce tress of wool; after which it supplants the preceding at the stove. Having both combs now hot, he holds one of them with his left hand over his knee, being seated upon a low stool, and seizing the other with his right hand, he combs the wool upon the first, by introducing the teeth of one comb into the wool stuck in the other, and drawing them through it. This manipulation is 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 manufacture.

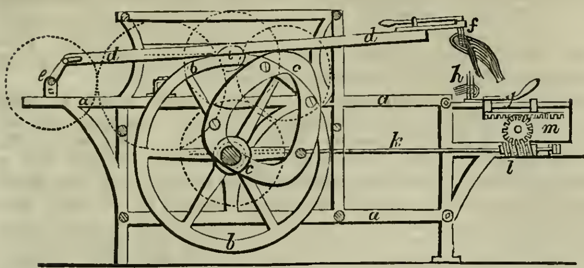
The wool finally drawn off from the comb, though it may form a uniform tress of straight filaments, must yet be combed again at a somewhat lower temperature, to prepare it perfectly for the spinning operation. From ten to twelve slivers are then arranged in one parcel.

To relieve the workman from this laborious and not very salubrious task, has been the object of many mechanical inventions. One of these, considerably employed in this country and in France, is the invention of the late Mr. John Collier, of Paris, for which a patent was obtained in England, under the name of John Platt, of Salford, in November, 1827. It consists of two comb-wheels, about ten feet in diameter, having hollow iron spokes filled with steam, in order to keep the whole apparatus at a proper combing heat. The comb forms a circle, made fast to the periphery of the wheel, the teeth being at right angles to the plane of the wheel. The shafts of the two wheels are mounted in a strong frame of cast iron; not, however, in horizontal positions, but inclined at acute angles to the horizon, and in planes crossing each other, so that the teeth of one circular comb sweep with a steady obliquity over the teeth of the other, in a most ingenious manner, with the effect of combing the tresses of wool hung upon them. The proper quantity of long wool, in its ordinary state, is stuck in handfuls upon the wheel, revolving slowly, by a boy, seated upon the ground at one side of the machine. Whenever the wheel is dressed, the machine is made to revolve more rapidly, by shifting its driving-band on another pulley; and it is beautiful to observe the delicacy and precision with which it smooths the tangled tress. When the wools are set in rapid rotation, the loose ends of the fleece, by the centrifugal force, are thrown out, in the direction of radii, upon the teeth of the other revolving comb-wheel, so as to be drawn out and made truly straight. The operation commences upon the tips of the tresses, where the wheels, by the oblique posture of their shafts, are at the greatest distance apart; but as the planes slowly approach to parallelism, the teeth enter more deeply into the wool, till they progressively comb the whole length of its fibres. The machines being then thrown out of gear, the teeth are stripped of the tresses by the hand of the attendant; the *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 labor of children a substitute for the high-priced and often refractory exertions of workmen too prone to capricious combinations. The chief precaution to be taken with this machine, is to keep the steam-joints tight, so as not to wet the apartments, and to provide due ventilation for the operatives.

The following machine, patented by James Noble, of Halifax, worsted-spinner, in February, 1834, deserves particular notice, as its mode of operation adapts it well also for heckling flax. In *fig.* 1205 the internal structure is exhibited. The frame-work *a*, *a*, supports the axle of a wheel, *b*, *b*, in suitable bearings on each side. To the face of this wheel is affixed the eccentric or heart-wheel cam *c*, *c*. On the upper part of the periphery of this cam or heart-wheel, a lever *d*, *d*, bears merely by its gravity; one end of which lever is connected by a joint to the crank *e*. By the rotation of the crank *e*, it will be perceived that the lever *d*, will be slidden to and fro on the upper part of the periphery of the eccentric or heart-wheel cam *c*, the outer end of the lever *d*, carrying the upper or working comb or needle-points *f*, as it moves, performing an elliptical curve, which curve will be dependant upon the position of the heart-wheel cam *c*, that guides it. A moveable 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.

1205



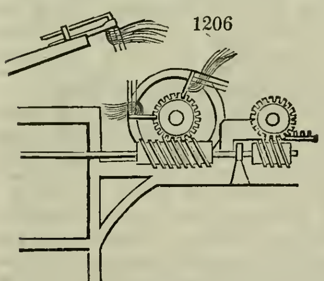
As it is important, in order to prevent waste, that the ends of the wool should be first combed out, and that the needle-points should be made to penetrate the wool progressively, the moveable frame *g*, is in the first instance placed as far back as possible; and the action of the lever *d*, during the whole operation, is so directed by the varying positions of the cam-wheel, as to allow the upper comb to enter at first a very little way only into the wool; but as the operation of combing goes on, the frame with the lower combs is made to advance gradually, and the relative positions of the revolving heart cam-wheel *c*, being also gradually changed, the upper or working needles are at length allowed to be drawn completely through the wool, for the purpose of combing out straight the whole length of its fibre.

In order to give to the machine the necessary movements, a train of toothed wheels and pinions is mounted, mostly on studs attached to the side of the frame; which train of wheels and pinions is shown by dots in the figure, to avoid confusion. The driving power, a horse or steam-engine, is communicated by a band to a rigger on the short axle *i;* which axle carries a pinion, taking into one of the wheels of the train. From this wheel the crank *e*, that works the lever *d*, is driven; and also by gear from the same pinion, the axle of the wheel *b*, carrying the eccentric or heart-wheel cam, is also actuated, but slower than the crank-axle.

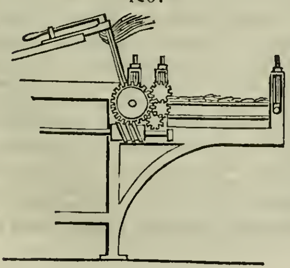
At the end of the axle of the wheel *b*, and cam *c*, a bevel pinion is affixed, which gears into a corresponding bevel pinion on the end of the lateral shaft *k*. The reverse end of this shaft has a worm or endless screw *l*, taking into a toothed wheel *m;* and this last-mentioned toothed wheel gears into a rack at the under part of the frame *g*.

It will hence be perceived, that by the movements of the train of wheels, a slow motion is given to the frame *g*, by which the lower needles carrying the wool are progressively advanced as the operation goes on; and also, that by the other wheels of the train, the heart-wheel cam is made to rotate, for the purpose of giving such varying directions to the stroke of the lever which slides upon its periphery, and to the working comb, as shall cause the comb to operate gradually upon the wool as it is brought forward. The construction of the frames which hold the needles, and the manner of fixing them in the machine, present no features of importance; it is therefore unnecessary to describe them farther, than to say, that the heckles are to be heated when used for combing wool. Instead of introducing the wool to be combed into the lower needles by hand, it is sometimes fed in, by means of an endless feeding-cloth, as shown in *fig.* 1206. 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.

1206



1207



A slight variation in the machine is shown at *fig.* 1207, 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 moveable 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*. The slivers are rolled up by the combers ten or twelve together, in balls called tops, each of which weighs half a pound. At the spinning-mill these are unrolled, and the slivers are laid on a long plank or trough, with the ends lapping over, in order to splice the long end of one sliver into the short end of another. The long end is that which was drawn off first from the comb, and contains the longer fibres; the short is that which comes last from the comb, and contains the shorter. The wool-comber lays all the slivers of each ball the same way, and marks the long end of each by twisting up the end of the sliver. It is a curious circumstance, that when a top or ball of slivers is unrolled and stretched out straight, they will not separate from each other without tearing and breaking, if the separation is begun at the short ends; but if they are first parted at the long ends, they will readily separate.

The machine for combing long wool, for which Messrs. Donisthorpe and Rawson obtained a patent in April, 1835, has been found to work well, and therefore merits a detailed description:—

1208

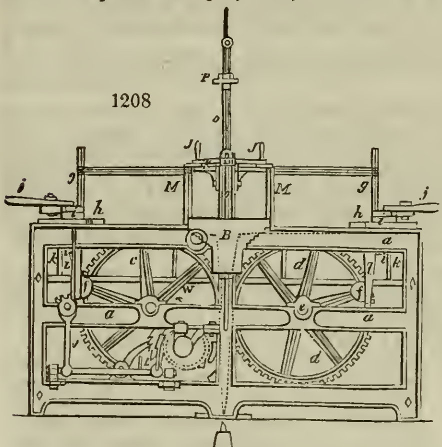
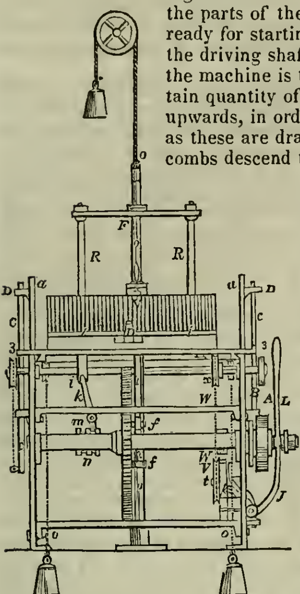


Fig. 1208, is an elevation; *fig.* 1209 an end view; and *fig.* 1210 a plan; in which *a*, *a*, is the framing; *b*, the main shaft, bearing a pinion which drives the wheel and shaft *c*, in gear with the wheel *d*, on the shaft *e*. Upon each of the wheels *c* and *d*, there are two projections or studs *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 groove *n*, made fast to the shaft *e*. The tables *h*, are drawn inwards, by weights suspended on cords or straps *o*, *o*, which pass over friction pulleys *p*, *p*; whereby the weights have a constant tendency to draw the combs into the centre of the machine, as soon as it is released by the studs *f*, passing beyond the projecting arms g, on the tables. On the shaft *c*, a driving-tooth or catch *r*, is fixed, which takes into the ratchet wheel *s*, and propels one of its teeth at every revolution of the shaft *c*. This ratchet wheel turns on an axis at *t*; to the ratchet the pulley *v* is made fast, to which the cord or band *w* is secured, as also to the pulley *x*, on the shaft *y*. On the shaft *y*, there are two other pulleys *z*, *z*, having the cords or bands 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.

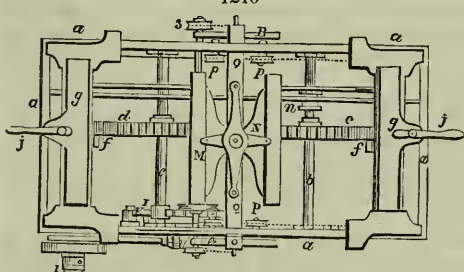
To the ratchet wheel *s*, an inclined projection E, is made fast, which in the course of the rotation of the ratchet wheel, comes under the lever F, fixed to the shaft G, that turns in bearings H. To this shaft the levers I and J, are also fixed; I serving to throw out the click or catch K, from the 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 combing a certain quantity of wool. The combs which hold the wool have a motion upwards, in order to take the wool out of the way of the combs *g*, *g*, as these are drawn into the centre of the machine; while the holding combs descend to lay the wool among the points of the combs *g*, *g*. For obtaining this upward and downward motion, the combs M, M, are placed upon the frame 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 the top of which, there is a strap passes over pulleys with a weight suspended to it; the cross-head being supported by the two guide-rods 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.

1209



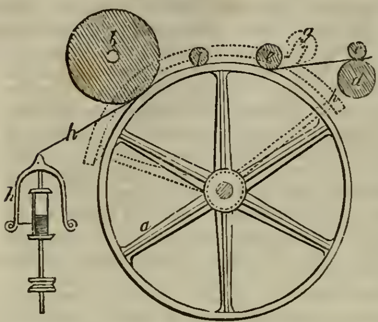
A quantity of wool is to be placed on each of the combs *g*, *g*, and M, M, the machine being in the position shown in *fig.* 1210. When the main shaft *b*, is set in motion, it will drive by its pinion the toothed wheel *c*, and therefrom the remaining parts of the machine. The first effect of the movement will be to raise the combs M, M, sufficiently high to remove the wood 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 H, H, 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.

1210



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 moveable 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 hollowed 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.

1211



These objects may be effected in several ways; that is, the machinery may be variously constructed, and still embrace the principles proposed. *Fig.* 1211, 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 flier *h*, where it becomes twisted or spun into a worsted thread.

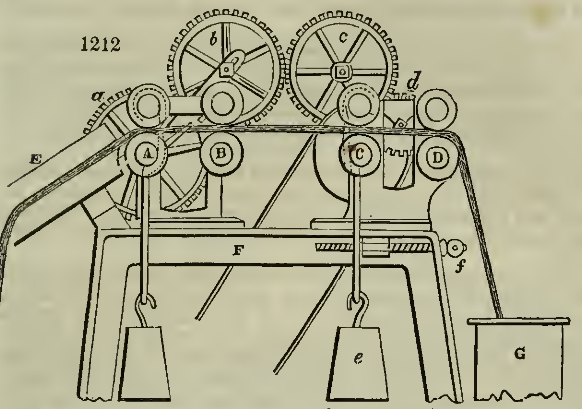
In order to increase or diminish the extent to which the fibres of wool are spread over the periphery of the wheel *a*, a regulating roller is adapted to the machine, as shown at *g*, in place of the tension roller *f*. This regulating roller *g*, is mounted by its pivots in bearings on the circular 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 the wool, the wheel *a*, is formed as a hollow drum, and steam from a boiler, in any convenient situation, is conveyed through the hollow axle to the interior of the drum, which, becoming heated by that means, communicates heat also to the wool, and thereby destroys its curl and elasticity.

Breaking-frame.—Here the slivers are *planked*, or spliced together, the long end of one to the short end of another; after which they are drawn out and extended by the rollers of the breaking-frame. A sketch of this machine is given in *fig.* 1212. It consists of 4 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 upon the axis of the roller A, and turned by the intermediate cog-wheels *b*, *c*, and *d*; the latter communicates between the rollers C and D. The pinions on the rollers C and D being only one third the size of the wheel *a*, C and D turn three times as fast as A, for *b*, *c*, and *d*, are only intermediate wheels. The rollers B turn at the same rate as A. The upper roller *e* is loaded with a heavy weight, similar to the rollers A; but the other rollers, B and D, are no further loaded than the weight of the rollers.

1212



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 moveable on centres; the centre for the piece which supports the wheel *b* is concentric with the axis of the roller A; and the supporting piece for the wheel *c* is fitted on the centre of the wheel *d*. By moving these pieces the intermediate wheels *b* and *c* can be always kept in contact, although the distance between the rollers is varied at times. By means of this breaking-frame, the perpetual sliver, which is made up by planking the sliver together, is equalized, and drawn out three times in length, and delivered into the can G.

Drawing-frame.—Three of these cans are removed to the drawing-frame, which is similar to the breaking-frame, except that there is no planking-table 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 $10\frac{1}{2}$ times as fast as A. In this case, the motion is given to the different rollers by means of bevelled wheels, and a horizontal axis, which extends across the ends of all the four rollers, to communicate motion from one pair of rollers to another.

There are three of these systems of rollers, which are all mounted on the same frame; and the first one through which the wool passes, is called the breaking-frame;

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 flier. 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.

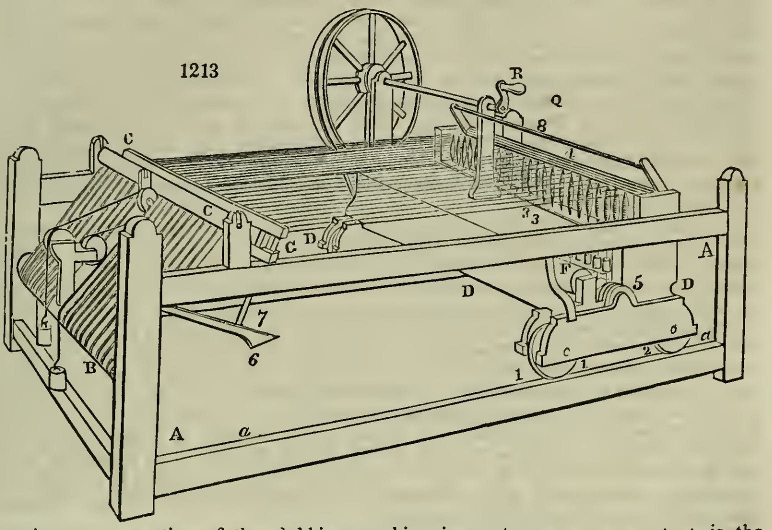
This denomination is different from that used for cotton, because the hank of cotton contains 840 yards, instead of 560; but in some places the worsted hank is made of the same length as the cotton.

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.* 1213 is a per-

1213



spective representation of the slubbing machine in most common use. A, A, is the wooden frame; within which is the moveable 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 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 moveable upper one being raised to let any aliquot portion of the roll pass freely. When this bar is again let down, it pinches the spongy carding fast; whence this mechanism is called the clasp. It is in fact the *clove*, originally used by Hargreaves in his cotton-jenny. The moveable 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 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, becomes 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 length; the one set, long, thin, and delicate, representing the points of the thistle; the other, shorter, stiffer, and blunter, being intended to stay the cloth, and to hinder the former from entering too far into it. But none of these processes have succeeded in discarding the natural teasel from the most eminent manufactories.

The French government purchased, in 1807, the patent of Douglas, an English mechanist, who had, in 1802, imported into France the best system of gig-mills then used in the west of England. A working set of his machines having been placed in the *Conservatoire des Arts*, for public inspection, they were soon introduced into most of the French establishments, so as generally to supersede teasling (*lainage*) by hand. A description of them was published in the third volume of the *Brevets d'Invention.* The following is an outline of some subsequent improvements :—

1. As it was imagined that the seesaw action of the hand operative was in some respects more effectual than the uniform rotation of a gig-mill, this was attempted to be imitated by an alternating movement.

* See this admirable machine fully described and delineated in my *Cotton Manufacture of Great Britain*, vol. ii.

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 rectilinear 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 corkscrew 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.

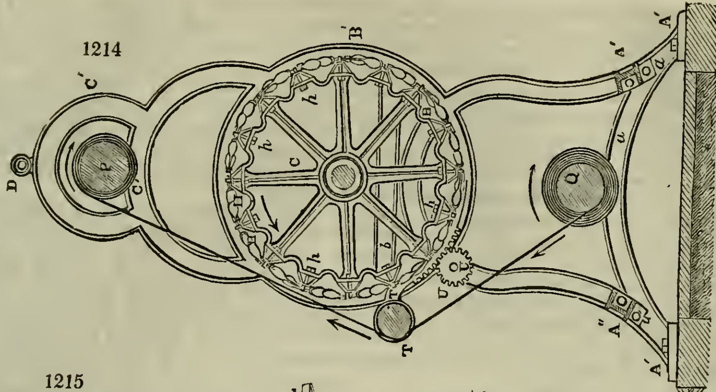
4. Others fancied that it would be beneficial to support the reverse side of the cloth by flat hard surfaces, while acting upon its face with cards, or teasels. Mr. Joseph Cliseld Daniell, having stretched the cloth upon smooth level stones, teasels them by hand. 5. Messrs. Charlesworth and Mellor obtained 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., 2d 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.

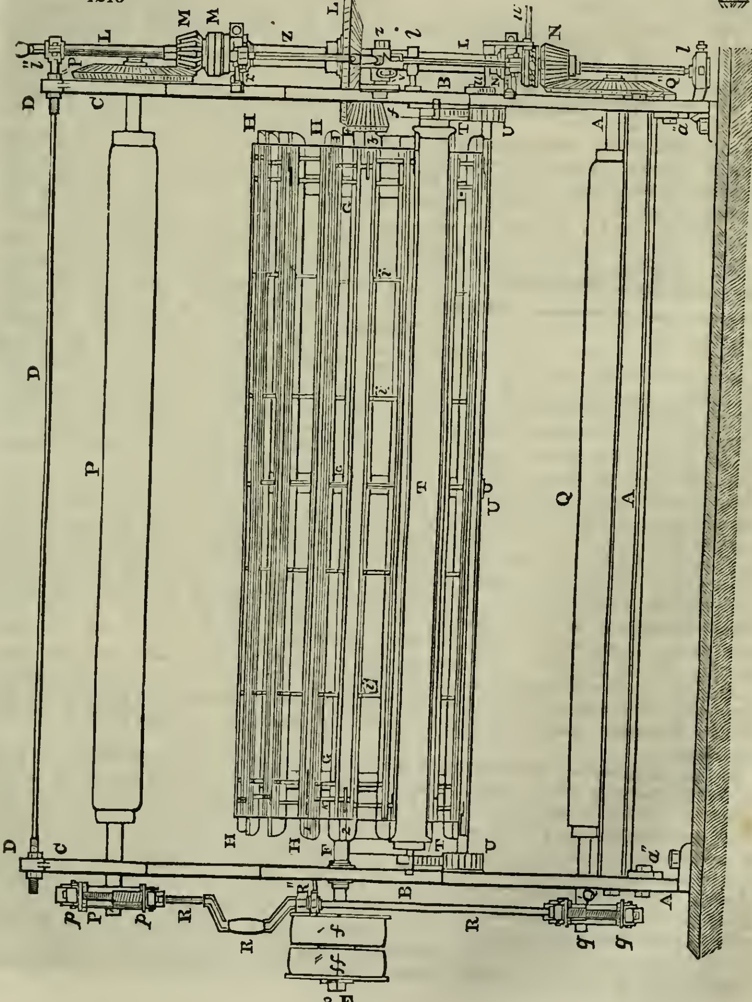
In the fulling-mill, the woollen web acquires body and thickness, at the expense of its other dimensions; for being thereby reduced about one third in length, and one half in breadth, its surface is diminished to one third of its size as it comes out of the loom; and it has, of course, increased threefold 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 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. 1214, 1215, 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 the wrought-iron stretcher-rod 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.* 1215), 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.* 1214, are, as usual, keyed by a wedge to the shaft F. Their contour is a sinuous

1214



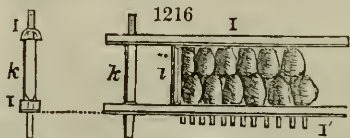
1215



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.* 1214. 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.* 1214, but rounded off at the end, *fig.* 1215, 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 would coincide with that of the shaft F.

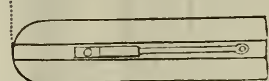
Between the 16 sides there are 16 intervals, which correspond to the 16 hollowings of each of the wheels. Into these intervals are adjusted, with proper precautions, 16 frames bearing the teasels which are to act upon the cloth. These are fitted in as follows:—Each has the shape of a rectangle, of a 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.* 1214.) A portion of the frame is represented in *fig.* 1216. 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.* 1214); 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.* 1217, 1218), 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.* 1215 (near the right end of the shaft F), shows the place of the clamp, *figs.* 1217, 1218. 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.

1216



1217

1218



The cloth is wound upon the lower beam Q, *fig.* 1214; 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, dependant 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.* 1215, 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, 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.* 1214), 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.* 1214, 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.* 1214), 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.* 1215), 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.

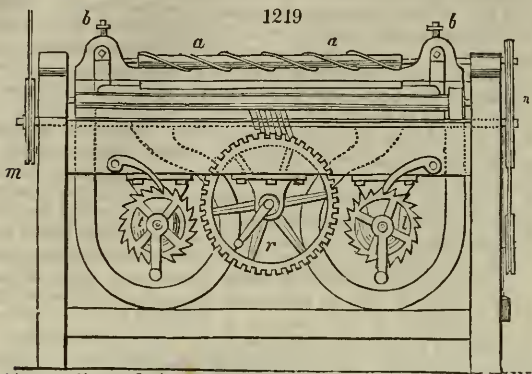
CLOTH CROPPING.

Of machines for cropping or shearing woollen cloths, those of Lewis and Davis have been very generally used.

Fig. 1219 is an end view, and *fig.* 1220 is a side view, of Lewis's machine for shearing cloth from list to list. *Fig.* 1221 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.* 1219, and, being hardened, is intended to constitute one edge of the shear or cutter.

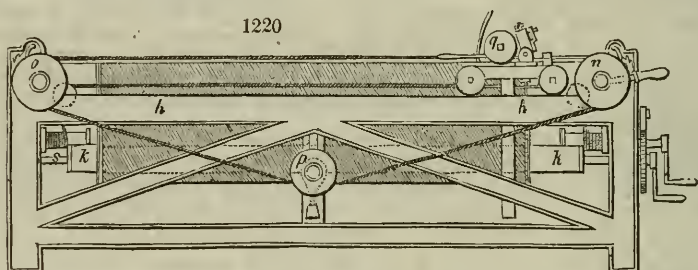
The axis of the cylindrical cutter *a*, turns in the frame *b*, which, having proper adjustments, is mounted upon pivots *c*, in the standard of the travelling carriage *d*, *d*; and *e*, is the fixed or ledger blade, attached to a bar *f*, which constitutes the other edge of the cutter; that is, the stationary blade, against which the edges of the rotatory cutter act; *f* and *g*, are flat springs, intended to keep the cloth (shown by dots) up against the cutting edges. The form of these flat springs *f*, *g*, is shown at *figs*. 1222 and 1223, as consisting of plates of thin metal cut into narrow slips (*fig.* 1222), or perforated with long holes, (*fig.* 1223.) Their object is to support the cloth, which is intended to pass between them, and operate as a spring bed, bearing the surface of the cloth against the cutters, so that its pile or nap may be cropped off or shorn as the carriage *d* is drawn along the top rails of the standard or frame of the machine *h*, *h*, by means of cords.

1219

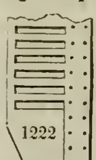


The piece of cloth to be shorn, is wound upon the beam *k*, and its end is then conducted through the machine, between the flat springs *f* and *g* (as shown in *fig.* 1221), to the other beam *l*, and is then made fast; the sides or lists of the cloth being held and stretched by small hooks, called habiting hooks. The cloth being thus placed in the machine, and drawn tight, is held dis-

1220

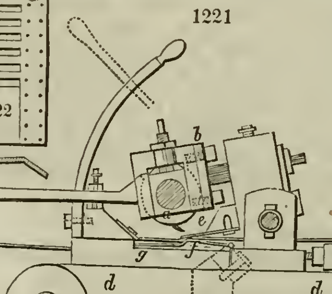


tended by means of ratchets on the ends of the beams *k* and *l*, and palls. In commencing the operation of shearing, the carriage *d*, must be brought back, as in *fig.* 1221, so that the cutters shall be close to the list; the frame of the cutters is raised up on its pivots as it recedes, in order 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.

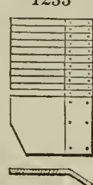


1222

1221



1233

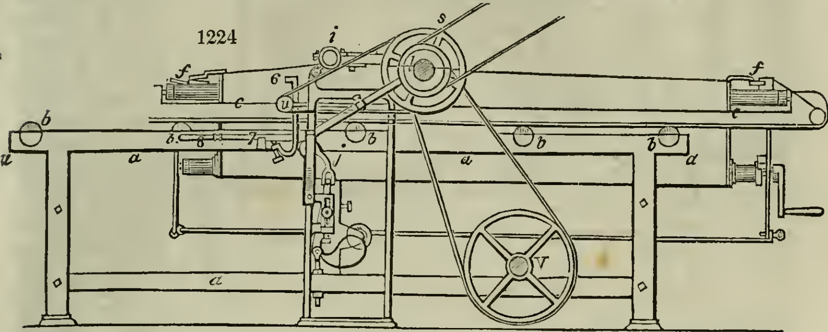


Upon the cutting cylinder, between the spiral blades, it is proposed to place stripes of plush, to answer the purpose of brushes, to raise the nap or pile as the cylinder goes around, and thereby assist in bringing the points of the wool up to the cutters.

The same contrivance is adapted to a machine for shearing the cloth lengthwise.

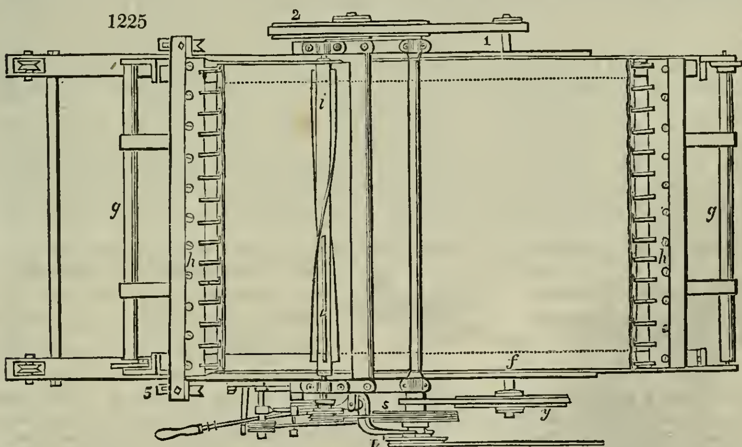
Fig. 1224, is a geometrical elevation of one side of Mr. Davis's machine. *Fig.* 1225, a plan or horizontal representation of the same, as seen in the top; and *fig.* 1226, a section taken vertically across the machine near the middle, for the purpose of displaying the working parts more perfectly than 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.

1224



there is a series of axles carrying anti-friction wheels *b, b, b,* upon which the side-rails *c, c,* of the carriage or frame that bears the cloth runs, when it is passing under the cutters in the operation of shearing. The side-rails *c, c,* are straight bars of iron, formed with edges *v,* on their under sides, which run smoothly in the grooves of the rollers *b, b, b.* These side-rails are firmly held together by the end stretchers *d, d.*

1225

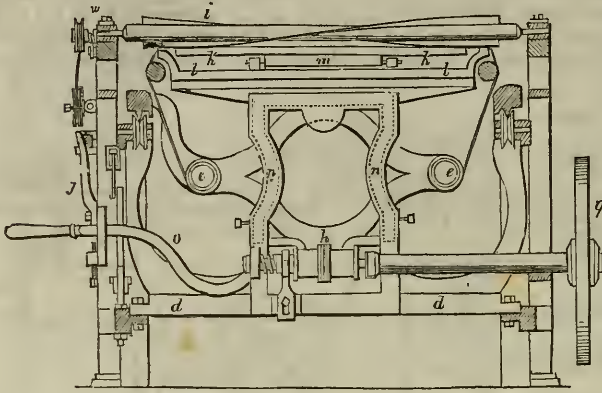


The sliding frame has attached to it the two lower rollers *e, e,* upon which the cloth intended to be shorn is wound; the two upper lateral rollers *f, f,* over which the cloth is conducted and held up; and the two end rollers *g, g,* by which the habiting rails *h, h,* are drawn tight.

In preparing to shear a piece of cloth, the whole length of the piece is, in the first place, tightly rolled upon one of the lower rollers *e,* which must be something longer than the breadth of the cloth from list to list. The end of the piece is then raised, and passed over the top of the lateral rollers *f, f,* whence it is carried down to the other roller *e,* and its end or farral is made fast to that roller. The 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 top standard rails by hand, so that the list shall be brought nearly up to the cutter *i*, *i*, ready to commence the shearing operation; the bed is then raised, which brings the cloth up against the edges of the shears.

The construction of the bed will be seen by reference to the cross section, *fig.* 1226. 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*, 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.

1226

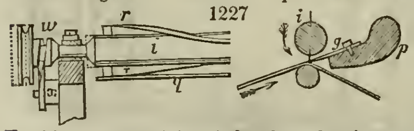


In order to allow the bed *k* to rise and fall, for the purpose of bringing the cloth up to the cutters to be shorn, or lowering it away from them after the operation, the frame *l*, *l*, is made to slide up and down in the grooved standard *n*, *n*, the moveable part enclosed within the standard being 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 raised or lowered, and when so raised, be held up by a spring catch *j*.

It being now explained by what means the bed which supports the cloth is constructed, and brought up, so as to keep the cloth in close contact with the cutters, while the operation of shearing is going on; it is necessary in the next place to describe the construction of the cutters, and their mode of working; for which purpose, in addition to what is shown in the first three figures, the cutters are also represented detached, and upon a larger scale, in *fig.* 1227.

In this figure is exhibited a portion of the cutters in the same situation as in *fig.* 1221; 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.* 1220. 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.

1227



The cutter or upper blade of the shears is formed by inserting two or more strips of plate steel *r*, *r*, in twisted directions, into grooves in the metallic cylinder *i*, *i*, the edges of which blades *r*, as the cylinder *i* revolves, traverse along the edge of the fixed or ledger blade *g*, and by their obliquity produce a cutting action like shears; the edges of the two blades taking hold of the pile or raised nap, as the cloth passes under it, shaves off the superfluous ends of the wool, and leaves the face smooth.

Rotatory motion is given to the cutting cylinder *i*, by means of a band leading from the wheel *s*, which passes round the pulley fixed on the end of the cylinder *i*, the wheel *s* being driven by a band leading from the rotatory part of a steam-engine, or any other first mover, and passed round the rigger *t*, fixed on the axle *s*. Tension is given to this band by a tightening pulley *u*, mounted on an adjustable sliding-piece *v*, which is secured to the standard by a screw; and this rigger is thrown in and out of gear by a clutch-box and lever, which sets the machine going, or stops it.

In order to give a drawing stroke to the cutter, which will cause the piece of cloth to be shorn off with better effect, the upper cutter has a slight lateral action, produced by the axle of the cutting cylinder being made sufficiently long to allow of its sliding laterally about an inch in its bearings; which sliding is effected by a cam *w*, fixed at one end. This cam is formed by an oblique groove, cut round the axle (see *w*, *fig.* 1227), 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.

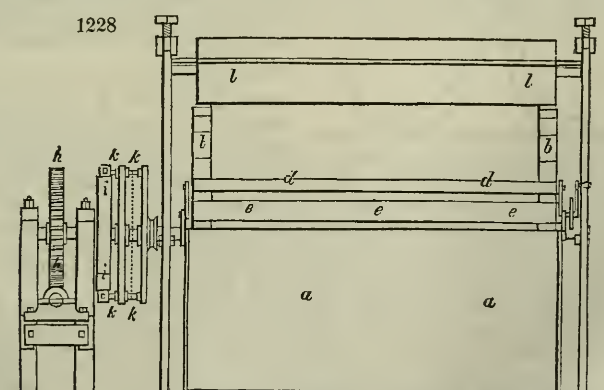
The manner of passing the cloth progressively under the cutters is as follows:—On the axle of the wheel *s*, and immediately behind that wheel, there is a small rigger, from which a band passes to a wheel *y*, mounted in an axle turning in bearings on the lower side-rail of the standard *a*. At the reverse 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.* 1226. Upon this axle there is a sliding pulley 4, round which a cord is passed several times, whose extremities are made fast to the ends of the sliding carriage *d*; when, therefore, this pulley is locked to the axle, which is done by a clutch box, the previously described movements of the machine cause the pulley 4 to revolve, and by means of the rope passed round it, to draw the frame, with the cloth, slowly and progressively along under the cutters.

It remains only to point out the contrivance whereby the machinery throws itself out of gear, and stops its operations, when the edge of the cloth or list arrives at the cutters. At the end of one of the habiting rails *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 over-heating them, which weakens the fibre of the wool, and also changes some colors, 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.

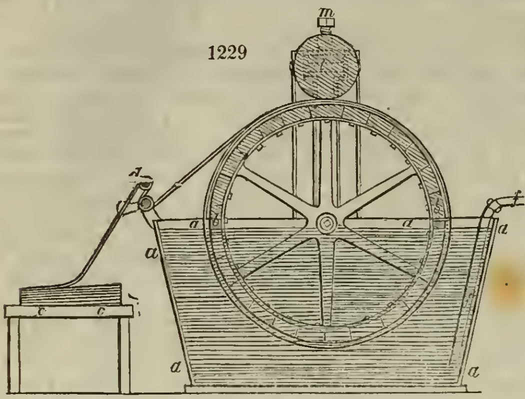
The apparatus which he proposes to employ for carrying on his improved process, is shown in the accompanying drawing. *Fig.* 1228, is a front view of the apparatus, com-

1228



plete, and in working order; *fig.* 1229, is a section, taken transversely through the middle of the machine, in the direction of *fig.* 1230; and *fig.* 1230, is an end view of the same; *a*, *a*, *a*, is a vessel or tank, made of iron or wood, or any other suitable material: sloping at the back and front, and perpendicular at the ends. This tank must be sufficiently large to admit of half the diameter of the cylinder or drum *b, b, 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.

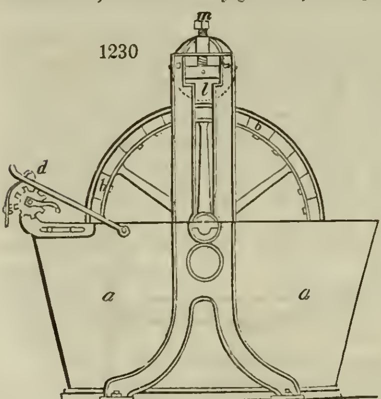
1229



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.* 1229, 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 canvass 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.* 1229, and opening the stop-cock 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.

1230



Uniform rotatory motion to the drum is shown in *fig.* 1228, 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.* 1228, 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 piece is folded backwards and forwards in yard lengths, so as to form a thick package on the board of a screw or hydraulic press. Between every fold sheets of glazed paper are placed to prevent the contiguous surfaces of 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 be come spotted and disfigured by rain.

WOOTZ, is the Indian name of steel.

WORT, is the fermentable infusion of malt or grains. See BEER.

WOULFE'S APPARATUS, is a series of vessels, connected by tubes, for the purpose of condensing gaseous products in water. See ACETIC ACID, *fig*. 1; also MURIATIC ACID.

X.

XANTHINE, is the name given by Kuhlmann to the yellow dyeing-matter contained in madder.

Y.

YEAST, is the froth of fermenting worts. See BEER and FERMENTATION.

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-oxyde*, *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 color to textile and other fibrous substances. Alumina and oxyde 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 oxyde of the metal yttrium.

Z.

ZAFFRE. See COBALT.

ZEDOARY, is the root of a plant which grows in Malabar, Ceylon, &c. It occurs in wrinkled pieces, externally ash-colored, internally brownish-red; possessed of a fragrant odor, somewhat resembling camphor; and of a pungent, aromatic, bitterish taste. It contains, according to Bucholz, 1·42 of volatile oil, of a burning camphorated taste; 3·60 of a soft, bitter, aromatic resin; 11·75 of a bitter aromatic extract, mixed with a little resin and potash-salts; 4·5 of gum; 9 of vegetable mucilage; 3·60 of starch; 8·0 of a starchy extract from the woody fibre, by means of caustic potassa, along with 31·2 of another matter, 12·89 of woody fibre, and 15 of water. According to Morin, this root contains, besides, an azotized substance, analogous to the extract of beef.

ZIMOME, is a principle supposed by Taddei to exist in the gluten of wheat-flour. Its identity is not recognised by later chemists.

ZIRCON. See HYACINTH and LAPIDARY.

ZIRCONIA, is a rare earth, extracted from the minerals zircon and hyacinth; it is an oxyde of zirconium, a substance possessing externally none of the metallic characters, but resembling rather charcoal powder, which burns briskly, and almost with explosive violence.

ZINC, is a metal of a bluish-white color, of considerable lustre when broken across, but easily tarnished by the air; its fracture is hackly, and foliated with small facets, irregularly set. It has little cohesion, and breaks in thin plates before the hammer, unless it has been previously subjected to a regulated process of lamination, at the temperature of from 220° to 300° F., whereby it becomes malleable, and retains its malleability and ductility afterwards. On this singular property, a patent was taken out by Messrs. Hobson and Sylvester, of Sheffield, many years ago, for manufacturing sheet zinc, for covering the roofs of houses, and sheathing ships; but the low price of copper at that time, and its superior tenacity, rendered their patent ineffective. The specific gravity of zinc varies from 6·9 to 7·2, according to the condensation it has received. It melts under a red heat, at about the 680th or 700th degree of Fahrenheit's scale. When exposed to this heat with contact of air, the metal takes fire, and burns with a brilliant bluish-white light, while a few flocculi, of a woolly-looking white matter, rise out of the crucible, and float in the air. The result of the combustion is a white powder, formerly called flowers, but now oxyde of zinc; consisting of 34 of metal, and 8 of oxygen, being their respective prime equivalents; or, in 100 parts, of 81 and 19.

The principal ores of zinc are, the sulphuret called *blende*, the silicate called *calamine*, and the sparry calamine, or the carbonate.

1. *Blende* crystallizes in the garnet-dodecahedron; its fracture is highly conchoidal; lustre, adamantine; colors, black, brown, red, yellow, and green; transparent or translucent; specific gravity, 4. It is a simple sulphuret of the metal; and, therefore, consists, in its pure state, of 34 of zinc, and 16 of sulphur. It dissolves in nitric acid, with disengagement of sulphureted 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.

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; color, 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 oxyde of zinc with silica and water; and its constituents are—zinc oxyde, 66·37; silica, 26·23; water, 7·4; in 100 parts. Reduced to powder, it is soluble in dilute sulphuric or nitric acid, and the solution gelatinizes on cooling. It emits a green phosphorescent light before the blowpipe. The second species, or rhombohedral calamine, is a carbonate of zinc. Its specific gravity is 4·442, much denser than the preceding. It occurs in kidney-shaped, botroidal, stalactitic, and other imitative shapes; surface generally rough, composition columnar. Massive, with a granular texture, sometimes impalpable; strongly coherent. According to Smithson's analysis, Derbyshire calamine consists of—oxyde of zinc, 65·2; carbonic acid, 34·8; which coincides almost exactly with a prime equivalent of the oxyde and acid, or $42 + 22 = 64$.

The mineral genus called *zinc-ore*, or red oxyde of zinc, is denser than either of the above, its spec. grav. being 5·432. It is a compound of oxyde of zinc 88, and oxyde of iron and manganese 12. It is found massive, of a granular texture, in large quantities, in several localities, in New Jersey. It is set free in several metallurgic processes, and occurs crystallized in six-sided prisms of a yellow color, in the smelting-works of Kœnigshutte in Silesia, according to Mitscherlich.

The zinc ores of England, like those of France, Flanders, and Silesia, occur in two geological localities.

The first is in veins in the carboniferous or mountain limestone. The blende and the calamine most usually accompany the numerous veins of galena which traverse that limestone; though there are many lead mines that yield no calamine; and, on the other hand, there are veins of calamine alone, as at Matlock, whence a very considerable quantity of this ore is obtained.

In almost every point of England where that metalliferous limestone appears, there are explorations for lead and zinc ores. The neighborhood of Alston-moor in Cumberland, of Castleton and Matlock in Derbyshire, and the small metalliferous belt of Flintshire, are peculiarly marked for their mineral riches. On the north side of the last county, calamine is mined in a rich vein of galena at Holywell, where it presents the singular appearance of occurring only in the ramifications that the lead vein makes from east to west, and never in those from north to south; while the blende, abundantly present in this mine, is found indifferently in all directions.

The second locality of calamine is in the magnesian limestone formation of the English geologists, the alpine limestone of the French, and the zechstein of the Germans. The calamine is disseminated through it in small contemporaneous veins, which, running in all directions, form the appearance of network. These veins have commonly a thickness of only a few inches; but in certain cases they extend to four feet, in consequence of the union of several small ones into a mass. The explorations of calamine in the magnesian limestone, are situated chiefly on the flanks of the Mendip Hills, a chain which extends in a northwest and southeast direction, from the canal of Bristol to Frome. The calamine is worked mostly in the parishes of Phipham and Roborough, as also near Rickford and Broadfield-Doron, by means of a great multitude of small shafts. The miners pay, for the privilege of working, a tax of 1*l.* sterling per annum to the Lords of the Treasury; and they sell the ores, mixed with a considerable quantity of carbonate of lime, for 1*l.* per ton, at Phipham, after washing it slightly in a sieve. They are despatched to Bristol, where they receive a new washing, in order to separate the galena.

OF THE SMELTING OF THE ORES OF ZINC.

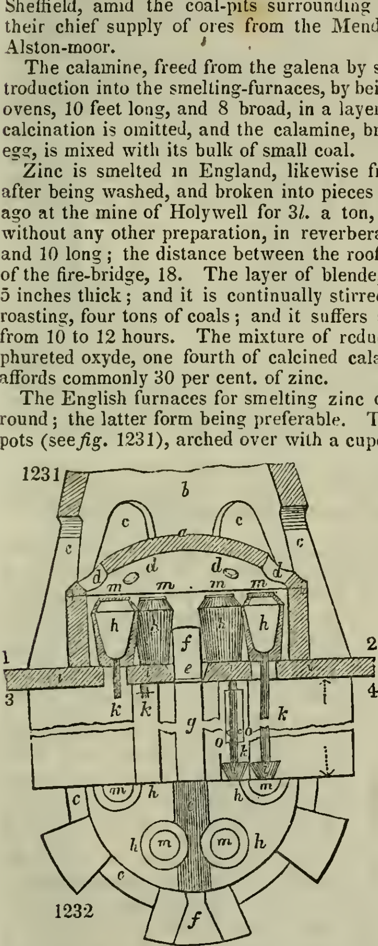
The greater part of the zinc works are situated in the neighborhood of Birmingham and Bristol. The manufacture of brass, which has been long one of the staple articles of these towns, was probably the cause of the introduction of this branch of industry, at the period when brass began to be made by the direct union of copper with metallic zinc, instead of calamine. A few zinc furnaces exist also in the neighborhood of Sheffield, amid the coal-pits surrounding that town. Bristol and Birmingham derive their chief supply of ores from the Mendip Hills and Flintshire; and Sheffield, from Alston-moor.

The calamine, freed from the galena by sorting with the hand, is calcined before its introduction into the smelting-furnaces, by being exposed, coarsely bruised, in reverberatory ovens, 10 feet long, and 8 broad, in a layer 6 inches thick. In some establishments the calcination is omitted, and the calamine, broken into pieces about the size of a pigeon's egg, is mixed with its bulk of small coal.

Zinc is smelted in England, likewise from blende, (sulphuret of zinc.) This ore, after being washed, and broken into pieces of the size of a filbert, was sold a few years ago at the mine of Holywell for 3*l.* a ton, or half the price of calamine. It is roasted, without any other preparation, in reverberatory furnaces; which are about 8 feet wide, and 10 long; the distance between the roof and the sole being 30 inches, and the height of the fire-bridge, 18. The layer of blende, which is placed on the hearth, is about 4 or 5 inches thick; and it is continually stirred up with rakes. One ton of it requires, for roasting, four tons of coals; and it suffers a loss of 20 per cent. The operation takes from 10 to 12 hours. The mixture of reducing consists of one fourth part of the desulphureted oxyde, one fourth of calcined calamine, and one half part of charcoal; which affords commonly 30 per cent. of zinc.

The English furnaces for smelting zinc ores are sometimes quadrangular, sometimes round; the latter form being preferable. They are mounted with from 6 to 8 crucibles or pots (see *fig.* 1231), 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 walls there are holes for taking out the pots, when they become unserviceable; after the pots are set, these holes are bricked up. The pots are heated to ignition in a reverberatory furnace before being set, and are put in by means of iron tong machinery supported upon two wheels, as is the case with glass-house pots. *e*, is the grate; *f*, the door for the fuel; *g*, the ash-pit. The pots *h*, *h*, *h*, have a hole in the centre of their bottom, which is closed with a wooden plug, when they are set charged with calamine, mixed with one seventh of coal; which coal prevents the mixture from falling through the orifice, when the heat rises and consumes the plug. The sole of the hearth *i*, *i*, upon which the crucibles stand, is perforated under each of them, so that they can be reached from below; to the bottom orifice of the pot, when the distillation begins, a long sheet-iron pipe *k*, is joined, which dips at its end into a water vessel *l*, for receiving in drops the condensed vapors of the zinc. The pot

1231



1232

is charged from above, through an orifice in the lid of the pot, which is left open after the firing, till the bluish color of the flame shows the volatilization of the metal; immediately whereupon the hole is covered with a fire-tile *m*. The iron tubes are apt to get obstructed during the distillation, and must therefore be occasionally cleared out with a redhot rod. When the distillation is finished, the iron pipes must be removed; the coaly and other contents of the pot cleared away. A pot lasts about four months upon an average. Five distillations may be made in the course of 14 days, in which from 6 to 10 tons of calamine may be worked up, and from 22 to 24 tons of coals consumed, with a product of two tons of zinc. The metal amounts to from 25 to 40 per cent. of the ore.

1, 2, is the level of the upper floor; 3, 4, level of the lower ceiling of the lower floor. *Fig.* 1232, ground plan on the level of 1, 2; only one half is here shown.

The zinc collected in this operation is in the form of drops, and a very fine powder, mingled with some oxyde. It must be melted in an iron pot or boiler, set in a proper furnace; and the oxyde is skimmed off the surface, to be returned into the crucibles. The metal is, lastly, cast into square bars or ingots.

The crucibles are discharged at the end of each operation, by withdrawing the condenser, breaking with a rake the piece of charcoal which shuts their bottom, and then emptying them completely, by shaking their upper part. In replacing the condenser-pipe *k* (see second pot from the right hand, *fig.* 1230), the flange at its top is covered with a ring of loam-lute, pressed against the conical bottom of the crucible, and secured in its place by means of two parallel rods *o*, *o*, which can be clamped by screws projecting horizontally from the vertical tunnel. See their places, indicated by two open dots near *o*, *o*.

A smelter and two laborers are employed in conducting a furnace; who make, with a mixture of equal parts of fire-clay, and cement of old pounds finely ground, the pots or crucibles, which last about four months. Five charges are made in 15 days; these work up from 6 to 10 tons of calamine, consume from 22 to 24 tons of coals, and produce 2 tons of zinc, upon an average. The following estimate of prices was made a few years ago:—

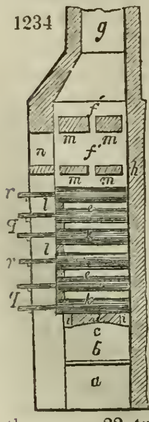
3 tons of calamine, at £6 - - - - - - -	£18	0	0
24 ditto coal, at 5*s*. - - - - - - - - - -	6	0	0
A smelter, at 2 guineas a week - - - - - - -	2	2	0
Two laborers, each at 4*s*. per day - - - - - -	2	16	0
Incidental expenses - - - - - - - - - -	1	0	0
	£29	18.	0

The calamine of Alston-moor, used at Sheffield, is not so rich; it produces at most only 25 per cent. of zinc. The coals are laid down at a cost of 5*s*. 8*d*. per ton; and the calamine laid down there 5*l*.; whence the zinc will amount to 32*l*. 14*s*. per ton. The considerable importations of zinc from Belgium and Germany, for some years back, have caused a considerable fall in its price.

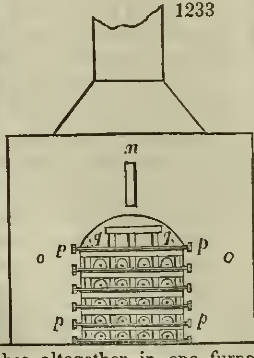
At Lüttich, where the calamine of Altenberg, near Aix-la-Chapelle, is smelted, a reduction furnace, containing long horizontal earthen tubes, is employed. The roasted calamine is finely ground, and mixed with from one third to two thirds its volume of coke or charcoal, broken to pieces the size of nuts.

Fig. 1233 represents this zinc furnace in elevation; and *fig.* 1234 in a vertical section through the middle. From the hearth to the bottom of the chimney it is 9 feet high, and the chimney itself is 18 or 20 feet high. *a*, is the ash-pit; *b*, the grate; *c*, the fireplace; *d*, the hearth; *e*, *e*, the laboratory; *f*, the upper arch, which closes in the laboratory; *f'*, the second arch, which forms the hood-cap of the furnace; *g*, the chimney; *h*, the fire-wall, which rests against a supporting wall of the smelting-house. Through the vaulted hearth the flame of the fire draws through ten flues *i*, *i*, two placed in one line; betwixt these five pairs of draught-openings, upon the sole of the hearth, the undermost earthen tubes *k*, immediately rest. The second and third rows of tubes *k*, *k*, lie in a parallel direction over each other, at about one inch apart; in the sixth row there are only two tubes; so that there are 22 tubes altogether in one furnace. At their two ends these tubes rest

1234



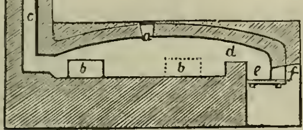
1233



upon fire-tiles, which form, with the side-walls, a kind of checker-work *l*, *l*. The tubes are 4 feet long, 4 to 5 inches in diameter within, five fourths of an inch thick. The fire, which arrives at the laboratory through the flues *i*, *i*, plays round the tubes, and passes off through the apertures *m*, *m*, in both arches of the furnace, into the chimney. *n*, is an opening in the front wall between the two arches, which serves to modify the draught, by admitting more or less of the external air.

The two slender side walls *o*, *o*, of the furnace, are a foot distant from the checker-work, so that on the horizontal iron bars *q*, *q*, supported by the hooks *p*, *p*, the iron receivers *r*, *r*, may have room to rest at their fore part. These receivers are conical pipes of cast iron, 1½ foot long, posteriorly 1½ inch, and anteriorly 1 inch wide at the utmost. After the earthen tubes have been filled with the ore to be smelted, these conical pipes are luted to them in a slightly slanting position. These cones last no more than three weeks; and are generally lengthened with narrow-mouthed wrought-iron tubes, to prevent the combustion of the zinc, by contact of air. When the furnace is in activity, a blue flame is to be seen at the mouths of all these pipes. Every two hours the liquefied metal is raked out into a shovel placed beneath; and in 12 hours the charge is distilled; after which the tubes are cleared out, and re-charged. 100 pounds of metallic zinc are the product of one operation. It is remelted at a loss of ten per cent., and cast into moulds for sale.

1235



1236

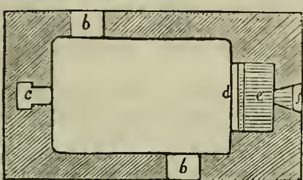
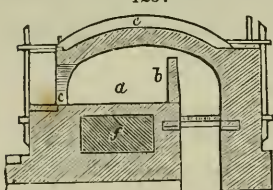


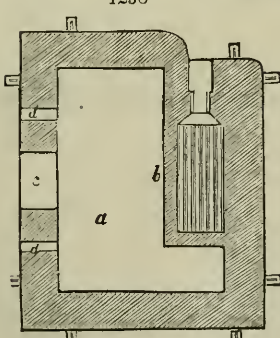
Fig. 1235 is a longitudinal section of the furnace for calcining calamine in Upper Silesia; *fig.* 1236 is a ground plan of the furnace. *a*, is the orifice in the vault or dome, for the introduction of the ore; *b*, *b*, apertures in the side-walls, shut with doors, through which the matter may be turned over; *c*, the chimney; *d*, the fire-bridge; *e*, the grate; *f*, the feed opening of the fire, the fuel being pitcoal. The calamine is stirred about every hour; and after being well calcined during 5 or 6 hours, it is withdrawn; and a new charge is put in. These Silesian furnaces admit of 30 cwts. at a time; and for roasting every 100 cwts. 15 Prussian bushels of fuel, equal to 23 English bushels, are employed. These calcining furnaces are sometimes built alongside of the zinc smelting-furnaces, and are heated by the waste flame of the latter. The roasting is performed in the Netherlands in shafts, like small blast iron-furnaces, called schachtofen.

1237



The hearth *a*, in *figs.* 1237, 1238, is constructed for working with 5 muffles, one of which is long, and four short. The muffles are made upon moulds, of fire-clay mixed with ground potsherds. The receivers are stoneware bottles. The grate is ten inches beneath the level of the hearth. *b*, the firebridge, is proportionally high to diminish the force of the flame upon the hearth, that it may not strike the muffles. *c*, is the opening through which the muffles are put in and taken out; during the firing it is partly filled with bricks, so that the smoke and flame may escape between them; *d*, *d*, are openings for adjusting the positions of the muffles; *e*, cross hoops of iron, to strengthen the brick arch; *f*, is a bed of sand under the sole of the hearth. During the first two days, the fire is applied under the grating; the heat must be very slowly raised to redness, at which pitch it must be maintained during two days. From 8 to 10 days are required for the firing of the muffles.

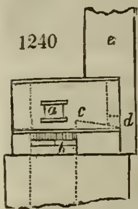
1238



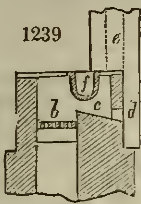
The furnace shown in *figs.* 1239, 1240, 1241, is for the melting of the metallic zinc. *Fig.* 1240 is a front view; *fig.* 1239 a transverse section; *fig.* 1241 a view from above; *a*, is the fire-door; *b*, the grate; *c*, the fire-bridge; *d*, the flue; *e*, the chimney; *f*, *f*, *f*, cast-iron melting-pots, which contain each about 10 cwts. of the metal. The heat is moderated by the successive addition of pieces of cold zinc. The inside of the pots should be coated with loam, to prevent the iron being attacked by the zinc. When the zinc is intended to be aminated, it should be melted with the lowest possible heat, and poured into hot moulds.

When the zinc ores contain cadmium, this metal distils over in the form of brown oxyde, with the first portions, being more volatile than zinc.

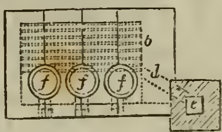
1240



1239



1241



Under Brass and Copper, the most useful alloys of zinc are described. The sulphate, vulgarly called white vitriol, is made from the sulphuret, by roasting it gently, and then exposing it upon sloping terraces to the action of air and moisture, as has been fully detailed under Sulphate of Iron. The purest sulphate of zinc is made by dissolving the metal in dilute sulphuric acid, digesting the solution over some of the metal, filtering, evaporating, and crystallizing.

Sulphate of zinc is added as a drier to japan varnishes.

The ordinary zinc found in the market is never pure; but contains lead, cadmium, arsenic, copper, iron, and carbon; from some of which, it may be freed in a great degree by distillation; but even after this process it retains a little lead, with all the arsenic and cadmium. The separation of the latter is described under Cadmium. Zinc, free from other metals, may be obtained by distilling a mixture of charcoal and its subcarbonate, precipitated from the crystallized sulphate by carbonate of soda. By holding a porcelain saucer over the flame of hydrogen produced from the action of dilute sulphuric acid upon any sample of the zinc of commerce, the presence of arsenic in it may be made manifest by the deposite of a gray film of the latter metal. Antimony, however, produces a somewhat similar effect to arsenic.

Zinc is extensively employed for making water-cisterns, baths, spouts, pipes, plates for the zincographer, for voltaic batteries, filings for fire-works, covering roofs, and a great many architectural purposes, especially in Berlin; because this metal, after it gets covered with a thin film of oxyde or carbonate, suffers no further change by long exposure to the weather. One capital objection to zinc as a roofing material, is its combustibility.

Chloride of zinc has been recently used with great advantage as an escharotic for removing cancerous tumors, and healing various ill-constitutioned ulcers. It, as also the nitrate, forms an ingredient in the resist pastes for the pale blues of the indigo vat.

Spelter (zinc) imported for home consumption—in 1835, 52,604 cwts.; in 1836, 47,406 cwts. Duty—in cakes, 2*s.*; not in cakes, 10*s.* per cwt.

THE END.

RECENT IMPROVEMENTS

IN

ARTS, MANUFACTURES,

AND

MINES:

BEING

A SUPPLEMENT TO HIS DICTIONARY.

BY

ANDREW URE, M. D.,

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PREFACE.

In laying this Supplement to my Dictionary of Arts, Manufactures, and Mines, before the world, while I gratefully acknowledge the indulgence with which that work has been received, may I be permitted to advert very briefly to some of my present endeavors to render it less undeserving of public favor, though, after all my efforts, it will by no means realize either my own wishes and intentions, or the expectations of all my readers?

To investigate thoroughly any single branch of art, we should examine it in its origin, objects, connexion with kindred arts, its progressive advancement, latest improved state, and theoretical perfection. The general principles on which it is founded, whether belonging to the mechanical, the physical, the chemical sciences, or to natural history, should be fully expounded, and tested by an application to its practical working on the great scale. The maximum effect of the machinery which it employs, and the maximum product of the chemical mixtures and operations which it involves, should in every case be calculated and compared with the actual results.

Such have been my motives in the numerous consultations I have had with manufacturers relatively to the establishment or amelioration of their factories, and when they are kept steadily in view, they seldom fail to disclose whatever is erroneous or defective, and thereby to lead to improvement. It will not be denied by any one conversant with the productive arts, that very few of them have been either cultivated or described in this spirit. It is to be hoped, however, that the period is not remote, under the intellectual excitement and emulation now so prevalent in a peaceful world, when manufactories will be erected, and conducted upon the most rational and economical principles, for the common benefit of mankind. Meanwhile it is the duty of every professor of practical science to contribute his mite toward this desirable consummation.

It is under a sense of this responsibility that I have written the leading articles of this Supplement, having enjoyed some peculiar advantages in my profession for making the requisite researches and comparisons. I trust that not many of them deserve to be regarded as trite compilations or as frivolous novelties, with the exception of a few of the notices of recent patents, which I have intentionally exhibited as beacons to deter from treacherous quicksands, not as lights to friendly havens. I have sought sincerely to make them all conducive, more or less, to utility; being either new contributions to the old stock of knowledge, or additions and corrections to the miscellaneous volume of which the present is the sequel.

Arrow Root is here for the first time treated as a well-organized manufacture, in conformity with my quondam definition: "Manufacture is a word which, in the vicissitude of language, has come to signify the reverse of its intrinsic meaning, for it now denotes every extensive product of art which is made by machinery, with little or no aid of the human hand; so that the most perfect manufacture is that which dispenses entirely with *manual* labor."*

Arrow root being the purest and most agreeable variety of *fecula*, and therefore one of the most powerful nutriments, deserves more attention from the colonial planter than it seems hitherto to have received. As it has been now so judiciously prepared in the island of St. Vincent, by the proprietor of the Hopewell estate,

* "Philosophy of Manufactures," page 1.

it will, I hope, amply repay his enterprising and liberal spirit, seeing that he supplies us with an article equal if not superior to the best from Bermudas, at two thirds of the price.

To Artesian Wells an interesting notice has been added of the successful labors of MM. Arago and Malot at Grenelle, near Paris.

I doubt not that should cockneys happen to read what is here said of Bavarian Beer, they will feel no little surprise, mixed with scorn and incredulity, when told that the mystery of brewing is more philosophically studied and incomparably better understood in Munich than in London, and indeed throughout all Bavaria, than in Old England; but such is certainly the fact, as every delicate stomach will experience which is cheered with the beverage of the former capital, and loaded with the *heavy-wet* of the latter. The brief outline here offered to my readers has been carefully drawn from the best sources of information, obtained during several excursions into Germany. It will, I hope, induce the brewers of this country to set more value on chemical science than they have heretofore done, and thereby eventually lead to *a radical reform* of our colossal establishments for extracting from malt a beverage more akin to that of fermented grape-juice, in its freedom from vinegar and gluten, so abundant now in the greater part of the British porters and beers.

Under Biscuits will be found a complete description, with figures, of the grand automatic bakeries of Deptford and Portsmouth, which provide our hardy tars with the staff of life in the soundest state.

The perusal of the article Bread will prompt the wish that our land-holding legislators would consent to let the people under their domination get, at a moderate cost, some of the wheat of southern Europe, much richer than that of our average home growth in the azotized glutinous principle, so essential to the formation of our blood and muscles; a wheat adapted to make a superior bread, such as that called *pain du gruau* in Paris, and also a superior macaroni, like the Neapolitan. In this department of industry, so important for the welfare of the population, the French have set us the example of applying to it the economical resources of the factory system, having organized a self-acting bakery, in which bread of the finest quality is made on the great scale, in smokeless ovens of a nicely regulated temperature. Meanwhile, the mass of her majesty's subjects are dependant for their bread upon a multitude of tradesmen of slender means, who earn a scanty livelihood by hard labor, and who work up a weak inferior flour into a bad bread, which they are too often tempted to whiten with alum and other unwholesome drugs. The penalty liable to be inflicted upon bakers for having alum on their premises, is commonly evaded by letting it be added to the flour in the mill. Why do not our wise legislators enact a law for the summary conviction and punishment of a baker selling bread with alum in it; a saline compound most easily detected by chemical analysis?

I was lately called upon professionally to examine the very white bread of a fashionable baker of high pretensions, and found it to contain a notable quantity of alum; so much so, as to have been directly offensive to the stomachs, and hurtful to the health of several individuals in the family using it. This is no solitary case, but is, I believe, that of a large proportion of the bakers in London, and suburbs, who operate upon a partially damaged flour, as one may easily surmise from the disagreeable odor exhaled from the hot loaves in too many of their shops. Yet what individual will be Quixotic enough to attack the numerous and ever-changing arms of this Briareus? Who would choose to incur the trouble, responsibility, and expense of prosecuting a frequent misdemeanor of this kind, relatively to which the want of fine wheat in the market is a principal motive and apology?

From these evils our grandees are exempt, as they bake their bread at home of the best materials. Though they are apparently regardless of the injury suffered by the public from this source, they are, however, quite alert in the execution of the game and excise laws, the stringent penalties of which are inexorably inflicted against petty transgressors, exposed to temptations often too strong for the infirmity of human nature to resist.

In every well-governed state of continental Europe there exists a Board of Health, or *Conseil de Salubrité*, composed of eminent physicians, chemists, and engineers, appointed to watch over whatever may affect injuriously the public health and comfort. In France, this commission consists, for the capital, of seven members, who have the surveillance, in this respect, of markets, factories, places of public amusement, bakeries, shambles, secret medicines, &c. This tribunal has discharged its functions to the entire satisfaction of their fellow-citizens, as appears from the following authentic report: "*Non seulement une foule de causes d'insalubrité disparurent, mais beaucoup de moyens, de procédés nouveaux furent proposés pour assainir les Arts et les Métiers, qui jusque là avaient paru inséparables de ces causes d'insalubrité; la plûpart de ces moyens eurent un plein succès. Il n'y a pas d'exemple que les membres du Conseil appelés à donner leur avis sur des plaintes formées contre des fabriques, aient jamais répondu qu'il fallait les suprimer sans avoir cherché eux-mêmes à aplanir les difficultés, que présentait aux fabricants, l'assainissement de leur art, et presque toujours ils sont parvenu à resoudre le problème. Le Conseil de Salubrité, que l'on ne saurait trop signaler à la reconnaissance de publique, est une institution que les nations étrangères admirent, et s'efforceront d'imiter sans doute.*"*

From this confident hope of emulation by other nations, the author of these excellent observations would have excepted the United Kingdom, had he known how little paternal care is felt by the government for the general interests of the people. In Germany, indeed, where the *fatherland* feeling is strong in the breasts even of those rulers whom we are apt to consider despots, similar boards of health are universally established, whereas our legislative oligarchy frames laws chiefly for the benefit of its own class and dependants; as happened in the old time, when there was no king in Israel to regard alike the interests of the poor and the rich.

The Prussian municipal law *(Allgemeine Landrecht)* contains the following enactments with regard to the sale of spoiled or adulterated victuals. Th. II. Tit. 20; Abschnitt 11; §§ 722 to 725. "No person shall knowingly sell or communicate to other persons for their use, articles of food or drink which possess properties prejudicial to health, under a penalty of fine or bodily punishment. Whosoever adulterates any such victuals in any manner prejudicial to health or mixes them with unwholesome materials, especially by adding any preparation of lead to liquors, shall, according to the circumstances of the case, and the degree of danger to health, be liable to imprisonment in a correction-house, or in a fortress, during a period varying from one to three years. Besides this punishment, those who are found guilty of knowingly selling victuals which are damaged or spoiled (*verdorbener*), or mixed with deleterious additions, shall be rendered incapable for ever of carrying on the same branch of business. The articles in question shall be destroyed, if incorrigibly bad, but if otherwise, they are to be improved as far as possible at the cost of the culprit, and then confiscated for the benefit of the poor. Further, whosoever mixes victuals or other goods with foreign materials, for the purpose of increasing their weight or bulk, or their seeming good qualities, in a deceitful manner, shall be punished as a swindler."

It is singular how, amid the law-making mania which has actuated our senators for many sessions, that not even one bill has been framed for the protection of the people from spoiled and adulterated foods and drinks.

For the article on Brick-Making, my readers are indebted to a valuable communication to the Institution of Civil Engineers, and the judicious remarks on it by several of its members. At its conclusion, a notice is inserted of one of those abuses which too often recur in our courts of judicature, in consequence of scientific witnesses merging the dispassionate philosopher in the mercenary partisan, and striving to mislead the judge and jury, by giving a one-sided view of the matter submitted to their candid examination. Such procedure is injurious, not merely to the individual casuist, but to the cause of science. What a close affinity is there between these quibblers and the venal philosophists so graphically portrayed by Lucian!

In addition to the sectional view of the four-colored calico-printing machine, given in the Dictionary, an outside view of this admirable mechanism is now presented to my readers; the two together constituting the only good representation of it hitherto made public.

* "Dictionnaire Technologique," tom. ii., p. 293.

The production, properties, and manufacture of caoutchouc, are treated here in considerable detail, peculiar facilities having occurred to me for the thorough investigation of this novel branch of industry. If, along with the account now given, the articles BOOKBINDING, BRAIDING MACHINE, and ELASTIC BANDS of the Dictionary be consulted, the student will possess a pretty complete knowledge of caoutchouc.

CHOCOLATE is also a new contribution to my work, which I have been enabled to make in consequence of extensive experimental researches. It is to be hoped that our intrepid sailors will be allowed to reap the full benefit of the investigations which I made in their behalf, by desire of the Lords Commissioners of the Admiralty, and that their daily breakfast beverage will be for the future more soluble, emulsive, and nutritious, than I found it to be on commencing my researches, at which time about three fourths of the cocoa was so coarsely ground, for the service of the navy, as to be left in a state altogether unfit for digestion.

The various new modes of producing pictorial impressions by the agency of light on chemically prepared surfaces are described under the titles, CALOTYPE, DAGUERROTYPE, PHOTOGRAPHY, &c. The somewhat kindred copying art by electricity, is treated under the article ELECTRO-METALLURGY.

FERMENTATION will be found a useful companion to the account of Bavarian beer; both being calculated to invite brewers and distillers to look more narrowly than they seem to have done into the interesting world of organic chemistry, so successfully explored in Germany and France, but so little studied in this country.

GAS LIGHT has been contributed by a most intelligent friend, and deserves tc be regarded as a standard treatise on this important branch of engineering, condensed into the shortest possible space consistent with perspicuity.

GUANO, destined ere long to become the chief pabulum of British agriculture and thereby to emancipate our landholders and farmers from their *exositophobia* their dread of the importation of foreign corn, has been discussed at considerable length from peculiar sources of information.

Under IRON and SMELTING are given descriptions, with figures, of the best plans of the apparatus for the hot-air blast, and for feeding the blast furnace with mine, limestone, and fuel; both being original contributions from an eminent engineer.

The SEED-CRUSHING oil manufacture is, I believe, now for the first time in this country represented by a complete set of figures, exhibiting the various parts of the wedge stamping-mill; the oldest and probably still the best plan of extracting oil from seeds.

PEPPER presents an instructive example of the fallacy of chemical evidence, sometimes too inconsiderately given in a court of justice. Were the solemn sanctity of an oath rightly impressed on the minds of scientific men, they would not testify to anything but what they did *most surely know*, and would escape the remorse and obloquy consequent, in feeling minds, on having borne false witness against their neighbor.

The SACCHAROMETER table printed at first for the Dictionary, but omitted along with some other articles of less importance, for want of room, is now given with certain improvements.

SMOKE-PREVENTION is a matter of such moment to the comfort and salubrity of all our large towns, and even of many semi-rural districts, that in promoting the publicity of Mr. Charles Wye Williams's unexceptionably simple and successful plan for effecting a consummation so earnestly to be wished for, I am conscious of merely discharging a professional duty.

SPINNING exhibits a short but systematic view of the admirable self-acting system invented by Mr. Bodmer, whereby all the operations in a cotton-factory are linked together in regular succession, and co-operate, with little or no manual aid, toward turning out a perfect product. This invention constitutes a true automatic era in textile factories. I trust the author of these inventions will be duly recompensed for the ingenuity and labors of very many years.

In the spinning of fine flax yarn by machinery, the greatest mechanical conquest which our factories have made in our own days over the industry of rival nations, a capital improvement has been recently made by Mr. Westly of Leeds His former invention, the screw gill or spiral comb described in the Dictionary, under FLAX, is now universally employed. His new contrivance is called the SLIVER ROVING, of which a description will be found in the APPENDIX, having come too lately to hand for insertion in its proper place. It promises to be a still more valuable improvement in this difficult branch of manufacture than even the spiral comb.

The table entitled SPIRITS exhibits the correspondence between the technical nomenclature of our excise as reckoned in over-proof and under-proof strengths, and the simple scale of specific gravity as understood and agreed upon all over the world. Since alcohol alone, and not water, is the subject of taxation, why not have an alcohol-meter, like that of Gay Lussac, which shows at once the proportion of taxable stuff in any spirit? (See ALCOHOL in the Dictionary.) As, however, our excise laws, like those of the Medes and Persians, are not likely to be changed in conformity with any scientific remarks, the above table is a desideratum to practical chemists.

SUGAR OF POTATOES, being a recent manufacture in this country, is fully investigated from my own professional resources.

TOBACCO is discussed at considerable length, valuable materials for this inquiry having been afforded in the Report of the recent Committee of the House of Commons. While this plant is a rank weed, conducive neither to the sustenance nor health of man, and therefore a most fit object for deriving from its consumers a fiscal revenue, it affords instructive lessons on the influence of our fiscal administration on arts and manufactures.

When the duty on an article is more than ten times its intrinsic value, it must become the subject of perpetual and enormous frauds, and engender innumerable misdemeanors and crimes. Toward the prevention and punishment of these transgressions of the fiscal laws, a cumbrous, complex, costly, somewhat arbitrary and despotic system of espionage and prosecution must be organized. The working of this vast machinery is well shown in the committee's report, and must excite uncomfortable feelings in every honorable mind. We here see, on a somewhat magnified scale, the system of interference with, and prying into, processes of art and manufacture which accompanies and characterizes all the operations of the excise. This device for collecting revenue for the necessities of the state is the Pandora's box of the dethroned Stuarts, and should have been expatriated with that ill-starred family. We may say of it, *Quicquid tangit, deornat.* No branch of industry can acquire its due development under its wiry training and fastening. Had the *incubus* of the excise overlaid our textile manufactures of wool, cotton, flax, and silk, how dwarfish would their stature have remained, and how meanly would they have quailed under the unrestrained labor of rival nations; whereas now they afford employment, with food, raiment, and lodging, to millions of our people. For the manufacture of glass in all its useful and ornamental branches, this country possesses indigenous resources superior to those of every other one, in its stores of fuel and vitrifiable materials of every kind, and yet it is surpassed by France, Switzerland, and Bavaria, in glass for optical purposes, and by Bohemia in the quality and execution of decorative glass. Our scientific chemists have been obliged to get all their best glass apparatus from Germany, *via* Hamburgh.

Surely our glass-makers are the same race of people as our manufacturers of iron, fine cotton yarn, muslin, bobbin-net, broad silks, &c., which defy the competition of the world, and if unshackled by the excise they would ere long turn the scale against their foreign rivals, now their superiors. The incessant and vexatious espionage of the excise is a bar to all invention in every art under its control. Who would expend thought, science, labor, and money, in maturing any discovery or improvement, by experiments necessarily conducted under the eyes of needy excisemen, who would tell all they have seen for a trifling bribe? Perhaps the gigantic scale of our spirit distilleries may be appealed to in proof of the fostering care of the excise, under which they have been reared. But this overgrowth, when well looked into, is no evidence of a sound constitution, but merely of the depravity of a grovelling uneducated people. In fact, our distilleries produced until very lately a very impure and offensive spirit, strongly imbued with noxious *fusel-oil*, or oil of grains (see ALCOHOL in this *Supplement*), and but for the recent introduction of Mr. Coffey's still into some distilleries, they would all have been yet sending forth a similar crude spirit. But though Mr. Coffey was for many years an officer of excise, and therefore did adapt his patent invention to all the just requirements of the revenue laws, he has met with very vexatious obstructions in the erection of his stills and on the most frivolous pretences.

As a general corollary from my long experience in the conduct of arts and manufactures, I feel warranted to declare, that the excise system is totally incompatible with their healthy growth, and is in itself the fruitful parent of fraud, perjury, theft, and occasionally murder. The sooner this portion of the revenue, so oppressively, so expensively, and so offensively collected, is replaced by an equitable tax on property, the better for the welfare of this great country. I have no quarrel with the gentlemen who administer the excise laws; several of them with whom I have been professionally conversant I esteem very highly as intelligent and upright men, who do what they deem their duty in a conscientious manner. But in concluding a very extensive survey of the great branches of our national industry, this vile obstacle to their progressive growth became so manifest, that it would have been pusillanimous to shrink from the task of pointing out the magnitude of the evil.

VENTILATION describes the plan now organized in the Reform Club House, which I inculcated in the Philosophy of Manufactures, published in 1835, as also in a paper read before the Royal Society in 1836, and which was copied into several of the scientific journals of that period. About the same time, Dr. Reid was erecting a huge factory furnace and chimney for the ventilation of the House of Commons, which would have been accomplished more effectually at one half of the expense, and without any architectural disfigurement, by my method of ventilating fans, which was, in fact, that long practised in our great textile factories. The doctor has, I understand, renounced his chimney draughts in ventilating the Court of Exchequer at Westminster, and adopted a similar system to that of the Reform Club House. I hope he will pursue the same plan in the new Houses of Parliament, as it may be mounted at a very small cost, and without occasioning the least unsightly appearance or any annoyance.

I have subjoined in an Appendix a brief treatise, entitled CHEMISTRY SIMPLIFIED, which, being duly studied, will prove a useful guide to practitioners in testing alkalis, acids, and bleaching substances, in several departments of the chemical arts.

A few of the articles marked in the Dictionary for reference to the Supplement, were, on reconsideration, not found susceptible of useful annotation. Most of these references were, indeed, statistical details, which are given from the latest and best sources in Mr. M'Culloch's excellent Dictionary of Commerce.

LONDON, 13 Charlotte Street, Bedford Square,
28th October, 1844.

A

SUPPLEMENT,

&c., &c.

ACETIC ACID. *Rapid acetification*, or the quick formation of vinegar, was practised upon malt worts in this country long before the rapid conversion of alcohol into vinegar was introduced into Germany. In the year 1842, Mr. Ham obtained his patent for an improved method of making vinegar, which is described in the dictionary. His son, Mr. F. Ham, of Norwich, civil engineer, states that for some years, four of the largest country manufactories in the kingdom have been at work upon his father's plan, and that they are now in successful competition with the great London establishments. The apparatus consists of a huge vat, in the centre of which is a revolving pump, having two or more shoots pierced with holes, whereby a constant shower of the fermented wort, called wash, is kept falling from the top. The under part of the vat contains the wash; the upper part, birch twigs properly prepared, which are so placed as not to interfere with the revolving shoots. Between the surface of the wash and the rafters which support the twigs, a space of a few inches is left vacant, into which one or more holes in the side of the vat admit the air spontaneously or have it forced in. The wash is maintained, by steam pipes immersed in it, at a temperature of from 90° to 100° F., so that, in consequence of the extensive application of the atmospheric oxygen during the trickling through the twigs, it may be made sour in the course of 48 hours; but, in general practice, it is completely acetified in from 15 to 20 days. By this apparatus, a wort brewed from raw grain, with only one seventh of malt, will produce a vinegar equal to that from malt alone; and the acetifying process may be arrested whenever it is completed, thus preventing the risk of the vinegar running into the putrefactive stage, as happens occasionally in the slow plan of fermentation. The admission of air is so moderated as not to dissipate the alcohol of the wash by evaporation. A wort of 24 lbs. gravity per Richardson's instrument, equal to 1·066 sp. gravity, will in this way yield an acid of revenue proof.

This old-going process is essentially the same with that for which John W. Neale and James Edouard Duyck obtained a patent in September, 1841, with this difference, that they employ the expressed juice of beet-roots instead of corn-wort.

The total number of vinegar factories in the United Kingdom was a few years ago only 48, of which five of the principal are in London, four being on the Surrey side of the Thames. In these, malt vinegar-making is associated with the manufacture of British wines, called "sweets" by the excise. The fermented wort or wash is acetified either by "stoving or fielding." By the first plan, casks containing the wash are arranged in close rooms, heated by steam-pipes or stoves. By the second plan, the casks, each holding somewhat more than 100 gallons, are laid on their sides, with the bung-holes up, and distributed in long parallel rows, two or more deep, with narrow lanes between. A flexible pipe or hose, in connexion with the great wash tun in the brew-house, is laid alongside of the casks, for the purpose of filling them, and keeping them supplied in case of leakage, or evaporation. The wash requires usually several months for its complete acetification, during which time the bung-holes are left open in fine weather, but covered with a tile in the time of rain. When the acetous fermentation is completed, the contents of the casks are transferred by a syphon into a shoot laid on the ground, whence it is drawn by a pump into a store vat within doors. It is next clarified in very large vats, called "rapes," because in them it is filtered slowly and repeatedly through a compacted heap of the stalks and skins of raisins, called rape, which is the refuse of the British wine manufacture.

In 1838, 2,628,978 gallons of vinegar paid duty in England; in 1839, 2,939,665;

and in 1840, 3,021,130; upon which the gross amount of duty was respectively, 21,908*l.* 3*s.*; 24,488*l.* 17*s.* 6*d.*; and 25,978*l.* 12*s.* 9*d.*

In Scotland, in the same years, 15,626 gallons; 14,532; and 12,967; on which the duty charged was, respectively, 130*l.* 4*s.* 4*d.*; 121*l.* 2*s.*; and 111*l.* 19*s.* 7*d.*

In Ireland, in the same years, 48,158 gallons; 50,508; and 56,812; on which the duty charged was, 401*l.* 6*s.* 4*d.*; 420*l.* 18*s.*; and 489*l.* 13*s.*

In the German process of Schützenbach for the rapid formation of vinegar, 180 measures (of 2 litres, or 2 quarts each) of water are added to 20 of alcohol of from 44 to 45 per cent. by Tralles, and 6½ of vinegar, containing 3½ per cent. of acetic acid. These 206½ measures produce on the average 203 to 204 of vinegar of the above strength. The process of acetification in the graduation tubes (*gradirfässer*) is finished in about 48 hours, and furnishes a vinegar of only 2·75 per cent. of acid strength. The liquid still contains some unchanged alcohol, and it is therefore transferred into tuns, where it completes its oxygenation. The heat of the chamber being about 90° F., occasions the stream of air that is passed through the above materials to carry off unproductively one tenth of the alcohol at least. Of the air tha passes through the apparatus, only 3 per cent. of its oxygen is converted into carbonic acid.* An increase in the proportion of alcohol in the mixture is not found favorable to increased production of vinegar.

The theory of the acetification of alcohol was first fully cleared up by the researches of Liebig on aldehyde. For the production of 100 pounds of hydrated acetic acid, 53 pounds of oxygen are required, which are contained in 227 pounds of air, and oxygenate 77 pounds of absolute alcohol.

The conversion of the alcohol of fermented liquors into vinegar may be chemically represented as follows: Alcohol is a compound of four atoms of carbon, six of hydrogen, and two of oxygen, or in symbols $C^4 H^6 O^2$. In certain circumstances (as the first stage of acetification) it loses two atoms of hydrogen, and becomes *aldehyde*, or dehydrogenated alcohol, $C^4 H^4 O^2$. This body readily absorbs two atoms of oxygen on exposure to air, and thus forms one atom acetic acid; in symbols, $C^4 H^3 O^3 + 1$ atom water (H O). These results are obtained in the exposure of vapor of alcohol to platinum sponge, or *platinum mohr*. In all cases it is presumed that aldehyde is first produced, then vinegar. The quick vinegar process has been in this country advantageously applied to the acetification of a solution of starch sugar made by the agency of either malt or sulphuric acid. But as our excise laws are adverse to the spirituous fermentation of such sugar, the starch liquor, after being boiled with one per cent. of sulphuric acid, is directly fermented into a crude wash, which is then acetified by the following method:—

A very large slightly conical tub or tun, 14 feet wide at bottom, 15 at top, and 13 high, turns out in a given time as much vinegar as is in Germany obtained from six tubs 8 feet high and 4 feet wide. Our larger mass of materials generates and maintains so much heat in the oxidation of the spirit, as to require no stove-heating in a properly constructed chamber. Two and a half feet above the bottom of the above tun, a false bottom is laid. The space above this bottom is filled with coopers' wood shavings and chips, and the space beneath is destined to receive the liquor as it trickles down on the true bottom, in order to be pumped up in continual circulation. At a moderate height above the tun, the reservoir of the wash is placed, which discharges itself through a regulating stop-cock, or valve, into a pipe in its bottom, which passes down through a pretty large hole in the middle of the lid of the tun, and terminates a few inches under it, in a cross pipe shut at the ends, which is made to revolve slowly by mechanical power, in a horizontal direction round the end of the vertical pipe. This cross pipe is long enough to reach nearly to the sides of the tun, and, being pierced with small holes in its under side, delivers the fermented liquor, in minute streams, equally all over the surface of the chips of wood. It thence falls into the lower compartment of the tun, through holes round the circumference of the false bottom, whence it is pumped up again, under certain modifications, to be presently described.

The air for oxygenating the alcohol into vinegar is supplied from two floating gasometers, which are made to rise and fall alternately by steam power. The ascending one draws its air from a pipe which passes into the centre of the tun, immediately under the false bottom, and as it redescends it discharges that air through a pipe into a cistern of water, which condenses, and retains the alcoholic vapor drawn off with the air. This water is used in making the next acetifying mixture. The fresh air is admitted in the top of the tun by the sides of the vertical liquor pipe, which is somewhat smaller than the hole through which it passes. Proper valves are placed upon the pipes connected with the gasometer pump, whereby the air drawn from the bottom compartment is prevented from returning thither. A small forcing-pump is employed to raise

* *Knapp*, Annal. der Chem. und Pharm. xlii. 113.

the liquor continually from the bottom of the tun to the cistern overhead. By this arrangement good vinegar may be made in a few days, without any perceptible loss of materials. The progress of the acetification in this apparatus is ascertained by testing the air for oxygen as it is slowly drawn into the gasometers, or expelled from them. For this purpose a bundle of twine, which has been impregnated with solution of sugar of lead, and dried, is set fire to, and plunged into a bottle filled with the air. In general, it is so well disoxygenated and carbonated, that the ignition is immediately extinguished. By regulating the warmth of the apartment, the motion of the gasometer, and the admission of air, the due progress of the acetification may be secured. The vinegar has an average strength of 5½ per cent. of acetic acid hydrate, and is immediately ready for the market.

Hitherto it has been generally imagined that the formation of vinegar is accomplished bv a peculiar fermentation, which has been called the *acetous*, in contradistinction from the vinous, the panary, the putrefactive, &c. But this doctrine is doubtful. The experiments which serve as its base, and which should reveal the nature of its peculiar ferment. as also the chemical reactions which take place in its progress, all seem to place this phenomenon somewhat out of the sphere of fermentation properly so called. Every fermentation operates by resolving a body into compounds less complex than itself. But the so-called acetic fermentation serves to combine, on the contrary, two bodies, viz., alcohol and aldehyde, with the oxygen of the air; and this is the only case where fermentation produces such an action, which is a true combustion.

Yet it must be confessed that the acetic seems to possess all the characters of the other fermentations; namely, the union of an organized body or ferment with a fermentable organic matter. The former is found in that mucous substance called *mother* of vinegar, and which is seen floating on the surface of vinegar in the act of its generation. It begins to appear with the acid fermentation, and it continues to be formed during its whole progress. It is at first a pellicle composed of globules much more minute than those which constitute yeast; and they are often irregularly grouped. The pellicle becomes afterward thicker in body and consistence, exhibits more distinct granular forms, and acquires a tendency to be distributed in stripes or narrow bands. The mode of the reproduction of these globules is quite unknown; but they seem somewhat akin to the slimy deposite of sulphureous mineral waters called *baregine.*

If the study of the acetic ferment be mysterious, it is, however, clear that the conversion of alcohol into vinegar never takes place in the common process without the presence of an albuminous substance, and of the condition favorable to all fermentations, besides the necessary access of air, not only at the commencement (as suffices for the vinous) but during all its course. Hence every weak spirituous liquor which contains an albuminous matter or any ferment may, with contact of air, and a temperature of from 60° to 90° F., give birth to vinegar. If the mixture be too rich in alcohol, or if the azotised matter be absent, or if the temperature be much above or below these two points, the phenomenon of acetification stops. There are, therefore, several indications of the existence of a peculiar vinegar fermentation; though it should be observed that the production of lactic acid (as from fermenting cabbage, starch, &c.) has sometimes misled chemists into the belief of an acetic fermentation. I shall, on this account, point out here briefly the distinction between the two processes.

The acetic fermentation requires the presence of ready formed alcohol and of the air; the lactic, on the contrary, proceeds with starchy or saccharine mixtures, without the intervention of alcohol or of atmospheric oxygen; and when once begun, it will go on of itself. The acetifying process presents, moreover, a striking analogy with the phenomenon of nitrification, in the necessity of an elevated temperature and the influence of porous bodies to divide the particles of the liquids and the air. Thus gaseous ammonia mixed with oxygen, when passed through a tube containing spongy platinum slightly heated, becomes nitric acid; when sulphurous acid gas and oxygen are passed through hot pumice-stone they become sulphuric acid; and when lime or potash, diffused through porous matter, is placed in contact with ammoniacal emanations, in the artificial nitre beds, or nitrifiable soils, nitrate of lime or potash is formed. In like manner, under the influence of spongy platinum, alcohol ($C^4H^4O + H^2O$) and air may, by a true oxidisement of the ethereous part of the alcohol (C^4H^4O) produce aldehyde ($C^4H^4O^2$), which passes afterward into acetic acid ($C^4H^3O^3 +$ water, HO). On these principles we may conceive that vinegar must be readily formed when alcoholic wash, at a proper temperature, is extensively exposed to atmospheric air, by being spread over the surfaces of wooden twigs, or chips in the German *graduators.* In some districts cider is rapidly acetified by being made to trickle cautiously along strings suspended vertically between two vats. See Acetic Acid and Graduator in the dictionary.

AGRICULTURAL CROPS, composition of, by M. Boussingault.—*Ann. de Chem. et Phys.* III. S. p. 234.

Substances.	Ashes inclusive.					Exclusive of Ashes.			
	Carbon.	Hydrogen.	Oxygen.	Azote.	Ashes.	Carbon.	Hydrogen.	Oxygen.	Azote.
Wheat - - -	46·1	5·8	43·4	2·3	2·4	47·2	6·0	44·4	2·4
Rye - - -	46·2	5·6	44·2	1·7	2·3	47·3	5·7	45·3	1·7
Oats - - -	50·7	6·4	36·7	2·2	4·0	52·9	6·6	38·2	2·3
Wheat straw - -	48·4	5·3	38·9	0·4	7·0	52·1	5·7	41.8	0·4
Rye straw - -	49·9	5·6	40·6	0·3	3·6	51·8	5·8	42·1	0·3
Oat straw - .	50·1	5·4	39·0	0·4	5·1	52·8	5·7	41·1	0·4
Potatoes - - -	44·0	5·8	44·7	1·5	4·0	45·9	6·1	46·4	1·6
Beetroot (field) - -	42·8	5·8	43·4	1·7	6·3	45·7	6·2	46·3	1·8
Turnips - - -	42·9	5·5	42·3	1·7	7·6	46·3	6·0	45·9	1·8
Jerusalem artichokes -	43·3	5·8	43·3	1·6	6·0	46·0	6·2	46.1	1·7
Yellow peas - -	46·5	6·2	40·0	4·2	3·1	48·0	6·4	41·3	4·3
Pease straw - -	45·8	5·0	35·6	2·3	11·3	51·5	5·6	40·3	2·6
Red trefoil hay - -	47·4	5·0	37·8	2·1	7·7	51·3	5·4	41·1	2·2
Jerusalem artichoke stems	45·7	5·4	45·7	0·4	2·8	47·0	5·6	47·0	0·4

ALCOHOL, as obtained by the distillation of wine, of fermented corn-wort, or potato syrup, possesses different flavors, which arise from what the Germans call Fusel oil, and which oil differs in those several spirituous liquors. That of wine has been called Onanthic ether. It is resolvable into ether (oxide of ethal), and a peculiar fatty acid, the Onanthic.

The œnanthic ether of corn spirit contains an additional oil, called corn oil, which has a most offensive smell. The potato fusel oil differs from that obtained from grain spirit. It has, at the first impression, in its pure state, a strong, not disagreeable smell, which afterward becomes extremely nauseous, and excites an acrid burning taste. The inhalation of its vapor causes a feeling of oppression, and vomiting. All these fusel oils are readily soluble in alcohol, but not in water, whence, when poured into the latter, they make a milky mixture. The potato fusel oil contains no *solanine* from the potatoes, as has been alleged, though this noxious principle exists in all potatoes, especially after germination. It is not a volatile product.

Corn damaged by rain in harvest-time affords, after mashing and fermentation, a most offensive fusel oil, which irritates the eyes and nostrils, and smells like a solution of cyanogen in alcohol. Spirits so contaminated intoxicate more powerfully than purer spirits, and are apt to bring on temporary madness and subsequent indisposition. This noxious substance does not combine with gases; and, being more volatile than alcohol, it may be drawn off by distillation in a concentrated state. It is separated to a considerable degree in Germany by diluting the foul spirits with water, mixing in a portion of olive or other bland oil, letting the oil gather on the top, drawing off the spirituous liquor from below, and subjecting it to rectification. When the spirit so rectified is kept for 2 or 3 months in a cask, corked, but not too closely, the noxious œnanthic compound disappears, in some measure by its spontaneous decomposition. For statistics and excise-proof table, see Spirits.

The high price of alcohol in this country, in consequence of the heavy fiscal duties, and its low price in most other countries, where it is nearly duty free, has led to its contraband importation under various disguises. Sometimes it is introduced under the mask of oil of turpentine, from which it can be sufficiently freed by rectification for the purpose of the gin manufacturers. Sometimes it is disguised with wood naphtha, or wood vinegar; from the latter of which it may be separated by distillation in a water bath; but from the former it is more difficult to extricate it, as alcohol and wood spirit are nearly equally volatile. It has also been disguised with coal naphtha; but from this it may be easily separated by distillation, on account of the great difference between the boiling points of the two liquids; besides, coal naphtha will not combine with water, as alcohol does.

When the object is to discover whether wood spirit contains alcohol, we may proceed as follows: Add to the suspected liquid a little nitric acid, of specific gravity 1·45. If alcohol be present, in even small proportions, an effervescence will ensue, from the evolution of etherised nitrous gas, with its characteristic ethereous smell. On treating the mixture with a nitrous solution of mercury, as in the process for fulminate of mercury, an effervescence will take place, the dense vapor of etherised mercurial gas will appear, and a certain proportion of fulminate will be formed, corresponding pretty closely to the proportion of alcohol in the wood naphtha mixture.

As the boiling point of wood spirit is only about 145°, while that of alcohol, of like specific gravity (0·825), is 173° F., a good criterion of the proportion of the two liquids present in the mixture may be found in its boiling temperature.

Pure wood spirit, when mixed with the above nitric acid, becomes of a ruby tint, but remains tranquil. Alcohol continues colorless, but enters into violent ebullition, and is nearly all dissipated in fumes.

Alcohol diluted with water has a less resultant density than wood spirit of like strength similarly diluted. While alcohol thus becomes of 0·920, wood spirit becomes 0·926 or 0·927.

If wood spirit be contained in alcohol, it may be detected to the greatest minuteness by the test of caustic potash, a little of which, in powder, causing wood spirit to become speedily yellow and brown, while it gives no tint to alcohol. Thus 1 per cent., of wood spirit may be discovered in any sample of spirits of wine. For further details upon this analytical inquiry, see my pamphlet, entitled *The Revenue in Jeopardy.*

ALGAROVILLA. This substance is called by the Spaniards *Algaroba*, from the resemblance it bears to the fruit of the Carob (*Ceratonia siliqua*), which is a native of Europe, in the southern countries of Spain and Portugal. The substance lately analysed by me is the fruit of a tree which grows in Chile, of which the botanical name is *Prosopis pallida*, according to Captain Bagnald, R. N., who first brought a sample of it to this country in the year 1832. It consists of pods bruised and agglutinated more or less with the extractive exudation of the seeds and husks. According to a more recent determination, algarovilla is said to be the product of the tree Juga Marthæ of Santa Martha, a province of New Carthagena.

It is an astringent substance replete with tannin, capable, by its infusion in water, of tanning leather, for which purpose it possesses more than four times the power of good oak bark. Its active matter is very soluble in water at a boiling temperature. The seeds are merely nutritive and demulcent, but contain no astringent property. This resides in the husks. The seeds in the entire pod constitute about 1-5th of the weight, and they are three or four in number in each oblong pod. Alcohol of 60 per cent. over proofs dissolves 64 parts in 100 of this substance. The solution consists chiefly of tannin, with a very little resinous matter. Water dissolves somewhat more of it, and affords a very styptic-tasted solution, which precipitates solution of isinglass very copiously, like infusion of galls and catechu. Its solution forms with sulphate of iron a black precipitate, which is kept floating by means of the gum present, and thereby constitutes good ink. My report to the merchant was written with a combination thus made, in proportions taken at random; and there is no doubt that by using a stronger decoction of the algarovilla, along with a proper proportion of copperas, an excellent black ink might be prepared without any other addition.

I find that a decoction of the algarovilla affords with cotton cloth, mordanted with tin solution, as also with acetate of alumina liquor, a brilliant yellow die; the former being the brighter and fuller of the two.

A tincture of algarovilla might be used as an astringent in medicine; or probably a decoction of the whole substance would be preferable, on account of the demulcent quality of the seeds when bruised. As an article of commerce it can not be rated at a high price, nor should it pay much duty till its value as an article of manufactures or medicine be fully ascertained.

ALMONDS. Imported in 1839, 28,261 cwt.; in 1840, 27,566. Retained for consumption, 9,785 and 7,935, respectively.

ALUM. In the alum works on the Yorkshire coast, 8 different liquors are met with.

1st. "Raw Liquor." The calcined alum shale is steeped in water till the liquor has acquired a specific gravity of 9 or 10 pennyweights, according to the language of the alum-maker.

2d. "Clarified Liquor." The raw liquor is brought to the boiling point in lead pans, and suffered to stand in a cistern till it has cleared: it is then called clarified liquor. Its gravity is raised to 10 or 11 pennyweights.

3d. "Concentrated Liquor." Clarified liquor is boiled down to about 20 pennyweights. This is kept merely as a test of the comparative value of the potash salts used by the alum-maker.

4th. "Alum Mother Liquor." The alum pans are fed with clarified liquor, which is boiled down to about 25 or 30 pennyweights, when a proper quantity of potash salt in solution is mixed with it, and the whole run into coolers to crystallize. The liquor pumped from these rough crystals is called "alum mothers."

5th. "Salts Mothers." The alum mothers are boiled down to a crystallizing point, and afford a crop of "Rough Epsom," which is a sulphate of magnesia and protoxide of iron.

6th and 7th. "Alum Washings." The rough crystals of alum (No. 4), are washed twice in water, the first washing being about 4 pennyweights, the second about $2\frac{1}{2}$, the difference in gravity being due to mother liquor clinging to the crystals.

8th. "Tun Liquor." The washed crystals are now dissolved in boiling water, and run into the "roaching tuns" (wood vessels lined with lead) to crystallize. The mother liquor of the "roach alum" is called "tun liquor;" it is, of course, not quite so pure as a solution of roach alum in water.

The alum-maker's sp. gr. bottle holds 80 pennyweights of water, and by 10 pennyweights he means 10 more than water, or 90.

The numbers on Twaddle's hydrometer, divided by 2·5, gave alum-maker's pennyweights.

The alum-maker tests his samples of potash salts comparatively by dissolving equal weights of the different samples in equal measures of alum liquor at 20 pennyweights, heated up to the boiling point, and weighing the quantity of alum crystals produced on cooling.

For the above information I am indebted to my friend Mr. Maurice Scanlan, who superintended for some time the Mulgrave alum works.

He informs me that $61\frac{1}{2}$ tons of the alum rock at the Mulgrave works to the north of Whitby, yield, after calcination, &c., one ton of alum.

It has been computed that with sulphur at 6*l.* per ton, sulphuric acid of spec. grav. 1·750 can be produced at 3*l.* per ton, including the mere cost of making: this acid contains 2 atoms of water: 174 tons of this acid, and $87\frac{1}{4}$ tons of sulphate of potash, with the pipe-clay, will form 474 tons of alum; so that the neat cost would be 522*l.*, for the acid+1047*l.* for the sulphate of potash=1569*l.*; which sum, divided by 474, gives a quotient of 3*l.* 6*s.* for the neat cost of 1 ton of alum by the direct process.

At the pit 1 ton of alum, rock or mine, coast 3*l.* 4*s.*; to which, adding the cost of the potash salt for 1 ton of alum, 3*l.* 15*s.*, they constitute together an amount of 6*l.* 19*s.* From the latter sum 1*l.* 10*s.* must, however, be deducted for the value of rough Epsom salt produced, leaving a balance of 5*l.* 9*s.* for the cost of a ton of mine-alum, prior to evaporation and crystallization.

A patent was obtained in November, 1839, by Mr. William Wiesmann, of Duesburg, for improvements in the manufacture of alum. He subjects potter's clay to a moderate red heat, grinds it, and subjects the powder, in leaden pans, to the action of concentrated sulphuric acid (66° Beaumé), taking care to use excess of clay and a moderate heat. This mixture is to be stirred till it is dry, then treated with boiling water, in order to dissolve the sulphate of alumina formed. So far the process is old and well-known. The novelty consists in freeing the saline solution from iron by ferrocyanure of potassium (prussiate of potash). When the iron has been all thrown down in the form of prussian blue, the liquor is allowed to settle, the supernatant pure sulphate is drawn off, and evaporated till it forms on cooling a concrete mass, which may be moulded into the shape of bricks, &c., for the convenience of packing. He proposes to crystallize his alum; but he will find this process rather difficult. The prussian blue obtained may be reconverted by any alkaline solution into a ferrocyanide, and again employed on a fresh quantity of the raw sulphate. How he is to precipitate the iron by sulphate of lime, as he states, I can not comprehend.

Dr. Turner's process for making alum from felspar is thus described by him in the specification of his patent, sealed October 8, 1842. If it be desired to make a potash alum, the best substance to operate upon is a potash felspar. This felspar is ground in a common edge-stone mill to the consistency of fine sand (a process which is much assisted by first heating it to redness, and then plunging it in cold water); it is then mixed with its own weight of sulphate of potash, and placed in the upper part of the inclined bed of a reverberatory furnace (being such a furnace as is known in the potteries as a frit furnace), and which furnace has previously been brought to a full white heat. When by the action of the heat a glass has been produced, and is obtained to flow down the inclined bed of the furnace, to such glass is to be added gradually, at the lower end of the furnace, as much carbonate of potash as was before used of sulphate of potash. And this process of placing the mixture of felspar and sulphate of potash at the upper part of the bed of the furnace is to be repeated, adding at the lower part of the bed, gradually and proportionally, as the glass flows down from the upper part, the carbonate of potash, as before mentioned. This is continued until the sack of the furnace is filled with the glass; this glass is then fit for the next process. The preparation of the glass may also be affected in a reverberatory furnace with a flat bed; and the facility of removing the glass from such a furnace is an advantage. In this case no carbonate must be added to the mixture until the sulphate of potash is observed to be completely decomposed. On boiling in water the glass thus obtained, the same quantity of potash as was added to the felspar and two thirds of the silica contained in the felspar are dissolved, while the remaining one third of the silica and the alumina, and an equal quantity of potash as the felspar originally contained, are left in the form of a light porous substance, similar in chemical composition to the mineral commonly called elæolite; this porous substance is carefully separated from the said solution, and washed with water until freed from the silicate of potash, then placed in an open leaden cistern or boiler, and boiled with dilute sulphuric acid of the specific gravity 1·2 (one and two tenths). This acid will contain about the quantity of water required for the solution and crystallization of the alum produced by the decomposition of the elæolite; the quantity of the dilute sulphuric must be such as will contain about 160 lbs. of dry sulphuric acid for every 285 lbs. of felspar rock (if that rock be used), and in like proportion to the silica and alumina contained in the substance, if any other substance be used, as it is important that the alum solution thus obtained should not contain an excess of acid. I recommend that only four fifths of the proposed quantity of dilute sulphuric acid should be used in the first operation, which will leave a portion of the elæolite undecomposed; but by acting upon this undecomposed portion, after the solution has been drawn off, with the full quantity of dilute acid to be used in the next operation, it will be completely decomposed, and the alum thus formed becomes part of the next batch. In this way a neutral solution of alum is obtained at each process. The boiling solution, after the sediment subsides, is drawn into coolers, such as are commonly used for the crystallization of alum; here about four fifths of the alum held in solution will form into crystals. The mother-liquor from the coolers is boiled in any convenient boiler to dryness, in order to render the silica it contains insoluble; the residuum is boiled either in water or in the mother-liquor from the roaching tubs, so as to dissolve the alum it contains, and the process of crystallization repeated. Had the above process been performed with the salts of soda instead of potash, a soda alum would have been formed. For this purpose the soda felspar or albite should be selected. The potash or soda (as the case may be) contained in the liquor, drawn as aforesaid from the elæolite (or nepheline, which is formed when soda is used), may be recovered by either of the following processes: The strong solutions which are obtained, about the specific gravity of 1·2 are placed in any convenient vessel in which a stream of carbonic acid gas, obtained in any convenient method, may be driven through them, the carbonic acid becomes absorbed, and the solution assumes the form of a gelatinous mass: this mass consists of carbonate of potash or soda and hydrate of silica. On drying this mass in a furnace, which must never be allowed to rise to red heat even in the dark, the silica loses its water and becomes insoluble; the potash or soda may then be separated from it in the form of a sesquicarbonate of potash or soda, by solution and evaporation to dryness. The other process, which under most circumstances will be found more economical and convenient, is to allow the boiling solution of silicate of potash or soda to filter through a bed of caustic lime, when it will be found that the lime has combined with the silicate, and a caustic potash or soda ley is obtained. This process may be conveniently conducted in an apparatus similar to that used by soap-makers for the preparation of their caustic leys. The potash or soda may then be readily obtained as caustic potash or soda, or as carbonate, by the known processes used in making soda. The weak solutions of silicate of potash or soda are used to decompose another portion of the glassy substance.

Now I do not claim as new, or as my invention, any particular form of vessel or apparatus in which or with which my operations may be conducted; nor do I claim any particular proportions in which the alkaline salts may be used. But I claim as new, and as my invention, the improvements aforesaid, and the production of substances similar to elæolite and nepheline artificially, by the decomposition by water of the glassy substances produced by the fusing of felspar as aforesaid, or other mineral substances containing silica and alumina, with salts of potash and soda, as aforesaid, and the use and application of such artificial elæolite and nepheline in the production and manufacture of alum, as aforesaid. I also claim the process, as above described, for separating the alkalies from silica by means of caustic lime.

ANCHOVIES, ESSENCE OF. I insert this article to show on what slender pretence of invention a patent may be obtained. Mr. John Masters, of Leicester, makes his improved transparent preparation, by placing in a kettle any given quantity of anchovies in the state in which they are imported, along with their own weight of water, exposing the kettle to a simmering heat for two or three hours, removing the kettle, and straining its contents when cold, first by suitable pressure through a strong canvas bag, and next filtered through a flannel or paper till a clear liquor is obtained. If it be desired to render the essence thicker, the material used for this purpose should be transparent. He says that flour is used for thickening the common essence. I presume he would prefer gelatine, gum, or arrow root for his transparent thickening, though he does not specify anything.

ANNOTTO or ANNATTO. Imported in 1839, 303,489 lbs.; in 1840, 108,469. Retained for consumption, 224,794 and 330,490, respectively.

ARCHIL has been lately the object of numerous chemical researches, but hitherto, it must be owned, without producing any results useful to the dyer, so as to promote the solidity of this beautiful and now cheap dye. The new experiments of Schunk, performed in Liebig's laboratory, tend to show that the whole matter is still involved in much mystery. By the action of either on the *Variolaria lactea* (one of the archil lichens), in an apparatus of displacement, he obtained crystals, which he calls *lecanorine.* It is convertible into the *orcine* of Robiquet and Heeren by hot barytes water. When moistened with water of ammonia, and exposed to the air, it gradually assumes the archil tint. Liebig is of opinion, that this product, and some other analogous ones, vary according to the nature of the solvents and the temperature of the digestions, so that they probably are mere metamorphoses of the self-same one or two substances, pre-existing in the lichens. Since *lecanorine* is decomposed by boiling water into carbonic acid, and orcine, it may also undergo this change from the boiling alcohol employed in Schunk's researches.

When ammonia acts upon orcine, it gives it a dark blood-red color, and converts it into *orceine*, a new compound containing azote, but in a different state of combination from what it is in ammonia. This orceine is the true coloring matter of the archil or orseille; and, according to Robiquet, it is here in the state of an *orceate* of ammonia, requiring for its production the co-operation of air and water. In these circumstances the orceine absorbs oxygen, and is transformed into orceate of ammonia, without any other product, even carbonic acid, being formed. *Variolarine*, *erythrine*, and *psuedo-erythrine*, three products obtained by Robiquet and Heeren; the first from *Variolaria dealbata*, the second and third from *Parmelia roccella*, and *Lecanora tartarea*, are interesting merely in a scientific point of view. The last two are transformed into red coloring matters by ammonia and air. "Latterly," says Liebeg, "Kane has made these two substances objects of a particular investigation; but the researches of this chemist are far, as appears to me, from clearing up their history."* I need not therefore, give any account of these researches, which occupy a large portion of a recent volume of the Philosophical Transactions.

Tournesole, or litmus, consists, according to Peretti, of a red coloring matter, rendered blue by combination with ammonia.

ARROW ROOT. This plant has been lately cultivated with great success, and its root manufactured in a superior manner, upon the Hopewell estate, in the island of St. Vincent. It grows there to the height of about 3 feet, and it sends down its tap roots from 12 to 18 inches into the ground. Its maturity is known by the flagging and falling down of the leaves, an event which takes place when the plant is from 10 to 12 months old. The roots being dug up with the hoe are transported to the washing-house, where they are thoroughly freed from all adhering earth, and next taken individually into the hand, and deprived by a knife of every portion of their skins, while every unsound part is cut away. This process must be performed with great nicety, for the cuticle contains a resinous matter, which imparts color and a disagreeable flavor to the fecula, which no subsequent treatment can remove. The skinned roots are thrown into a large cistern, with a perforated bottom, and there exposed to the action of a copious cascade of pure water, till this runs off quite unaltered. The cleansed roots are next put into the hopper of the mill, and are subjected to the powerful pressure of two pairs of polished rollers of hard brass; the lower pairs of rollers being set much closer together than the upper. (See the accompanying figure.) The starchy matter is thus ground into a pulp, which falls into the receiver placed beneath, and is thence transferred to large fixed copper cylinders, tinned inside, and perforated at the bottom with numerous minute orifices, like a kitchen drainer. Within these cylinders, wooden paddles are made to revolve with great velocity, by the power of a water-wheel, at the same time that a stream of pure water is admitted from above. The paddle-arms beat out the fecula from the fibres and parenchyma of the pulp, and discharge it in the form of a milk through the perforated bottom of the cylinder. This starchy water runs along pipes, and then through strainers of fine muslin into large reservoirs, where, after the fecula has subsided, the supernatant water is drawn off, and fresh water being let on, the whole is agitated and left again to repose. This process of ablution is repeated till the water no longer acquires anything from the fecula. Finally, all the deposites of fecula of the day's work are collected into one cistern, and, being covered and agitated with a fresh charge of water, are allowed to settle till next morning. The water being now let off, the deposite is skimmed with palette knives of German silver, to remove any of the superficial parts, in the slightest degree colored; and only the lower, purer, and denser portion is prepared by drying for the

* Traité de Chimie Organique, tom. ii., p. 477.

market. The drying-house on the Hopewell estate is constructed like the hot-house of an English garden. But instead of plants, it contains about 4 dozen of drying pans made of copper, $7\frac{1}{2}$ feet by $4\frac{1}{2}$, and tinned inside. Each pan is supported on a carriage, having iron axles, with lignum vitæ wheels, like those of a railway carriage, and they run on rails. Immediately after sunrise, these carriages with their pans covered with white gause, to exclude dust and insects, are run out into the open air, but if rain be apprehended, they are run back under the glazed roof. In about 4 days the fecula is thoroughly dry and ready to be packed, with German silver shovels, into tins or American flour barrels, lined with paper attached with arrow root paste. The packages are never sent to this country in the hold of the ship, as their contents are easily tainted by noisome effluvia, of sugar, &c. By such a skilful series of operations, and by such precautions, the arrow root thus manufactured may vie with any similar preparation in the Bermudas or any other part of the world. I have found it, on analysis and trial, to be pure, powerful, and agreeable, and a most wholesome article of food.

Fig. 1. Plan of arrow root grinding-mill, and of 2 sets of copper cylinder washing-

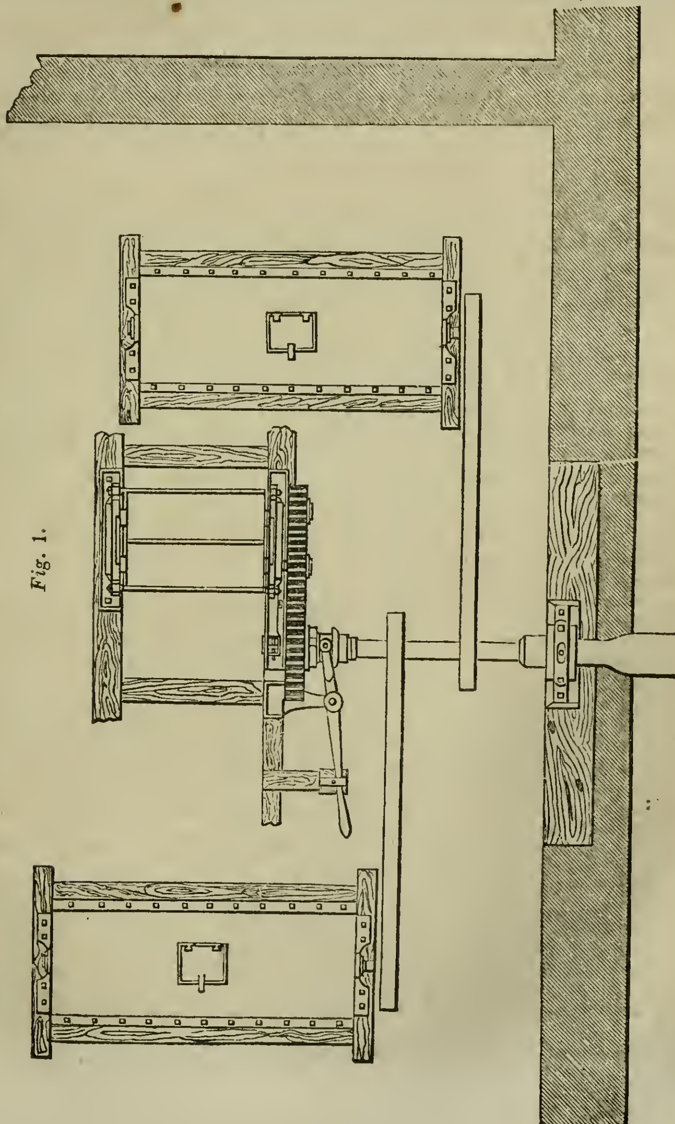
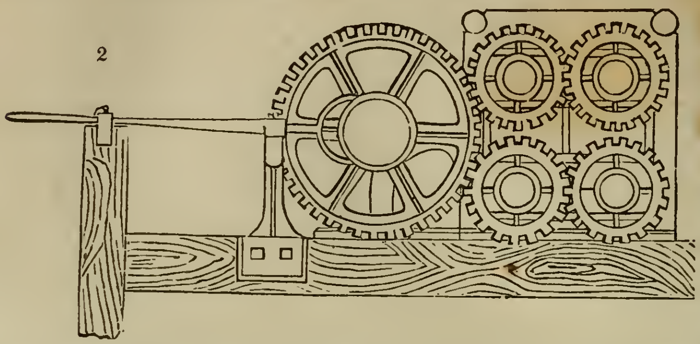


Fig. 1.

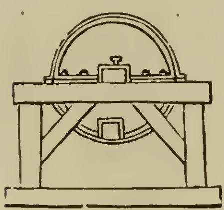
machines, with the connecting machinery for driving them; the washing agitator being driven from the connecting shaft with leathern belts. *Fig.* 2. End elevation of arrow-

2



root mill, with wheels and pinions, disengaging lever, &c. *Fig.* 3. End elevation of copper washing-cylinders, with press-framing, &c. The washing-cylinders are $6\frac{1}{2}$ feet long and $3\frac{1}{2}$ in diameter. The mill-rollers are 3 feet long and 1 foot in diameter.

3



The uses of arrow root are too well known and acknowledged to require recounting here. It is the most elegant and the richest of all the feculas, and being now manufactured, with the advantage of excellent machinery, and abundance of pure water, in the fertile island of St. Vincent, it may be brought into our market at a much more moderate price than it has heretofore been supplied from less favored localities. The Bermuda arrow root is treated necessarily with rain water collected in tanks, and therefore is occasionally soiled with insects, from which the St. Vincent article is entirely free.

The presence of potato starch in arrow root may be discovered by the microscope. Arrow root consists of regular ovoid particles of nearly equal size, whereas potato starch consists of particles of an irregular ovoid or truncated form, exceedingly irregular in their dimensions, some being so large as $\frac{1}{300}$ of an inch, and others only $\frac{1}{2000}$. But the most convenient test is dilute nitric acid of 1·10 (about the strength of single aquafortis), which, when triturated in a mortar with the starch, forms immediately a transparent very viscid paste or jelly. Flour starch exhibits a like appearance. Arrow root, however, forms an opaque paste, and takes a much longer time to become viscid. (*Dr. Scharling in Liebig's Annalen.*)

Arrow root may be distinguished from potato starch, not only by the different size of its particles, but by the difference of structure. Their surfaces in the arrow root are smooth, and free from the streaks and furrows seen in the potato particles by a good microscope. The arrow root, moreover, is destitute of that fetid unwholesome oil, extractable by alcohol from potato starch.

Liebig places the powers of arrow root, as a nutriment to man, in a very remarkable point of view, when he states that 15 pounds of flesh contain no more carbon for supplying animal heat by its combustion into carbonic acid in the system, than 4 pounds of starch; and that if a savage, with one animal and an equal weight of starch, could maintain life and health for a certain number of days, he would be compelled, if confined to flesh alone, in order to procure the carbon necessary for respiration, during the same time, to consume five such animals.

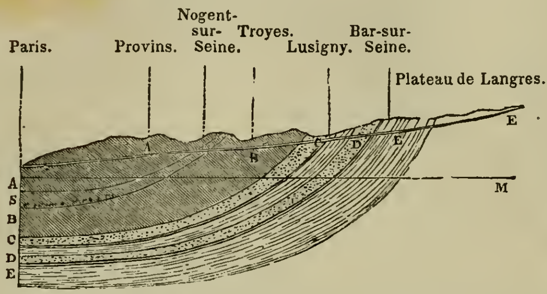
Arrow root imported in 1839, 303,489; in 1840, 408,469 lbs.; retained for consumption, 224,794 and 330,490 lbs. respectively.

ARTESIAN WELLS. *Fig.* 4,* represents the manner in which the condensed water of the heavens distributes itself under the surface of our globe. Here we have a geological section, showing the succession of the several formations, and the sheets or laminæ of water that exist at their boundaries, as well as in their sandy beds. The figure shows also very plainly that the height to which the water reascends in the bore of a well, depends upon the height of the reservoir which supplies the sheet of water to which the well is perforated. Thus the two wells, A, *a*, having gone down to

* At the end of the volume.

the two aqueous expanses below, whose respective waters of supply are derived from the percolations M A′ and M B′, will afford rising waters, which will come to the surface; while in the well B, supplied by the sheet P, C′ D′, the waters will spout above the surface, and in the well C they will remain short of it. The same figure shows that these wells often traverse sheets of water that rise to different heights. Thus in the well C, there are five columns of ascending waters, which rise to heights proportional to the points whence they take their origin. Several of these will be spouting or overflowing, but some will remain beneath the surface.

4



The older geological formations are seldom propitious to the construction of Artesian wells, on account of the compact massiveness of their rocks, of the few fissures or porous places in them, and of the rarity of filtering strata overlying retentive ones. It is therefore vain to attempt the formation of an overflowing spring, upon the above principles, in territories of granite, gneiss, mountain limestone, and basalt. Among transition and secondary formations, such wells will rarely furnish a supply of good water. The latter strata of alternating clay and variegated sandstone contain so much gypsum and rock salt as to impregnate therewith the waters derived from them to an unpalatable degree. It is in the sandy, calcareous, and argillaceous strata of the Jura limestone, indeed, that borings may most probably be made for brine springs. The hot springs which burst out of the ground in primitive rocky districts come undoubtedly from a great depth under the surface, and derive their temperature, and also probably their waters, from the vapors of deep-seated volcanoes in connexion with the sea. A miniature representation of such springs is exhibited in the intermitting fountains of fresh water on the shoulder of Vesuvius. Springs of this kind, which vary with the seasons, may derive a portion of their water from the surface of the earth, from which it may sink through clefts in the primitive rocks, till meeting in its descent with stony obstructions and ascending steam, it is forced to remount in a heated state to the day, like the Geisers in Iceland. The most remarkable example of an Artesian well is that recently formed at Grenelle, a suburb at the southwest of Paris, where there was a great want of water. It cost eight years of difficult labor to perforate. The geological strata round the French capital are all of the tertiary class, and constitute a basin, like that shown in *fig.* 4. The bottom of this basin is chalk; A A are tertiary strata above the chalk; B B, chalk or cretaceous carbonate of lime; C C, D D, green sand and clay; E E, oolite and Jura limestone (*muschelkalk*); E A, general slope of the surface of the country from Langres to Paris; M A, the level of the sea. Over a circular space, of which Paris is the centre, and which is bounded by the towns of Laon, Mantes, Blois, Sancerre, Nogent-sur-Seine, and Epernay, these strata are found upon the surface, concealing the chalk; but on the other side of these towns, the edge of the basin being passed, the chalk is generally the superficial bed. By looking at the order of these tertiary strata, it is easy to perceive the obstacles that M. Malot, the engineer of the well, had to overcome, and the difficulty and hazard of his undertaking. The surface at Grenelle consists of gravel, pebbles, and fragments of rock, which have been deposited by the waters at some period anterior to any historical record. Below this layer of detritus, it was known to the engineer, by geological induction, as well as previous experience, that at Grenelle, marl and clay would be found, instead of the limestone which generally forms the immediately subjacent stratum. He was aware that he had to bore about 440 yards ! deep before he should arrive at the sheet of water (S, *figure*) which flows in the gravel below the limestone, and supplies the wells of St. Ouen, St. Denis, and Stains. Underneath the marl and the clay, the boring rods had to perforate pure gravel, plastic clay, and finally chalk, which forms the bottom of the general tertiary basin, as we have seen. No calculation from geological data could determine the thickness of this stratum of chalk, which, from its powers of resistance, might present an almost insuperable obstacle. The experience acquired in boring the wells of

Elbeuf, Rouen, and Tours, was in this respect but a very imperfect guide. But supposing this obstacle to be overcome, was he sure of finding a supply of water below this mass of chalk? In the first place, the strata C D below the chalk possessed, as we shall see, all the necessary conditions for producing Artesian springs, namely, successive layers of clay and gravel, or of pervious and impervious beds. M. Malot confidently relied on his former experience of the borings of the wells at Rouen, Elbeuf, and Tours, where abundant supplies of water had been found below the chalk, between similar strata of clay and gravel.

But one other condition is requisite to ensure the rising of the water in an Artesian well, namely, that the feeding level of infiltration should be higher than the orifice in the bore above which the water is to ascend. This, however, turned out to be the case with Grenelle. M. Arago had shown that the water of the spring here would necessarily rise to the surface, because in the well at Elbeuf, which is nearly 9 yards above the level of the sea, the water rises from 27 to 29 yards above the surface of the earth, and, consequently, from 36 to 38 yards above the ocean level. Now, as the orifice of the bore at Grenelle is only 34 yards above the same level, it follows, that if the identical spring be met with, the water must rise above the earth's surface at Grenelle.

The necessary works were commenced with boring rods about 9 yards long, attached to each other, and which could be raised or lowered by mechanical power, while an ingenious method was adopted for giving them a rotary motion. The diameter of the bore was about 6 inches. The instrument affixed to the end of the lowest boring rod was changed according to the different strata which were successively attacked; the form suited for passing through the softer materials near the surface being unsuitable for boring through the chalk and flint, as a hollow tube was used for the former, while a chisel-shaped tool was employed to penetrate the latter. The size of the rods was lessened as the depth increased; and, since the subterranean water was not reached so soon as was expected, it became requisite to enlarge five several times the diameter of the bore, in order to permit the work to be successfully prosecuted. Accidents occurred which tried the patience of the projectors. In May, 1837, when the boring had extended down to a depth of 418 yards, the hollow tube, with nearly 90 yards of the long rods attached to it, broke, and fell to the bottom of the hole, whence it became necessary to extract the broken parts before any further progress could be made. The difficulty of accomplishing this task may be conceived; for the different fragments were not all extracted until after the constant labor of 15 months. Again, in April, 1840, in passing through the chalk, the chisel attached to the boring rod got detached, and before it could be recovered, several months were spent in digging around about it. A similar occurrence created an obstacle which impeded the work for 3 months, but, instead of withdrawing the detached part, it was forcibly driven down among the stratum of gravel. At length, in February, 1841, after 8 years' labor, the rods suddenly descended several yards, having pierced into the vault of the subterranean waters so long sought after by the indefatigable engineer. A few hours afterward, he was rewarded for all his anxious toils; for lo! the water rose to the surface, and discharged itself at the rate of 600,000 gallons per hour!

The depth reached down was 602 yards, or about three times the height of St. Paul's. The pipe by which the water reaches the surface has been recently carried to a height nearly level with the source of supply. The portion of the pipe above the ground is surrounded with a monumental pagoda of ornamental carpentry, and it discharges a circular cascade of clear water continually into a circular iron reservoir, to be thence conveyed by a lateral pipe to the ground. The water is well adapted for all domestic uses, and it will be unfailing, being supplied from the infiltration of a surface of country nearly 200 miles in diameter. The Artesian wells of Elbeuf, Rouen, and Tours, which were formed many years ago, overflow in never-varying streams; and the ancient Artesian well at Lillers, in the Pas de Calais, has for about seven centuries furnished a constant and equable supply.

The opportunity of ascertaining the temperature of the earth at different depths, was not neglected during the progress of the works at Grenelle. Thermometers placed at a depth of thirty yards in the wells of the Paris Observatory invariably stand at 53° Fahrenheit. In the well at Grenelle the thermometer indicated 74° F. at a depth of 442 yards, and at 550 yards it stood at 79°. At the depth finally arrived at of 602 yards, the temperature of the water which rose to the surface was 81°, corroborating previous calculations on the subject. For a descent of 572 yards there is an increase of temperature equal to 28° F., which is 20·4 yards, or 61·2 feet for each degree of that scale. Now that the skilful labor of so many years is terminated, the Parisians regret that the subterranean sheet of water had not lain 1,000 yards beneath the surface, that they might have had an overflowing stream of water at 104°, to furnish a cheap supply to their numerous hot-bath establishments.

ASPHALTIC PAVEMENT; see BITUMEN.

B.

BALSAM OF CAPIVI, or *Copaiva Balsam.* This substance, which is extensively used in medicine, is often adulterated. Formerly some unctuous oil was mixed with it, but as this is easily discovered by its insolubility in alcohol, castor oil has since been used. The presence of this cheaper oil may be detected, 1, by agitating the balsam with a solution of caustic soda, and setting the mixture aside to repose; when the balsam will come to float clear on the top, and leave a soapy thick magma of the oil below; 2, when the balsam is boiled with water, in a thin film, for some hours, it will become a brittle resin on cooling, but it will remain viscid if mixed with castor oil; 3, if a drop of the oil on white paper be held over a lamp, at a proper distance, its volatile oil will evaporate and leave the brittle resin, without causing any stain around, which the presence of oil will produce; 4, when three drops of the balsam are poured into a watch-glass, alongside of one drop of sulphuric acid, it becomes yellow at the point of contact, and altogether of a saffron hue when stirred about with a glass rod, but if sophisticated with castor oil, the mixture soon becomes nearly colorless like white honey, though after some time the acid blackens the whole in either case; 5, if 3 parts in bulk of the balsam be mixed with 1 of good water of ammonia (of 0·970 sp. grav.) in a glass tube, it will form a transparent solution, if it be pure, but will form a white liniment if it contain castor oil; 6, if the balsam be triturated with a little of the common magnesia alba, it will form a clear solution, from which acids dissolve out the magnesia, and leave the oil transparent if it be pure, but opaque if it be adulterated. When turpentine is employed to falsify the balsam, the fraud is detected by the smell on heating the compound.

BARILLA. Imported in 1841, 2,131 tons; in 1842, 2,141. Retained for consumption, 2,369 and 2,139, respectively.

BEER. The Germans from time immemorial have been habitually beer-drinkers, and have exercised much of their technical and scientific skill in the production of beer of many different kinds, some of which are little known to our nation, while one at least, called Bavarian, possesses excellent qualities, entitling it to the attention of all brewers and consumers of this beverage. The peculiarities in the manufacture of Bavarian beer have recently attracted the attention of the most eminent chemists in Germany, especially of Professor Liebig, and much new light has thereby been thrown upon this curious portion of vegetable chemistry, which I shall endeavor to reflect upon the present article.

The following is a list of the principal beers at present brewed in Germany :—

1. Brown beer of Merseburg; of pure barley malt.
2. — — barley malt and beer-root sugar.
3. — barley malt, potatoes, and beet-root syrup.
4. — refined beet-root syrup alone.
5. Covent or thin beer.
6. Berlin white beer, or the Champagne of the north.
7. Broyhan, a famous Hanoverian beer.
8. Double beer of Grünthal.
9. Bavarian beer; 1. Summer beer; 2. Winter beer.
10. — Bock-beer.
11. Wheat *Lager*-beer (slowly fermented).
12. White bitter beer of Erlangen.

Considerable interest among men of science, in favor of the Bavarian beer process, has been excited ever since the appearance of Liebig's Organic Chemistry, first published about three years ago. In the introduction to this admirable work, he says:

"The beers of England and France, and the most part of those of Germany, become gradually sour by contact of air. This defect does not belong to the beers of Bavaria, which may be preserved at pleasure in half-full casks, as well as full ones, without alteration in the air. This precious quality must be ascribed to a peculiar process employed for fermenting the wort, called in Germany *untergährung*, or fermentation from below; which has solved one of the finest theoretical problems.

"Wort is proportionally richer in soluble gluten than in sugar.* When it is set to ferment by the ordinary process, it evolves a large quantity of yeast, in the state of a thick froth, with bubbles of carbonic acid gas attached to it, whereby it is floated to the surface of the liquid. This phenomenon is easily explained. In the body of the wort alongside of particles of sugar decomposing, there are particles of gluten being oxidized

* It does not surely contain more gluten than it does sugar; at least no experiments, known to me, prove this proposition.

at the same time, and enveloping as it were the former particles, whence the carbonic acid of the sugar and the insoluble ferment from the gluten being simultaneously produced, should mutually adhere. When the metamorphosis of the sugar is completed, there remains still a large quantity of gluten dissolved in the fermented liquor, which gluten, in virtue of its tendency to appropriate oxygen, and to get decomposed, induces also the transformation of the alcohol into acetic acid (vinegar). But were all the matters susceptible of oxidizement as well as this vinegar ferment removed, the beer would thereby lose its faculty of becoming sour. These conditions are duly fulfilled in the process followed in Bavaria.

"In that country the malt-wort is set to ferment in open backs, with an extensive surface, and placed in cool cellars, having an atmospheric temperature not exceeding 8° or 10° centigrade (46½° or 50° F.). The operation lasts from 3 to 4 weeks; the carbonic acid is disengaged, not in large bubbles that burst on the surface of the liquid, but in very small vesicles, like those of a mineral water, or of a liquor saturated with carbonic acid, when the pressure is removed. The surface of the fermenting wort is always in contact with the oxygen of the atmosphere, as it is hardly covered with froth, and as all the yeast is deposited at the bottom of the back under the form of a very viscid sediment, called in German *unterhefe*.

"In order to form an exact idea of the difference between the two processes of fermentation, it must be borne in mind that the metamorphosis of gluten and of azotized bodies in general is accomplished successively in two principal periods, and that it is in the *first* that the gluten is transformed in the interior of the liquid into an insoluble ferment, and that it separates alongside of the carbonic acid proceeding from the sugar. This separation is the consequence of an absorption of oxygen. It is, however, hardly possible to decide if this oxygen comes from the sugar, from the water, or even from an intestine change of the gluten itself, or, in other words, whether the oxygen combines directly with the gluten, to give it a higher degree of oxidation, or whether it lays hold of its hydrogen to form water.

"This oxidation of the gluten, from whichever cause, and the transformation of the sugar into carbonic acid and alcohol, are two actions so correlated, that by an exclusion of the one, the other is immediately stopped."

The *superficial* ferment (*oberhefe* in German) which covers the surface of the fermenting works is gluten oxidized in a state of putrefaction; and the ferment of *deposite* is the gluten oxidized in a state of *érémacausie.*

The surface yeast, or barm, excites in liquids containing sugar and gluten the same alteration which itself is undergoing, whereby the sugar and the gluten suffer a rapid and tumultuous metamorphosis. We may form an exact idea of the different states of these two kinds of yeast by comparing the *superficial* to vegetable matters putrefying at the bottom of a marsh, and the *bottom* yeast to the rotting of wood in a state of *érémacausie*, that is, of slow combustion. The peculiar condition of the elements of the *sediment* ferment causes them to act upon the elements of the sugar in an extremely slow manner, and excites the change into alcohol and carbonic acid, without that of the dissolved gluten.

Sugar, which at ordinary temperatures has no tendency to combine with oxygen, enters in the above predicament into fermentation; but the action is rendered much slower by the low temperature, while the affinity of the dissolved gluten for the oxygen of the air is aided by the contact of the sediment. The superficial yeast may be removed without stopping the fermentation, but the under yeast can not be removed without arresting all the phenomena of disoxidation of the second period. These would immediately cease; and if the temperature were now raised, they would be succeeded by the phenomena of the first period. The deposite does not excite the phenomena of tumultuous fermentation, for which reason it is totally unfit for panification (bread-baking), while the superficial yeast alone is suitable to this purpose.

If to wort at a temperature of from 46½° to 50° F. the top yeast be added, a quiet slow fermentation is produced, but one accompanied with a rising up of the mass, while yeast collects both at the surface and bottom of the backs. If this deposite be removed to make use of it in other operations, it requires by little and little the characters of the *unterhefe*, and becomes incapable of exciting the phenomena of the first fermenting period, causing only, of 59° F., those of the second; namely, sedimentary fermentation. It must be carefully observed that the right *unterhefe* is not the precipitate which falls to the bottom of backs in the ordinary fermentation of beer, but is a matter entirely different. Peculiar pains must be taken to get it genuine, and in a proper condition at the commencement. Hence the brewers of Hessia and Prussia, who wished to make Bavarian beer, found it more to their interest to send for the article to Wurtzburg, or Bamberg, in Bavaria, than to prepare it themselves. When once the due primary fermentation has been established and well regulated in a brewery, abundance of the true *unterhefe* may be obtained for all future operations.

In a wort made to ferment at a low temperature with deposite only, the presence of the *unterhefe* is the first condition essential to the metamorphosis of the *saccharum*, but it is not competent to bring about the oxidation of the gluten dissolved in the wort, and its transformation into an insoluble state. This change must be accomplished at the cost of the atmospherical oxygen.

In the tendency of soluble gluten to absorb oxygen, and in the free access of the air, all the conditions necessary for its *érêmacausis*, or slow combustion, are to be found. It is known that the presence of oxygen and soluble gluten are also the conditions of acetification (vinegar-making), but they are not the only ones; for this process requires a temperature of a certain elevation for the alcohol to experience this slow combustion. Hence, by excluding that temperature, the combustion (oxidation) of alcohol is obstructed, while the gluten alone combines with the oxygen of the air. This property does not belong to alcohol at a low temperature, so that during the oxidation in this case of the gluten, the alcohol exists alongside of it, in the same condition as the gluten alongside of sulphurous acid in the *muted* wines. In wines not impregnated with the fumes of burning sulphur, the oxygen which would have combined at the same time with the gluten and the alcohol does not seize either of them in wines which have been subjected to *mutism*, but it unites itself to the sulphurous acid to convert it into the sulphuric. The action called *sedimentary* fermentation is therefore merely a simultaneous metamorphosis of putrefaction and slow combustion; the sugar and the *unterhefe* putrefy, and the soluble gluten gets oxidized, not at the expense of the oxygen of the water and the sugar, but of the oxygen of the air, and the gluten then falls in the insoluble state. The process of Appert for the preservation of provisions is founded upon the same principle as the Bavarian process of fermentation; in which all the putrescible matters are separated by the intervention of the air at a temperature too low for the alcohol to become oxidized. By removing them in this way, the tendency of the beer to grow sour, or to suffer a further change, is prevented. Appert's method consists in placing in presence of vegetables or meat which we wish to preserve the oxygen at a high temperature, so as to produce slow combustion, but without putrefaction or even fermentation. By removing the residuary oxygen after the combustion is finished, all the causes of an ulterior change are removed. In the sedimentary fermentation of beer, we remove the matter which *experiences* the combustion; whereas, on the contrary, in the method of Appert, we remove that which produces it.

It is uncertain whether the dissolved gluten, in being converted into insoluble yeast by the action of the oxygen, combines directly *with* the oxygen; that is to say, whether the yeast differs from the soluble gluten merely by having absorbed an additional quantity of oxygen. This question is in fact very difficult to solve by analysis. If the gluten be regarded as a hydrogenated combination, it is obvious that in the fermentation of wine-must, and malt-wort, the hydrogen will be carried off by the oxygen, and the action will then be the same as the transformation of alcohol into *aldehyde*. When the contact of the atmosphere is excluded, this oxygen can not evidently be derived from the elements of the air, or from those of the water; for it can not be supposed that oxygen will take hydrogen from the water, in order to recompose water with the hydrogen of the gluten. The elements of the *saccharum* must therefore furnish this oxygen; or in the course of the formation of the yeast, a portion of the sugar will be decomposed; but thts decomposition is not of the same kind as that which results from the immediate metamorphosis of the sugar into carbonic acid and alcohol; hence a certain portion of the sugar will afford neither alcohol nor carbonic acid, but it will yield less oxgenated products from its elements. These products occasion the great difference in the qualities of fermented liquors, and particularly in their alcoholic strength. In the ordinary fermentation of grape-juice and worts, these liquids do not furnish a quantity of alcohol equivalent to the sugar which they contain, because a certain portion of the sugar serves for the oxidation of the gluten, and is not transformed like the rest. But whenever the liquor has arrived at the second period, the product in alcohol ought to be equivalent to the quantity of sugar present, as happens in all fermentations which are not accompanied with a formation, but a disappearance of the yeast. It is well ascertained that worts furnish in the Bavarian breweries 10 or 20 per cent. more alcohol than they do by the ordinary process of fermentation. It is also a well-established fact that in the manufacture of spirits from potatoes, where no yeast is produced, or merely a quantity corresponding to the proportion of barley-malt added to the potato-wort, a quantity of alcohol may be produced, as also of carbonic acid, corresponding exactly to the quantity of carbon in the fecula employed. But, on the contrary, in the fermentation of beet-root juice, it is hardly possible to determine precisely, from the quantity of carbonic acid evolved, the quantity of sugar contained in the beets, for there is always less carbonic acid than the juice of the fresh root would furnish. In equal volumes, the beer made by the *unterhefe* process contains more alcohol, and is therefore more heady than that formed by the ordinary process.

The temperature at which fermentation is carried on has a very marked influence upon the quantity of alcohol produced. It is known that the juice of beets set to ferment between 86° and 95 Fahr. does not yield alcohol, and its sugar is replaced by a less oxygenated substance, *mannite*, and lactic acid, resulting from the mucilage. In proportion as the temperature is lowered the mannite fermentation diminishes. As to azotized juices, however, it is hardly possible to define the conditions under which the transformation of the sugar will take place, without being accompanied with another decomposition which modifies its products. The fermentation of beer by *deposite* demonstrates that by the simultaneous action of the oxygen of the air and a low temperature, the metamorphosis of sugar is effected in a complete manner; for the vessels in which the operation is carried on are so disposed that the oxygen of the air may act upon a surface great enough to transform all the gluten into insoluble yeast, and thus to present to the sugar a matter constantly undergoing decomposition. The oxidizement of the dissolved gluten goes on, but that of the alcohol requires a higher temperature; whence it can not suffer eremacausis, that is, acetification, or conversion into vinegar.

At the beginning of the fermentation of must and wort, the quantity of matter undergoing change is obviously the largest. All the phenomena which accompany it, the disengagement of gas and the rise of temperature, are most active at this period, and in proportion as the decomposition advances, the external signs of it become less perceptible, without, however, disappearing completely before the transformation has reached its limit. The slow and continuous decomposition which succeeds to the rapid and violent disengagement of gases is denominated the *after* or *complementary* fermentation. For wine and beer it lasts till all the sugar has disappeared, so that the specific gravity of the liquors progressively diminishes during several months. This slow fermentation is in most cases a truly depositary fermentation; for by the progressive decomposition of the less, the sugar still in solution gets completely transformed; but when the air is excluded, that decomposition does not occasion the complete separation of the azotized matters in an insoluble shape.

In several states of the German confederation, the favorable influence of a rational process of fermentation upon the quality of the beers has been fully recognised. In the Grand Dutchy of Hesse considerable premiums were proposed for the brewing of beer according to the process pursued in Bavaria, which were decreed to those brewers who were able to prove that their product (neither strong nor highly hopped) had kept six months in the casks without becoming at all sour. When the first trials were being made several thousand barrels were spoiled, till eventually experience led to the discovery of the true practical conditions which theory had foreseen and prescribed.

Neither the richness in alcohol, nor in hops, nor both combined, can hinder ordinary beer from getting tart. In England, says Liebig, an immense capital is sacrificed to preserve the better sorts of ale and porter from souring, by leaving them for several years in enormous tuns quite full, and very well closed, while their tops are covered with sand. This treatment is identical with that applied to wines to make them deposite the wine-stone. A slight transpiration of air goes on in this case through the pores of the wood; but the quantity of azotized matter contained in the beer is so great, relatively to the proportion of oxygen admitted, that this element can not act upon the alcohol. And yet the beer thus managed will not keep sweet more than two months in smaller casks to which air has access. The grand secret of the Munich brewers is to conduct the fermentation of the wort at too low a temperature to permit of the acetification of the alcohol, and to cause all the azotized matters to be completely separated by the intervention of the oxygen of the air, and not by the sacrifice of the sugar, It is only in March and October that the good store beer is begun to be made in Bavaria.

In our ordinary breweries, the copious disengagement of carbonic acid from the frothy top of the fermenting tuns and gyles prevents the contact of oxygen from the worts; so that, as the gluten can not be oxidized by the air, it attracts oxygen from the sugar, and thus gives rise to several adventitious hydrogenated products, just as the fetid oil is generated in the rapid fermentation of spirit-wash by the distillers. In this case no inconsiderable portion of the gluten remains undecomposed in the beer, which, by its extreme proneness to corruption, afterward attracts oxygen greedily from the air, and. at temperature above 52°, imparts this *contact action* to the alcohol, and, by a species of infection, changes it into vinegar. Indeed, in most of the rapid fermentations a portion of vinegar is formed, which itself serves as an acetous ferment to the rest of the alcohol; whereas the result of the *bottom* fermentation is a beer free from vinegar, and certainly hardly a trace of gluten; so that it does not possess the conditions requisite to intestine change or deterioration. This perfection is, however, in my opinion, rarely attained. In my several journeys into Germany I have met with much spurious or ill-made Bavarian beer. The best contains, when brought to England, a little acid, but no perceptible gluten on the addition of ammonia in excess. Most of our beers, ales, &c., deposite more or less gluten when thus treated.

The following table exhibits the results of the chemical examinations of the undermentioned kinds of beer:—

Name of the Beer.	Quantity in 100 parts by weight				Analyst.
	Water.	Malt extr.	Alcohol.	Carb. acid.	
Augustine double beer—Munich	88·86	8·0	3·6	0·14	Kaiser.
Salvator beer — do.	87·62	8·0	4·2	0·18	Do.
Bock-beer, from the Royal brewery — do.	88·64	7·2	4·0	0·16	Do.
Schenk (pot) beer, from a Bavarian country brewery; a kind of small beer	92·94	4·0	2·9	0·16	Do.
Bock-beer of Brunswick, of the Bavarian kind	88·50	6.50	5·0	- -	Balhorn.
Lager (store) beer, of Brunswick, of the Bavarian kind	91·0	5·4	3·50	- -	Otto.
Brunswick sweet small beer	84·70	14·0	1·30	- -	Do.
Brunswick mum	59·2	39·0	1.80	0·1	Kaiser.

Malting in Munich.—The barley is steeped till the acrospire, embryo, or seed-germ, seems to be quickened; a circumstance denoted by a swelling at the end of that ear which was attached to the foot-stalk, as also when, on pressing a pile between two fingers against the thumb-nail, a slight projection of the embryo is perceptible. As long, however, as the seed-germ sticks too firm to the husk, it has not been steeped enough for exposure on the underground malt-floor. Nor can deficient steeping be safely made up for afterward by sprinkling the malt-couch with a watering-can, which is apt to render the malting irregular. The steep-water should be changed repeatedly, according to the degree of foulness and hardness of the barley; first, six hours after immersion, having previously stirred the whole mass several times; afterward, in winter, every twenty-four hours, but in summer every twelve hours. It loses none of its substance in this way, whatever vulgar prejudice may think to the contrary. After letting off the last water from the stone cistern, the Bavarians leave the barley to drain in it during four or six hours. It is now taken out, and laid on the couch floor, in a square heap, eight or ten inches high, and it is turned over, morning and evening, with dexterity, so as to throw the middle portion upon the top and bottom of the new-made couch. When the acrospire has become as long as the grain itself, the malt is carried to the *withering* (*welkboden*) or drying-floor, in the open air, where it is exposed (in dry weather) during from eight to fourteen days, being daily turned over three times with a winnowing shovel. It is next dried on a well-constructed cylinder or flue-heated malt-kin, at a gentle clear heat, without being browned in the slightest degree, while it turns friable into a fine white meal. Smoked malt is entirely rejected by the best Bavarian brewers. Their malt is dried on a series of wove wire horizontal shelves, placed over each other; up through whose interstices or perforations streams of air, heated to only 122° Fahr., rise from the surfaces of rows of hot sheet-iron pipe-flues, arranged a little way below the shelves. Into these pipes the smoke and burned air of a little furnace on the ground are admitted. The whole is enclosed in a vaulted chamber, from whose top a large wooden pipe issues, for conveying away the steam from the drying malt. Each charge of malt may be completely dried on this kiln in the space of from eighteen to twenty-four hours, by a gentle uniform heat, which does not injure the diastase, or discolor the farina.*

The malt for store-beer should be kept three months at least before using it, and be freed by rubbing and sifting from the acrospires before being sent to the mill, where it should be crushed pretty fine. The barley employed is the best *distichon* or common kind, styled *hordeum vulgare.*

The hops are of the best and freshest growth of Bavaria, called the fine *spalter,* or *saatser Bohemian townhops,* and are twice as dear as the best ordinary hops of the rest of Germany. They are in such esteem as to be exported even into France.

The Bavarians are so much attached to the beer beverage, which they have enjoyed from their remotest ancestry, that they regard the use of distilled spirits, even in moderation, as so immoral a practice, as to disqualify dram-drinkers for decent society.

* I have a set of designs of the Bavarian kiln, but I believe the above description will make its construction sufficiently intelligible.

Their government has taken great pains to improve this national beverage, by encouraging the growth of the best qualities of hops and barley. The vaults in which the beer is fermented, ripened, and kept, are all underground, and mostly in stony excavations, called *felsenkeller* or rock-cellars. The beer is divided into two sorts, called *summer* and *winter*. The latter is light, and, being intended for immediate retail in tankards, is termed *schankbier*. The other, or the *lagerbier*, very sensibly increases in vinous strength in proportion as it decreases in sweetness, by the judicious management of the *nachgährung*, or fermentation in the casks. In several parts of Germany a keeping quality is communicated to beers by burning sulphur in the casks before filling them, or by the introduction of sulphite of lime. But the flavor thus imparted is disliked in Munich, Bayreuth, Regensburg, Nürnberg, Hof, and the other chief towns of Bavaria; instead of which a preservative virtue is sought for in an aromatic mineral or Tyrol *pitch*, with which the insides of the casks are carefully coated, and in which the ripe beer is kept and exported. In December and January, after the casks are charged with the summer or store-beer, the double doors of the cellars are closed, and lumps of ice are piled up against them, to prevent all access of warm air. The cellar is not opened till next August, in order to take out the beer for consumption. In these circumstances the beer becomes transparent like champagne wine; and, since but little carbonic acid gas has been disengaged, little or none of the additionally generated alcohol is lost by evaporation.

The winter or schank (pot) beer is brewed in the months of October, November, March, and April; but the summer or store-beer in December, January, and February, or the period of the coldest weather. For the former beer, the hopped worts are cooled down only to from 51° to 55°, but for the latter to from 41° to 42½° Fahr. The winter beer is also a little weaker than the summer beer, being intended to be sooner consumed; since four bushels* (Berlin measure) of fine, dry, sifted malt, of large heavy *hordeum vulgare distichon*, affords seven *eimers* of winter beer, but not more than from five and a half to six of summer beer.† At the second infusion of the worts, small beer is obtained to the amount of twenty quarts from the above quantity of malt. For the above quantity of winter beer, six pounds of middling hops are reckoned sufficient; but for the summer beer, from seven to eight pounds of the finest hops. The winter beer may be sent out to the publicans in barrels five days after the fermentation has been completed in the tuns, and, though not quite clear, it will become so in the course of six days; yet they generally do not serve it out in pots for two or three weeks. But the summer beer must be perfectly bright and still before it is racked off into casks for sale.

Statement of the Products of a Brewing of Bavarian Beer.—The quantity brewed is 41 Munich eimers (64 *maass*) = 85½ Berlin quarts; and 60 Berlin quarts = 1 eimer; or 24 Munich barrels (of 100 Berlin quarts each); 1 Munich eimer = 15 gallons imperial. The beer contains from 50 to 60 parts by weight, of dry saccharum in 1,000 parts.

Expenditure.	*Thaler.*	*Slbg.*
24 Berlin bushels of white kiln-dried barley, rather finely crushed, weighing from 12 to 13 cwts. - - - - - -	24	0
36 pounds of new fine *spalter* (parted) hops at 46 thalers the cwt. -	16	17
½ pound of Carageen moss, for clarifying - - - -	0	3
1 quart of yeast.		
1 quart of Tyrol pitch - - - - - - -	11	0
Mash—tax (in Bavaria and Prussia) upon 12 cwts. malt, at the rate of 20 *silbergroschen* = 2*s*., the cwt. - - - -	8	0
Cost of crushing - - - - - - -	1	0
Fuel - - - - - - - - - -	4	0
Wages of labor, in the brewhouse and vault - - -	6	0
Do. Do. for cooper in pitching the casks - - -	3	0
Sundry small expenses . - - - - - - -	2	10
Or 11*l*. 8*s*.	76	0
1 *thaler* = 30 *silbergroschen* = 3 shillings		
Deduct for the grains of 12 cwts. of malt, at 10 *silbergroschen*, or 1*s*. per cwt. = 4 *thalers*, and for the value in yeast produced = 2 *thalers* more - - - - - - - -	6	0
Total neat expenditure = 10*l*. 10*s*. - - - - - -	70	0

* An English quarter of grain is equal to 5 bushels (*scheffel*) and nearly one third Prussian measure

† 1 Eimer Prussian = 15 English imperial gallons; one Munich *scheffel* is equal to four Berlin *scheffels*. 1 Lit Munich = 1·235 *Eng. lbs. Avoird.*: 1 Lib. Berlin = 1·031 *lbs. Avoird.*

This cost for 42 eimers (1 eimer = 14¾ galls. Imp.) = 619½ gallons = 17·2 London porter barrels, amounts to 4½*d.* per gallon, or 12*s.* 2*d.* per barrel. By the above reckoning, a good profit accrues to the brewer, after allowing a liberal sum for the rent of premises, interest of capital, &c.

He has less profit from the summer beer. For a brewing of 33 eimers = 505 gallons Imp., containing from 60 to 65 pounds of saccharum in 1,000 pounds of the beer, by Hermstaedt's saccharometer.

Expenditure.

	Thaler.	Slbg.
24 Berlin scheffels of white kiln-dried barley-malt, weighing from 12 to 13 centners*	24	0
48 Berlin pounds of fresh Bavarian fine hops, at 46 thaler per centner	20	0
½ pound of Carageen moss	0	3
1 quart setting yeast (*unterhefe*).		
1 centner pitch	11	0
Malt tax on 12 centners	8	0
Crushing the malt	1	0
Fuel	4	0
Wages, 6 thalers; coopers' do., 3 thalers; and sundries, 3 th. 27 sq.	12	27
	81	0
Deduct for grains 4 thalers, and yeast 2 thalers	6	0
Neat cost	75	0

This cost of 11*l.* 5*s.* for 505 gallons amounts to fully 5⅓*d.* per gallon, and 16*s.* 6*d.* the barrel.

The cost at Munich is 2½ thalers the eimer, and 4 thalers the barrel. The eimer of the summer beer, or *lagerbier*, is sold for 4 thalers. The publicans there, as in London, are known to add more or less water to their beer before retailing it.

The yeast (*unterhefe*) is carefully freed by a scraper from the portions of light top yeast that may have fallen to the bottom; the true *unterhefe* is then carefully sliced off from the slimy sediment on the wood.

In Munich the malt is moistened slightly 12 or 16 hours before crushing it, with from 2 to 3 *maas*† of water for every bushel; the malt being well dried, and several months old. The mash-tun into which the malt is immediately conveyed is, in middle-sized breweries, a round oaken tub, about 4½ feet deep, 10 feet in diameter at bottom and 9 at top, outside measure, containing about 6,000 Berlin quarts. Into this tun cold water is admitted late in the evening, to the amount of 25 quarts for each *scheffel*, or 600 quarts for the 24 *scheffels* of the ground malt, which are then shot in and stirred about and worked well about with the oars and rakes, till a uniform pasty is formed without lumps. It is left thus for three or four hours; 3,000 quarts of water being put into the copper, and made to boil; and 1,800 quarts are gradually run down into the mash-tun, and worked about in it, producing a mean temperature of 142·5° Fahr. After an hour's interval, during which the copper has been kept full, 1,800 additional quarts of water are run into the tun, with suitable mashing. The copper being now emptied of water, the mash-mixture from the tun is transferred into it, and brought quickly to the boiling point, with careful stirring to prevent its setting on the bottom and getting burned, and it is kept at that temperature for half an hour. When the mash rises by the ebullition, it needs no more stirring. This process is called, in Bavaria, boiling the thick mash, *dickmaisch kochen.* The mash is next returned to the tun, and well worked about in it. A few barrels of a thin mash-wort are kept ready to be put into the copper the moment it is emptied of the thick mash. After a quarter of an hour's repose the portion of liquid filtered through the sieve-part of the bottom of the tun into the wort-cistern is put into the copper, thrown back boiling hot into the mash in the tun, which is once more worked thoroughly.

The copper is next cleared out, filled up with water, which is made to boil for the after or small-beer brewing. After two hours settling in the open tun, the worts are drawn off clear.

Into the copper, filled up one foot high with the wort, the hops are introduced, and the mixture is made to boil during a quarter of an hour. This is called *roasting the hops.* The rest of the wort is now put into the copper, and boiled along with the hops during at least an hour or an hour and a half. The mixture is then laded out through the hop-filter into the cooling-cistern, where it stands three or four inches deep, and is exposed upon an extensive surface to natural or artificial currents of cold air, so as to

* 1 Centner = 110 Prussian pounds = 113·44 lbs. Avoird.
† A Bavarian *maas* = 1¼ quarts English measure.

be quickly cooled. For every 20 barrels of lagerbier, there are allowed 10 of small beer; so that 30 barrels of wort are made in all.

For the winter or pot-beer the worts are brought down to about 59° Fahr. in the cooler, and the beer is to be transferred into the fermenting-tuns at from 54·5° to 59° Fahr.; for the summer or *lagerbier*, the worts must be brought down in the cooler to from 43° to 45½°, and put into the fermenting-tuns at to from 41° to 43° Fahr.

A few hours beforehand, while the wort is still at the temperature of 63½° Fahr., a quantity of *lobb* must be made, called *vorstellen* (*fore-setting*) in German, by mixing the proportion of *unterhefe* (yeast) intended for the whole brewing with a barrel or a barrel and a half of the worts, in a small tub called the *gähr-tiene*, stirring them well together, so that they may immediately run into fermentation. This *lobb* is in this state to be added to the worts. The *lobb* is known to be ready when it is covered with a white froth from one quarter to one half an inch thick; during which it must be well covered up. The large fermenting-tun must in like manner be kept covered, even in the vault. The colder the worts, the more yeast must be used. For the above quantity, at

From 57° to 59° Fahr.,	6	*maas of unterhefe.*
53° to 55°	8	—
48° to 50°	10	—
41° to 33°	12	—

Some recommend that wort for this kind of fermentation (the *untergährung*) should be set with the yeast at from 48° to 57°; but the general practice at Munich is to set the summer *lager* beer at from 41° to 43° F.

By following the preceding directions, the wort in the tun should, in the course of from twelve to twenty-four hours, exhibit a white froth round the rim, and even a slight whiteness in the middle. After another twelve or twenty-four hours, the froth should appear in curls; and, in a third like period, these curls should be changed into a still higher frothy brownish mass. In from twenty-four to forty-eight hours more, the barm should have fallen down in portions through the beer, so as to allow it to be seen in certain points. In this case it may be turned over into the smaller ripening tuns in the course of other five or six days. But when the worts have been set to ferment at from 41° to 43° Fahr., they require from eight to nine days. The beer is transferred, after being freed from the top yeast by a skimmer, by means of the stopcock near the bottom of the large tun. It is either first run into an intermediate vessel, in order that the top and bottom portions may be well mixed, or into each of the *lager* casks, in a numbered series, like quantities of the top and bottom portions are introduced. In the ripening cellars the temperature can not be too low. The best keeping beer can never be brewed unless the temperature of the worts at setting, and of course the fermenting-vault, be as low as 50° F. In Bavaria, where this manufacture is carried on under government inspectors, a brewing period is prescribed by law, which is, for the under fermenting *lager* beer, from Michaelmas (29th September) to St. George (23d April). From the latter to the former period the ordinary top-barm beer alone is to be made. The ripening-casks must not be quite full, and they are to be closed merely with a loose bung, in order to allow of the working over of the ferment. But should the fermentation appear too languid, after six or eight days, a little briskly fermenting *lager* beer may be introduced. The *store* lager beer-tuns are not to be quite filled, so as to prevent all the yeasty particles from being discharged in the ripening fermentation; but the *pot* lager beer-tuns must be made quite full, as this beverage is intended for speedy sale within a few weeks of its being made.

As soon as the summer beer-vaults are charged with their ripening-casks, and with ice-cold air, they are closed air-tight with triple doors, having small intervals between, so that one may be entered and shut again, before the next is opened. These vaults are sometimes made in ranges radiating from a centre, and at others in rooms set off at right angles to a main gallery; so that in either case, when the external opening is well secured, with triple air-tight doors, it may be entered at any time, in order to inspect the interior, without the admission of warm air to the beer-barrels. The wooden bungs for loosely stopping them must be coated with the proper pitch, to prevent the possibility of their imparting any acetous ferment. In the *Beer Brewer** of A. F. Zimmermann, teacher of theoretical and practical brewing, who has devoted thirty-five years to this business, it is stated, that a ripened tun of lager or store-beer must be racked off all at once, for when it is left half full it becomes flat (*schaal*); and that the tun of pot *lager* beer must, if possible, be all drunk off in the same day it is tapped; because on the following day the beer gets an unpleasant taste, even when the bung has not been taken out, but only a small hole has been made, which is opened only at the time of drawing the beer, and is immediately closed again with a

* *Der Bier-Brauer*, als Meister in seinem fache, &c., illustrates with many plates, Berlin, 1842.

spigot. He ascribes this change to the loss of the carbonic acid gas, with which the beer has got strongly impregnated during the latter period of its ripening, while being kept in tightly-bunged casks. The residuums in these casks are, however, bottled up in Bavaria, whereby the beer, after some time, recovers its brisk and pungent taste. But the beer-topers in Bavaria, who are professedly very numerous, indulge so delicate and fastidious a palate, that when assembled in their favorite pot-house, they wait impatiently for the tapping of a fresh cask, and cease for a while to tipple whenever it is half empty, puffing the time away with their pipes till another fresh tap be made. In the well-frequented beer-shops of Munich a common-sized cask of *lager* beer is thus drank off in an hour. A reputation for superior brewing is there the readiest road to fortune.

Bock-Beer of Bavaria.—This is a favorite double strong beverage, of the best *lager* description, which is so named from causing its consumers to prance and tumble about like a buck or a goat; for the German word *bock* has both these meanings. It is merely a beer having a specific gravity one third greater, and is therefore made with a third greater proportion of malt, but with the same proportion of hops, and flavored with a few coriander-seeds. It has a somewhat darker color than the general *lager* beer, occasionally brownish, taste less bitter on account of the predominating malt, and somewhat aromatic. It is an eminently intoxicating beverage. It is brewed in December and January, and takes a long time to ferment and ripen; but still it contains too large a quantity of unchanged *saccharum* and *dextrine* for its hops, so that it tastes too luscious for habitual topers, and is drunk only from the beginning of May till the end of July, when the fashion and appetite for it are over for the year.

Statement of a Brewing of Bavarian Bock-Beer.

For 41 Bavarian eimers of 64 maass each (about 15 gallons Imperial) per *eimer*, or 615 gallons, nearly 17 barrels English in all:—

Expenditure.

	Thaler.	*Slbg.*
32 Berlin scheffels of the best pale malt freed from its acrospires, weighing $17\frac{1}{2}$ centners, at 1 thaler per centner - -	32	0
48 lbs. (Berlin) of the best Bavarian hops - - -	20	0
$\frac{1}{2}$ lb. Carageen moss for clarifying - - - -	0	3
1 lb. Coriander-seeds - - - - - -	0	$1\frac{1}{2}$
1 Quart setting yeast.		
1 Centner Tyrolese pitch - - - - - -	11	0
Malt-tax — - - - - - - -	11	20
Malt-crushing, fuel, wages, coopering, &c. - - -	16	$5\frac{1}{2}$
Thalers of 3*s.* each - -	91	0
Deduct for the value of grains and yeast - - -	7	0
Thalers of neat cost - - - - - -	84	0

This statement makes the eimer of the Bavarian bock-beer amount to about 2 thalers, or 6 shillings; being at the rate of nearly 5 pence per gallon; though without counting rent, interest of capital, or profit. It is, in fact, a malt or barley sweet wine or *liqueur;* but a very cheap one, as we see by this computation.

The chief difference in the process for making bock-beer lies in the mash-worts, and in the hops being boiled a shorter time, to preserve more of the aroma, and acquire less of the bitterness of the hop. The coriander-seeds are coarsely bruised, and added along with the hops and Carageen moss, to the boiling mash-worts, about twenty or thirty minutes before they are laded or drawn off into the mash-tun. Sometimes the hops are boiled apart in a little clear wort, as formerly described. The bock-beer is retailed in Munich at 3 silver groschen, about $3\frac{1}{2}d.$ the *seidel,* or pot, which is one English pint. The 25 gallon cask (*tonne*) is sold at 10 thalers, or 30 shillings. The publicans, therefore, have a very remunerating profit per pot, even supposing that they do not reduce the beer with water like our London craftsmen.

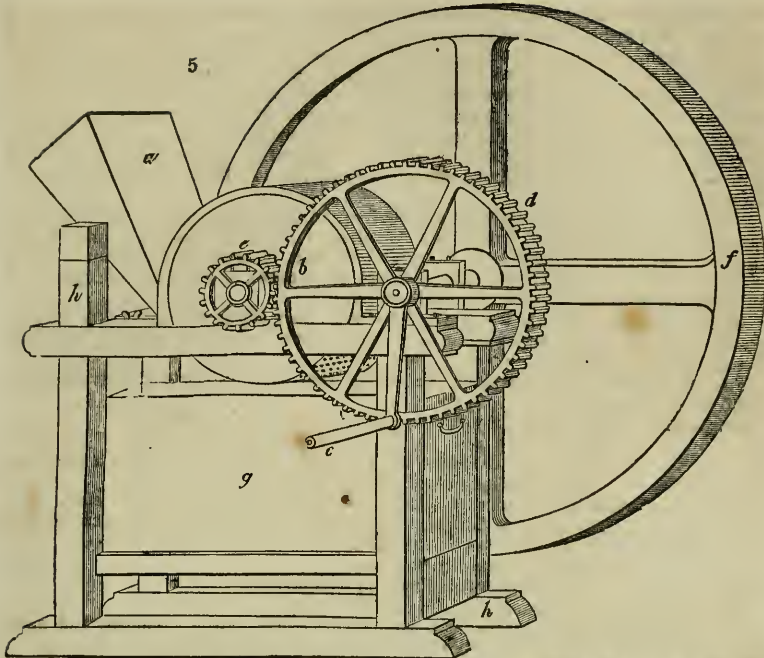
Zimmermann assumes the merit of having introduced Carageen moss as a clarifier into the beer manufacture. I do not know whether it may not have been used in this country for the same purpose, or in Ireland, where this *fucus* (*Chondra crispa*) grows abundantly. He says that 1 ounce of it is sufficient for 25 gallons of beer; and that it operates, not only in the act of boiling with the hops, but in that of cooling, as also in the squares and backs before the fermentation is begun. Whenever this change, however, takes place, the commixture throws up the gluten and moss to the surface of the liquid in a black scum, which is to be skimmed off, so that the proper yeast may not be soiled with it. It occasions the separation of much of the vegetable slime, or mucilage, called by the German brewers *pech* (pitch).

On the Clarifying or Clearing of Beers.—Clarifiers act either chemically—by being soluble in the beer, and by forming an insoluble compound with the vegetable gluten, and other viscid vegetable extracts; gelatine and albumen, under one shape or other, have been most used; the former for beer, the latter, as white of egg, for wine—or mechanically, by being diffused in fine particles through the turbid liquor, and, in their precipitation, carrying down with them the floating vegetable matters. To this class belong sand, bone-black (in some measure, but not entirely), and other such articles. The latter means are very imperfect, and can take down only such matters as exist already in an insoluble state; of the former class, milk, blood, glue, calf's-foot jelly, hartshorn-shavings, and isinglass, have been chiefly recommended. Calve's-foot jelly is much used in many parts of Germany, where veal forms so common a kind of butcher-meat; but in summer it is apt to acquire a putrid taint, and to impart the same to the beer. In these islands, isinglass swollen and partly dissolved in vinegar, or sour beer, is almost the sole clarifier, called finings, employed. It is costly, when the best article is used; but an inferior kind of isinglass is imported for the brewers. The solvent or medium through or with which it is administered is eminently injudicious, as it never fails to infect the beer with an acetous ferment. In Germany their tart wine has been used hitherto for dissolving the isinglass; and this has also the same bad property. Mr. Zimmermann professes to have discovered an unexceptionable solvent in tartaric acid, one pound of which dissolved in 24 quarts of water is capable of dissolving two pounds of ordinary isinglass; forming finings which may be afterward diluted with pure water at pleasure. Such isinglass imported from Petersburg into Berlin costs there only 3*s*. per lb. These finings are best added, as already mentioned, to the worts prior to fermentation, as soon as they are let in to the setting-back or tun, immediately after adding the yeast to it. They are best administered by mixing them in a small tub with thrice their volume of wort, raising the mixture into a froth with a whisk (*twig-besom*, in German), and then stirring it into the worts. The clarification becomes manifest in the course of a few hours, and when the fermentation is completed, the beer will be as brilliant as can be wished; the test of which with the German topers is when they can read a newspaper while a tall glass beaker of beer is placed between the paper and the candle. One quart of finings of the above strength will be generally found adequate to the clearing of 100 gallons of well-brewed lager-beer, though it will be surer to use double that proportion of finings. The Carageen moss, as finings, is to be cut in fine shreds, thrown into the boiling thin wort, when the flocks begin to separate, and before adding the hops; after which the boiling is continued for an hour and a half or two hours, as need be. The clarifying with this kind of finings takes place in the cooler, so that a limpid wort may be drawn off into the fermenting back.

Berlin White or Pale Beer (*Weiss-bier*).—This is the truly patriotic beverage of Prussia Proper, and he is not deemed a friend to his *Vaterland* who does not swig it. It is brewed from 1 part of barley-malt and 5 parts of wheat-malt, mingled, moistened, and coarsely crushed between rollers. This mixture is worked up first with water at 95° Fahr., in the proportion of 30 quarts per *scheffel* of the malt, to which pasty mixture 70 quarts of boiling water are forthwith added, and the whole is mashed in the tun. After it has been left here a little to settle, a portion of the thin liquor is drawn off by the tap, transferred to the copper, and then for each bushel of malt there is added to it a decoction of half a pound of *Altmark* hops separately prepared. This hopped wort, after half an hour's boiling, is turned back with the hops into the mash-tun, of which the temperature should now be 162½° Fahr., but not more. In half an hour the wort is to be drawn off from the grains, and pumped into the cooler. The grains are afterward mashed with from 40 to 50 quarts of boiling water per *scheffel* of malt, and this infusion is drawn off and added to the former worts. The whole mixture is set at 66° Fahr., with a due proportion of top yeast or ordinary barm, and very moderately fermented. According to Zimmermann, a very competent judge, this his native beer is very apt to turn sour, and therefore it must be very speedily consumed. This proneness to acetification is the character of all wheat-malt beers. He recommends, what he himself has made for many years, a substitution of potato-starch sugar for this sort of malt, and as much tartaric acid as to give the degree of tartness peculiar to the pale Berlin beer, even in its best state. This acid moreover prevents the beer from running into the acetous fermentation.

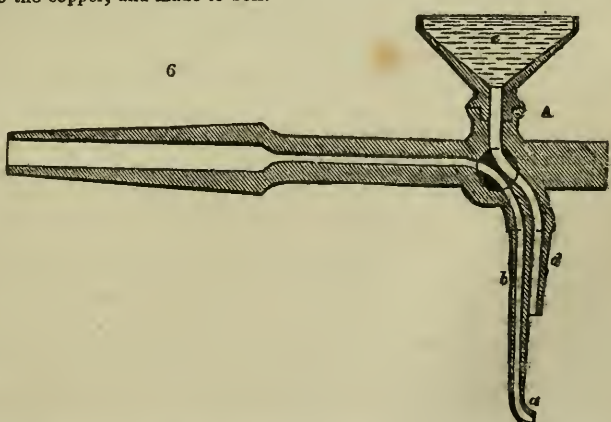
Potato-Beer.—The potatoes being well washed are to be rubbed down to a pulp by such a grating cylinder-machine as is represented in *fig*. 5, where *a* is the hopper for receiving the roots (whether potato or beet, as in the French sugar-factories; *b* is the crushing and grinding-drum; *c*, the handle for turning the spur-wheel *d*, which drives the pinion *e*, and the fly-wheel *f*; *g*, *h*, is the frame. The dotted lines above *c*, are the

5



cullender through which the pulp passes. *Fig.* 6. is the stopcock used in Bavaria for bottling beer. For every scheffel of potatoes 80 quarts of water are to be put with them into the copper, and made to boil.

6



Crushed malt, to the amount of 12 scheffels, is to be well worked about in the mash-tun with 360 quarts, or 90 gallons (English) of cold water, to a thick pap, and then 840 additional quarts, or about 6 barrels (English) of cold water are to be successively introduced with constant stirring, and left to stand an hour at rest.

The potatoes having been meanwhile boiled to a fine starch paste, the whole malt-mash, thin and thick, is to be speedily laded into the copper, and the mixture in it is to be well stirred for an hour, taking care to keep the temperature at from 144° to 156° Fahr. all the time, in order that the *diastase* of the malt may convert the starch present in the two substances into sugar and dextrine. This transformation is made manifest by the white pasty liquid becoming transparent and thin. Whenever this happens the fire is to be raised, to make the mash boil, and to keep it at this heat for 10 minutes. The fire is then withdrawn, the contents of the copper are to be transferred into the mash, worked well there, and left to settle for half an hour; during which time the copper is to be washed out, and quickly charged once more with boiling water.

The clear wort is to be drawn off from the top of the tun, as usual, and boiled as soon as possible with the due proportion of hops; and the boiling water may be added in any desired quantity to the drained mash, for the second mashing. Wort made in this way is said to have no flavor whatever of the potato, and to clarify more easily than malt-wort, from its containing a smaller proportion of gluten relatively to that of saccharum.

A scheffel of good mealy potatoes affords from 26 to 27½ pounds of thick well-boiled syrup, of the density of 36° Baumé (*see* Areometer in the Dictionary); and 26 lbs. of such syrup are equivalent to a scheffel of malt in saccharine strength. Zimmermann thinks beer so brewed from potatoes quite equal, at least, if not superior, to pure malt beer, both in appearance and quality.

Porter and Brown Stout.—I offer the following statement of the process for brewing genuine London porter, believing it to be more near that really practised than any formula hitherto published.

For 180 barrels of brown stout, containing from 80 to 85 parts of malt extract in 1,000 by weight:—

Components.—530 bushels (English measure) of good barley malt.
10 do. of kiln-browned malt.
12 cwt. of *Essentia-bina, Caramel,* or sugar fused over a fire into a dark brown or black syrupy mass.
1500 lbs. of hops, or about three pounds to each bushel of malt.
10 quarts of *Calfini*, a preparation made with the oil distilled from the outer bark of the birch.
5 quarts of good porter yeast.
finings of isinglass dissolved in sour beer.

For the brewing process see Beer in the Dictionary.

The *essentia-bina* may be dissolved in hot worts in a separate copper, and mixed with the rest by running it into the cooler, immediately after the boiled wort is strained from the hops in the hop-back. The *Calfini* (a *hocus-pocus* term of the brewers) is prepared as follows:—

Put one ounce of birch-bark oil into a bottle with 4 quarts of spirits of wine 60 per cent. over proof; cork the mouth of the bottle, and place it in a slightly warm position till the oil be thoroughly combined with the alcohol, with the aid of occasional shaking. This solution being cooled is to be filtered through paper, and kept for use. The birch oil is an empyreumatic product made in large quantities in Russia and Poland, for the purpose of giving flavor and conservative properties to the Russia leather. It is sold for one shilling the quart. The dose of *Calfini* in porter is varied according to the taste of the brewers and consumers.

In concluding this supplementary article, I take occasion to refer my readers to the *Practical Treatise on Brewing*, by Mr. William Black, a gentleman experienced in the business, who has the merit of discovering the evil influence of galvanic combinations in the metallic parts of the fermenting backs and the beer tuns in our breweries. This little work contains much useful information. I have pleasure also in announcing that Messrs. Beamish and Crawford, the eminent porter brewers of Cork, have taken measures to establish the manufacture of genuine Bavarian beer on the best principles: having, with this view, caused their intelligent head brewer, Mr. Topp, to study the practical details of brewing in Munich. They have recently produced excellent brown stout, equal, if not superior, to any in London, by means of the Bavarian fermentation. It is nearly free from gluten, and will therefore prove light and wholesome to weak stomachs. It needs no finings to clarify it.

Professor Leo of Munich has given the following analysis of two kinds of Munich beer:—

	Bock-bier.	Heiliger-Vater
Specific gravity -	1·020	1·030
Alcohol - - - -	4·000	5·000
Extract - - - -	8·200	13·500
Carbonic Acid - -	0·085	0·077
Water - - - -	87·393	81·923
	100·000	100·000

Carl states the alcohol in the Bavarian beer of Bamberg at only 2·840 in 100. Extract, 6·349.

The following analyses of other German beers are also by Leo:—

	Lichtenhain.	Upper Weimar.	Ilmenau.	Jena.	Double Jena.
Alcohol - -	3·168	2·567	3·096	3·018	2·080
Albumen - -	0·048	0·020	0.079	0·045	0·028
Extract - -	4·485	7·316	7·072	6·144	7·153
Water - .	92·299	90·097	89·753	90·793	90·739
	100·000	100·000	100·000	100·000	100·000

Under the term extract, in these analyses, is meant a mixture of starch, sugar, dextrine, lactic acid, various salts, certain extractive and aromatic parts of the hop, gluten, and fatty matter.

The following statement is from some of the published analyses of other beers:—

	Alcohol.
English ale - - - - -	8·5 in 100
Burton - - - - -	6·2
Scotch - - - - -	5·8
Common London ale - - -	5·0
Brown stout - - - -	5·0
London porter - - - -	4·0

To the above I add the following analyses of certain ales made lately by myself, as follows:—

1. After exposing a portion of the liquor in a wine-glass till the bubbles of carbonic acid were disengaged, I took the specific gravity in a globe with a capillary bored stopper.

2. I then saturated 5,000 grain measures of the ale with a test solution of pure carbonate of soda, to determine the quantity of acid present, after which I added an excess of the alkali to precipitate the gluten; which, however, being but small in amount, I did not separate by a filter, dry, and weigh.

3. I subjected the supersaturated liquid to distillation by the heat of 230° F. in a chlor-zinc bath till I drew off all its alcohol, of which I noted the quantity in water grain measures, and the specifie gravity.

4. I evaporated to dryness 500 water grain measures slowly in a porcelain capsule, to determine the extract.

	Bavarian.	Do. Bock.	Allsop's.	Bass's.
Specific gravity -	1·004	1·013	1·010	1·006
Alcohol - -	4·00	4·50	6·00	7·00
Extract - -	4·50	6·40	5·00	4·80
Acetic acid - -	0·20	0·20	0·20	0.18
Water - -	91·30	88·90	88·80	88.02
	100·00	100·00	100·00	100·00

The Bavarian beers had been recently imported from Germany in casks lined with pitch. The two samples of English ale are those made chiefly for the Indian market, but, being highly hopped, and comparatively clean, as the brewers say, have been recommended as a tonic beverage, by the faculty. Hodgson's bitter beer was the original of this quality.

The above Bavarian beers afford no precipitate of gluten with carbonate of potash; the two English ales become mottled thereby, and yield a small portion of gluten, which had been held in solution by the acid, which is here estimated as the acetic. Common vinegar, excise strength, contains 5 per cent. of such acid as is stated in the above analysis, indicating from 3 to 4 per cent. of table vinegar in the above varieties of beer.

BICARBONATE OF POTASH AND OF SODA. These salts, so much used in medicine, may, according to M. Behrens, be very readily prepared by gradually adding acetic acid to a strong solution of their carbonates; that of soda being hot. The carbonic acid, at the moment of its disengagement, by the stronger affinity of the acetic for the alkalis, combines with a portion of them to form bicarbonates, which fall to the bottom of the vessel in which the mixture is made. The supernatant acetate being separated by decantation, the residuary bicarbonate is to be pressed in linen, washed with ice-cold water, and dried. This ingenious process may be practised by the chamber chemist, but will not afford the bicarbonates at so cheap a rate as the ordinary modes of manufacture.

BIRDLIME. All the parts of the misletoe contain a peculiar viscid gluey substance, which they yield by decoction, particularly of the bark and green portions; as also from the expressed juice of the bark or berries, when it is kneaded with the fingers under water. The birdlime is thus obtained in the form of a white opaque mass, sticking to the fingers. It may also be extracted from the berries of the misletoe by means of ether, repeatedly applied, digested with them. It dissolves at first a mixture of green wax and birdlime, but afterward birdlime alone. By distilling off the ether, the birdlime remains colorless and pure. Birdlime may be considered as a kind of viscid resin which does not dry, and resembling in this respect an ointment of oil or lard and rosin melted together—the old *basilicon* of the surgeon. Alcohol, even boiling hot, dissolves hardly any birdlime; but merely its waxy impurities, which it deposites in flocks on cooling. It is soluble in the oils of rosemary and turpentine, as also in petroleum. Heated with the ley of caustic potash, it forms a compound soluble in alcohol. Nitric acid converts it into oxalic acid, and into a fat which solidifies.

Macaire has examined a substance which exudes from the receptacle and involucre of the *atractylis gummifera*, and describes it as the pure matter of birdlime, which he styles *viscine*. It is said to be composed in 100 parts of 75·6 carbon, 9·2 hydrogen, and 15·2 oxygen. Common birdlime may be regarded as a mixture of viscine, vegetable mucilage, and vinegar. The young shoots of the *ficus elastica* afford a milky juice, which is viscine, while the old branches afford a juice rich in caoutchouc.

BISCUITS. For the following account of the mechanical system of baking biscuits for the royal navy, I am indebted to the ingenious inventor, Thomas Grant, Esq., of Gosport.

Ships' biscuits are now made by machinery; and one of the reasons for this has been that the manual preparation of them was too slow and too costly during the last war. A landsman knows very little of the true value of a biscuit: with a seaman, biscuit is the only bread that he eats for months together. There are many reasons why common loaves of bread could not be used during a long voyage: because, containing a fermenting principle, they would soon become musty and unfit for food, if made previous to the voyage; while the preparation of them on board ship is subject to insuperable objections. Biscuits contain no leaven, and, when well baked throughout, they suffer little change during a long voyage.

The allowance of biscuit to each seaman on board a queen's ship is a pound per day (averaging six biscuits to the pound). The supply of a man-of-war for several months is, consequently, very large; and it often happened during the last war that the difficulty of making biscuits fast enough was so great, that at Portsmouth wagon-loads were unpacked in the streets and conveyed on board ships.

We shall now describe the mode of making biscuits by hand; and afterward speak of the improved method. The bakehouse at Gosport contained nine ovens, and to each was attached a gang of five men—the "turner," the "mate," the "driver," the "breakman," and the "idleman." The requisite proportions of flour and water were put into a large trough, and the "driver," with his naked arms, mixed the whole up together in the form of dough—a very laborious operation. The dough was then taken from the trough and put on a wooden platform called the break: on this platform worked a lever called the break-staff, five or six inches in diameter, and seven feet long; one end of this was loosely attached by a kind of staple to the wall, and the breakman, riding, or sitting on the other end, worked this lever to and fro over the dough, by an uncouth jumping or shuffling movement. When the dough had become kneaded by this barbarous method into a thin sheet, it was removed to the moulding-board, and cut into slips by means of an enormous knife; these slips were then broken into pieces, each large enough for one biscuit, and then worked into a circular form by the hand. As each biscuit was shaped it was handed to a second workman, who stamped the king's mark, the number of the oven, &c., on the biscuit. The biscuit was then docked, that is, pierced with holes by an instrument adapted to the purpose. The finishing part of the process was one in which remarkable dexterity was displayed. A man stood before the open door of the oven, having in his hand the handle of a long shovel called a peel, the other end of which was lying flat in the oven. Another man took the biscuits as fast as they were formed and stamped, and jerked or threw them into the oven with such undeviating accuracy that they should always fall on the peel. The man with the peel then arranged the biscuits side by side over the whole floor of the oven. Nothing could exceed (in manual labor alone) the regu larity with which this was all done. Seventy biscuits were thrown into the oven and regularly arranged in one minute; the attention of each man being vigorously directed to his own department; for a delay of a single second on the part of any one man would have disturbed the whole gang. The biscuits do not require many minutes' baking; and as the oven is kept open during the time that it is being filled, the biscuits first thrown in would be overbaked were not some precaution taken to prevent it. The moulder therefore made those which were to be first thrown into the oven larger than the subsequent ones, and diminished the size by a nice gradation.

The mode in which, since about the year 1831, ships' biscuits have been made by machinery invented by T. T. Grant, Esq., of the Royal Clarence yard, is this: the meal or flour is conveyed into a hollow cylinder four or five feet long and about three feet in diameter, and the water, the quantity of which is regulated by a gauge admitted to it; a shaft, armed with long knifes, works rapidly round in the cylinder, with such astonishing effect that, in the short space of three minutes, 340 pounds of dough are produced, infinitely better made than that mixed by the naked arms of a man. The dough is removed from the cylinder and placed under the breaking-rollers; these latter, which perform the office of kneading, are two in number, and weigh 15 cwt. each; they are rolled to and fro over the surface of the dough by means of machinery, and in five minutes the dough is perfectly kneaded. The sheet of dough, which is about two inches thick, is then cut into pieces half a yard square, which pass under a second set of rollers, by which each piece is extended to the size of six feet by three, and reduced to the proper thickness for biscuits. The sheet of dough is now to be cut up into biscuits, and no part of the operation is more beautiful than the mode by which this is accomplished. The dough is brought under a stamping or cutting-out press, similar in effect, but not in detail, to that by which circular pieces for coins are cut out of a sheet of metal. A series of sharp knives are so arranged that, by one movement, they cut out of a piece of dough a yard square about sixty hexagonal biscuits. The reason for a hexagonal (six-sided) shape is, that not a particle of waste is thereby occasioned, as the sides of the hexagonals accurately fit into those of the adjoining biscuits; whereas circular pieces cut out of a large surface always leave vacant spaces between. That a flat sheet can be divided into hexagonal pieces without any waste of material is obvious.

Each biscuit is stamped with the queen's mark, as well as punctured with holes by the same movement which cuts it out of the piece of dough. The hexagonal cutters do not sever the biscuits completely asunder; so that a whole sheet of them can be put into the oven at once on a large peel or shovel adapted for the purpose. About fifteen minutes are sufficient to bake them; they are then withdrawn and broken asunder by the hand.

The corn for the biscuits is purchased at the markets, and cleaned, ground, and dressed; at the government mills; in quality it is a mixture of fine flour and middlings, the bran and pollard being removed. The ovens for baking are formed of fire-brick and tile, with an area of about 160 feet. About 112 lbs. weight of biscuits are put into the ovens at once. This is called a suit, and is reduced to about 110 lbs. by the baking. From twelve to sixteen suits can be baked in each oven every day, or after the rate of 224 lbs. per hour. The men engaged are dressed in clean check shirts and white linen trowsers, apron, and cap; and every endeavor is made to observe the most scrupulous cleanliness.

We may now make a few remarks on the comparative merits of the hand and the machine processes. If the meal and the water with which the biscuits are made be not thoroughly mixed up, there will be some parts moister than others. Now, it was formerly found that the dough was not well mixed by the arms of the workman; the consequence of which was that the dry parts became burnt up, or else that the moist parts acquired a peculiar kind of hardness which the sailors called "flint:" these defects are now removed by the thorough mixing and kneading which the ingredients receive by the machine.

We have seen that 450 lbs. of dough may be mixed by the machine in four minutes, and kneaded in five or six minutes; we need hardly say how much quicker this is than men's hands could effect it. The biscuits are cut out and stamped sixty at a time, instead of singly: besides the time thus saved, the biscuits become more equally baked, by the oven being more speedily filled. The nine ovens at Gosport used to employ 45 men to produce about 1,500 lbs. of biscuit per hour; 16 men and boys will now produce, by the same number of ovens, 2,240 lbs. of biscuits (one ton) per hour.

The comparative expense is thus stated: Under the old system, wages, and wear and tear of utensils, cost about 1*s.* 6*d.* per cwt. of biscuit: under the new system, the cost is 5*d.*

The bakehouses at Deptford, Gosport, and Plymouth, could produce 7,000 or 8,000 tons of biscuits annually, at a saving of 12,000*l.* per annum from the cost under the old system. The advantages of machine-made over hand-made biscuits, therefore, are many: quality, cleanliness, expedition, cheapness, and independence of government contractors.

Fig. 7, represents the biscuit machinery, as executed beautifully by Messrs. Rennie,

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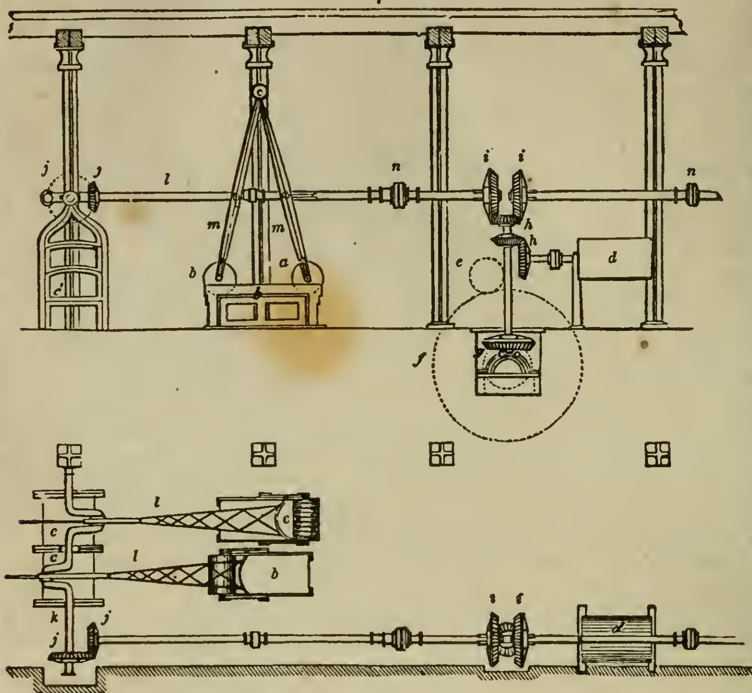


Engineers. *a*, is the breaking roller, table and roller; *b*, the finishing roller, table and roller; *c*, *c*, docking machines for stamping out the biscuits; *d*, mixing machine for making the dough; *e*, spur pinion to engine shaft; *f*, spur-wheel; *g*, *g*, bevel mitre-wheels to give the upright motion; *h*, *h*, bevel-wheels for working the mixing machine; *i*, *i*, *i*, ditto for communicating motion to the rolling machines *j*, *j*; *k*, the crank shaft; *l*, *l*, connecting rods; *m*, *m*, pendulums for giving motion to rollers; *n*, *n*, clutches for connecting either half of the machinery to the other.

BITUMEN. It is a very remarkable fact, in the history of the useful arts, that asphalt, which was so generally employed as a solid and durable cement in the earliest constructions upon record, as in the walls of Babylon, should for so many thousand years have fallen well nigh into disuse among civilized nations. For there is certainly no class of mineral substances so well fitted as the bituminous, by their plasticity, fusibility, tenacity, adhesiveness by surfaces, impenetrability by water, and unchangeableness in the atmosphere, to enter into the composition of terraces, foot-pavements, roofs, and every kind of hydraulic work. Bitumen, combined with calcareous earth, forms a compact, semi-elastic solid, which is not liable to suffer injury by the greatest alternations of frost and thaw, which often disintegrate in a few years the hardest stone, nor can it be ground to dust and worn away by the attrition of the feet of men and animals, as sandstone, flags, and even blocks of granite are. An asphalt pavement, rightly tempered in tenacity, solidity, and elasticity, seems to be incapable of suffering abrasion in the most crowded thoroughfares; a fact exemplified of late in a few places in London, but much more extensively, and for a much longer time, in Paris.

The great Place de la Concorde (formerly Place Louis Quinze) is covered with a beautiful mosaic pavement of asphalt; many of the promenades on the Boulevards, formerly so filthy in wet weather, are now covered with a thin bed of bituminous mastich, free alike from dust and mud; the foot-paths of the Pont Royal and Pont Carousel, and the areas of the great public slaughter-houses, have been for several years paved in a similar manner with perfect success. It is much to be regretted that the asphalt companies of London made the ill-judged, and nearly abortive attempt, to pave the carriage-way near the east end of Oxford street, and especially at a moist season, most unpropitious to the laying of bituminous mastich. Being formed of blocks not more than three or four inches thick, many of which contained much siliceous sand, such a pavement could not possibly resist the crash and vibration of many thousand heavy drays, wagons, and omnibuses, daily rolling over it.* This failure can afford, however, no argument against rightly-constructed foot-pavements and terraces of asphalt. Numerous experiments and observations have led me to conclude that fossil bitumen possesses far more valuable properties, for making a durable mastich, than the solid pitch obtained by boiling wood or coal tar. The latter, when inspissated to a proper degree of hardness, becomes brittle, and may be readily crushed into powder; while the former, in like circumstances, retains sufficient tenacity to resist abrasion. Factitious tar and pitch being generated by the force of fire, seem to have a propensity to decompose by the joint agency of water and air, whereas mineral pitch has been known to remain for ages without alteration.

Bitumen alone is not so well adapted for making a substantial mastich as the native compound of bitumen and calcareous earth, which has been properly called asphaltic rock, of which the richest and most extensive mine is unquestionably that of the *Val-de-Travers*, in the canton of Neufchâtel. This interesting mineral deposite occurs in the Jurassic limestone formation, the equivalent of the English oolite. The mine is very accessible, and may be readily excavated by blasting with gunpowder. The stone is massive, of irregular fracture, of a liver-brown color, and is interspersed with a few minute spangles of calcareous spar. Though it may be scratched with the nail, it is difficult to break by the hammer. When exposed to a very moderate heat it exhales a fragrant ambrosial smell, a property which at once distinguishes it from all compounds of factitious bitumen. Its specific gravity is 2·114, water being 1,000, being nearly the density of bricks. It may be most conveniently analyzed by digesting it in successive portions of hot oil of turpentine, whereby it affords 80 parts of a white pulverulent carbonic of lime, and 20 parts of bitumen in 100. The asphalt rock of Val-de-Travers seems therefore to be far richer than that of Pyrimont, which, according to the statement in the specification of Claridge's patent, of November, 1837, contains "carbonate of lime and bitumen in about the proportion of 90 parts of carbonate of lime to about 10 parts of bitumen."

The calcareous matter is so intimately combined and penetrated with the bitumen, as to resist the action not only of air and water for any length of time, but even of muriatic acid; a circumstance partly due to the total absence of moisture in the mineral, but chiefly to the vast incumbent pressure under which the two materials have been incorporated in the bowels of the earth. It would indeed be a difficult matter to combine, by artificial methods, calcareous earth thus intimately with bitumen, and for this reason the mastichs made in this way are found to be much more perishable. Many of the factitious asphalt cements contain a considerable quantity of siliceous sand, from which they derive the property of cracking and crumbling down when trodden upon. In fact, there seems to be so little attraction between siliceous matter and bitumen, that their parts separate from each other by a very small disruptive force.

Since the asphalt rock of Val-de-Travers is naturally rich enough in concrete bitumen, it may be converted into a plastic workable mastich of excellent quality for foot pavements and hydraulic works at very little expense, merely by the addition of a very small quantity of mineral or coal tar, amounting to not more than 6 or 8 per cent. The union between these materials may be effected in an iron caldron, by the application of a very moderate heat, as the asphalt bitumen readily coalesces with the tar into a tenacious solid.

The mode adopted for making the beautiful asphalt pavement at the Place de la Concorde in Paris was as follows: The ground was made uniformly smooth, either in a horizontal plane or with a gentle slope to carry off the water; the curb-stones were then laid round the margin by the mason, about 4 inches above the level of the ground. This hollow space was filled to a depth of 3 inches with concrete, containing about a sixth part of hydraulic lime, well pressed upon its bed. The surface was next smoothed with a thin coat of mortar. When the whole mass had become perfectly dry, the mosaic pattern was set out on the surface, the moulds being formed of flat iron bars, rings, &c., about half an inch thick, into which the fluid mastich was poured by ladles from a caldron, and spread evenly over.

The mastich was made in the following way: The asphalt rock was first of all roasted in an oven, about 10 feet long and 3 broad, in order to render it friable.

* See the conclusion of this article.

The bottom of the oven was sheet iron, heated below by a brisk fire. A volatile matter exhaled, probably of the nature of naphtha, to the amount of one fortieth the weight of asphalt; after roasting, the asphalt became so friable as to be easily reduced to powder, and passed through a sieve, having meshes about one fourth of an inch square.

The bitumen destined to render the asphalt fusible and plastic, was melted in small quantities at a time, in an iron caldron, and then the asphalt in powder was gradually stirred in to the amount of 12 or 13 times the weight of bitumen. When the mixture became fluid, nearly a bucketful of very small, clean gravel, previously heated apart, was stirred into it; and, as soon as the whole began to simmer with a treacley consistence, it was fit for use. It was transported in buckets, and poured into the moulds.

For the reasons above assigned, I consider this addition of rounded, polished, siliceous stones to be very injudicious. If anything of the kind be wanted to give solidity to the pavement, it should be a granitic or hard calcareous sand, whose angular form will secure the cohesion of the mass. I conceive, also, that tar, in moderate quantity, should be used to give toughness to the asphaltic combination, and prevent its being pulverized and abraded by friction.

In the able report of the Bastenne and Gaujac Bitumen company, drawn up by Messrs. Goldsmid and Russell, these gentlemen have made an interesting comparison between the properties of mineral tar and vegetable tar: the bitumen composed of the latter substance, including various modifications, extracted from coal and gas, have, so far as they were able to ascertain, entirely failed. This bitumen, owing to the qualities and defects of vegetable tar, becomes soft at 115° of Fahrenheit's scale, and is brittle at the freezing point; while the bitumen, into which mineral tar enters, will sustain 170° of heat, without injury. In the course of the winter, 1837–'38, when the cold was at 14½° below zero, C., the bitumen of Bastenne and Gaujac, with which one side of the Pont Neuf at Paris is paved, was not at all impaired, and would, apparently, have resisted any degree of cold; while that in some parts of the Boulevard, which was composed of vegetable tar, cracked and opened in white fissures. The French government, instructed by these experiments, has required, when any of the vegetable bitumens are laid, that the pavement should be an inch and a quarter thick; whereas, where the bitumen composed of mineral tar is used, a thickness of three quarters of an inch is deemed sufficient. The pavement of the bonding warehouse at Bordeaux has been laid upward of 15 years by the Bastenne company, and is now in a condition as perfect as when first formed. The reservoirs constructed to contain the waters of the Seine at Batignolles, near Paris, have been mounted 6 years, and, notwithstanding the intense cold of the winter of 1837, which froze the whole of their contents into one solid mass, and the perpetual water pressure to which they are exposed, they have not betrayed the slightest imperfection in any point. The repairs done to the ancient fortifications at Bayonne, have answered so well, that the government, 2 years ago, entered into a very large contract with the company for additional works, while the whole of the arches of the St. Germain and St. Cloud railways, and the pavements and floorings necessary for these works, are being laid with the Bastenne bitumen.

The mineral tar in the mines of Bastenne and Gaujac is easily separated from the earthy matter with which it is naturally mixed by the process of boiling, and is then transported in barrels to Paris or London, being laid down in the latter place to the company at 17*l.* per ton, in virtue of a monopoly of the article purchased by the company at a sum, it is said, of 8,000*l.*

Mr. Harvey, the able superintendent of the Bastenne company, was good enough to supply me with various samples of mineral tar, bitumen, and asphaltic rock, for analysis. The tar of Bastenne is an exceedingly viscid mass, without any earthy impurity. It has the consistence of baker's dough at 60° of Fahrenheit; at 80° it yields to the slightest pressure of the finger; at 150 degrees it resembles a soft extract; and at 212 degrees it has the fluidity of molasses. It is admirably adapted to give plasticity to the calcareous asphalts.

A specimen of Egyptian asphalt which he brought me, gave, by analysis, the very same composition as the Val-de-Travers, namely, 80 per cent. of pure carbonate of lime, and 20 of bitumen. A specimen of mastich, prepared in France, was found to consist, in 100 parts, of 29 of bitumen, 52 of carbonate of lime, and 19 of siliceous sand. A portion of stone called the natural Bastenne rock, afforded me 80 parts of gritty siliceous matter and 20 of thick tar. The Trinidad bitumen contains a considerable portion of foreign earthy matter; one specimen having yielded me 25 per cent. of siliceous sand; a second, 28; a third, 20; and a fourth, 30: the remainder was pure pitch. One specimen of Egyptian bitumen, specific gravity 1·2, was found to be perfectly pure, for it dissolved in oil of turpentine without leaving any appreciable residuum.

Robinson's Parisian Bitumen company use a mastich made with the pitch obtained from boiling coal-tar mixed with chalk. One piece laid down by this company at Knightsbridge and another at Brighton, are said to have gone to pieces. The portion of pavement laid down by them in Oxford street, next Charles street, has been taken up. Claridge's company have laid down their mastich under the archway of the Horse-Guards, and in the carriage-entrance at the Ordnance Office; the latter has cracked at the junction with the old pavement of Yorkshire curb-stone. The foot-pavement laid down by Claridge's company at Whitehall has stood well. The Bastenne company has exhibited the best specimen of asphalt pavement in Oxford street; they have laid down an excellent piece of foot-pavement near Northumberland House; a piece, 40 feet by 7, on Blackfriars' Bridge; they have made a substantial job in paving 830 superficial feet in front of the guard-room at Woolwich, which, though much traversed by foot-passengers, and beat by the guard in grounding arms, remains sound; lastly, the floor of the stalls belonging to the cavalry barracks of the Blues at Knightsbridge, is probably the best example of asphaltic pavement laid down in this country, as it has received no injury from the beating of the horses' feet.

As the specific gravity of properly-made mastich is nearly double that of water, a cubic foot of it will weigh from 125 to 130 lbs.; and a square foot, three quarters of an inch thick, will weigh very nearly eight pounds. A ton of it will therefore cover 280 square feet. The prices at which the Bastenne Bitumen company sell their products is as follows:—

Pure Mineral tar, 24*l*. per ton, or 28*s*. per cwt.
Mastich 8*l*. 8*s*. per ton, or 10*s*. per cwt.

		Side Pavement.		Roofs and Terraces.
From 50	to 100	feet, 1*s*. 3*d*. per foot.	-	1*s*. 6*d*. per foot.
100	250	1*s*. 1*d*. -	-	1*s*. 4*d*.
250	500	11*d*. -	-	1*s*. 1*d*.
500	750	10*d*. -	-	1*s*. 0*d*.
750	1000	9*d*. -	-	11*d*.
1000	2000	8*d*. -	-	10*d*.
2000	5000	7*d*. -	-	9*d*.

Where the work exceeds 5,000 feet, contracts may be entered into.

For filling up joints of brickwork, &c., from 1*d*. to 1¼*d*. per foot, run according to quantity.

These prices are calculated for half an inch thickness, at which rate a ton will cover 420 square feet.

As the Val-de-Travers company engage to lay down their rich asphaltic rock in London at 5*l*. per ton; and as the mineral tar equal to that of Seissel may probably be had in England at one fourth the price of that foreign article, they may afford to lay their mastich three quarters of an inch thick per the thousand feet, including a sub-stratum of concrete, at a rate of fivepence per square foot, instead of fifteenpence, being the rate charged under that condition by the Bastenne company.

These charges are for London and its immediate vicinity.

Report of the experimental Pavements laid down in Oxford street, from Charles street to Tottenham Court Road, January, 1839.

1. Robinson's Parisian bitumen, laid in blocks 12 inches square and 5 inches deep; the substance is a compound of bitumen, lime, &c., and five granite stones are inserted in the top of each block; the work is laid in straight courses, the joints cemented with hot bitumen. The quantity of this is 97 square yards, the length is 20 feet, and the price, if adopted, 9*s*. per square yard.

2. Same as 1, but the courses laid diagonally. The quantity is 97 square yards, the length is 20 feet.

3. Granite paving, 9 inches deep, jointed with Claridge's asphalt, the work laid in straight courses. The cost to the parish has been 11*s*. 7*d*. per yard superficial for the stone and laying, &c., no charge being made by Claridge's company for the asphalt. The quantity is 240 yards, the length 54 feet.

4. Granite paving, 4½ inches deep, jointed with Claridge's asphalt, the work laid in diagonal courses. Cost to the parish 9*s*. 6*d*. per square yard. No charge made for the asphalt. The quantity is 88 square yards, the length 20 feet.

5. The Bastenne Bitumen company. The blocks are 12 inches long, 6¼ wide, and 3¾ deep, with bevelled joints, close at bottom, and ½ inch open at top; the joints cemented with hot bitumen; the substance is bituminous, with a very large proportion of granite imbedded in each block; the price, if adopted 13*s*. 6*d*. per square yard; the length, in straight courses, 20 feet.

6. Same as 5, but the courses laid diagonally. The length 40 feet; the total quantity in 5 and 6 is 274 square yards.

7. Aberdeen granite paving, 9 inches deep; laid on a concrete bottom, formed of gravel and lime, the joints of the pavement run with hot lime grout, in straight courses. The length is 69 feet; cost, 16*s*. 5*d*. per square yard.

8. Same as 7, but the courses laid diagonally; length 38 feet.

9. Aberdeen granite paving, 9 inches deep, in straight courses, without a concrete bottom; joints filled with fine gravel; cost, 12*s*. 5*d*. per yard; length, 24 feet.

10. The Scotch Asphaltum company. The work is laid in blocks of divers length, 9 inches wide, and 6½ deep; the side joints are straight, the end joints are bevelled alternately. The work is laid in straight courses, and jointed in Roman cement; the substance is, apparently, a bituminous matter mixed with fine gravel. The length is 50 feet; the number of square yards, 210; the price, per yard, if adopted, 13*s*. 6*d*.

11. The wood-paving. The blocks are sexagon on the plan, and (with the exception of a few courses that are only 8 inches), 12 inches deep. The work is laid endwise of the grain; the blocks are mostly 8 inches diameter—a few courses are 7 inches. The material is Norway fir; there is no prepared bottom—the blocks are laid on the plain ground, a small layer of gravel being spread to bed them in. From the west end, 22 rows of courses of blocks are of wood in its natural state; 31 rows have been Kyanised; 9 rows at the eastern end have been dipped in Claridge's asphalt; 6 rows have been dipped in a solution prepared by the patentee; the remainder are of wood in the natural state. The length of this piece is 60 feet: the number of yards, 230; price per yard, if approved, 10*s*. 6*d*.

12. Val-de-Travers company. Blocks in straight courses, 12 inches square, 5 inches deep, with square joints. The substance of the blocks is bituminous, with a very large proportion of granite imbedded in each block, the joints cemented with hot bitumen. The length is 25 feet; number of square yards 94; the work is performed gratuitously.

13. The same company. A layer of clean chippings and hot asphalt poured thereon. The face up, with hot asphalt and broken stone imbedded therein. The length is 25 feet: number of yards, 94; the work is gratuitous.

14. Same as 9. The length 47 feet.

By order of the Committee,
H. Kensett, Chairman.

Statement of the number of carriages passing through Oxford street at the undernamed times and places.

Date. 1839.	Time.	Place.	Gents. 2-Wheel.	Gents. 4-Wheel.	Omnibuses.	2-Wheel Hackney Carriages.	4-Wheel Hackney Carriages.	Stage Coaches.	Wagons, Drays, &c.	Light Carts and Sundries.	Total.
Jan. 16.	6 in the morning till 12 at	by the Pantheon.	347	935	890	621	752	91	372	1507	5515
18.	do. [night.	by Stratford place.	254	603	1213	401	728	89	472	993	4753
22.	do.	by Newman street.	339	1241	1015	584	1288	85	958	1382	6992
26.	do. [morning.	by Stratford place.	371	766	1337	542	762	92	881	1292	5943
26.	12 at night till 6 in the	do.	—	4	1	82	139	2	38	58	324

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 crystallizing point. This potash-sulphate of iron has a fine amethyst color 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 colors, from light gray 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.

BLACK PIGMENT. A fine lamp-black is obtained by the combustion of a thick torch of coal-gas, supplied with a quantity of air adequate to burn only its hydrogen. In this case, the whole of its carbon is deposited in the form of a very fine black powder of extreme lightness. This black is used in making the better qualities of printer's ink.

BLACKING FOR SHOES. (*Cirage des bottes*, Fr.; *Schuhschwärze.*)

The following prescription for making liquid and paste blacking is given by William Bryant and Edward James, under the title of a patent, dated December, 1836. Their improvement consists in the introduction of caoutchouc, with the view, possibly, of making the blacking waterproof:—

18 ounces of caoutchouc are to be dissolved in about 9 pounds of hot rape oil. To this solution 60 pounds of fine ivory black, and 45 pounds of molasses, are to be added, along with 1 pound of finely ground gum arabic, previously dissolved in 20 gallons of vinegar, of strength No. 24. These mixed ingredients are to be finely triturated in a paint mill till the mixture becomes perfectly smooth. To this varnish 12 pounds of sulphuric acid are to be now added in small successive quantities, with powerful stirring for half an hour. The blacking thus compounded is allowed to stand for 14 days, it being stirred half an hour daily; at the end of which time, 3 pounds of finely ground gum arabic are added; after which the stirring is repeated half an hour every day for 14 days longer, when the liquid blacking is ready for use.

In making the paste blacking, the patentees prescribe the above quantity of India rubber oil, ivory black, molasses, and gum arabic, the latter being dissolved in only 12 pounds of vinegar. These ingredients are to be well mixed, and then ground together in a mill till they form a perfectly smooth paste. To this paste 12 pounds of sulphuric acid are to be added in small quantities at a time, with powerful stirring, which is to be continued for half an hour after the last portion of the acid has been introduced. This paste will be found fit for use in about seven days.

BLEACHING OF PAPER. The following are the proportions of liquid chloride of lime, at 10° of Gay Lussac's *Chlorometre*, employed for the different sorts of rags, consisting of two piles, or 200 pounds French.

Cotton.		litres.
No. 1.	Fine cotton rags	10
2.	Clean calicoes	12
3.	————	14
4.	White dirty calico, coarse cotton	16
5.	Coarse cotton	18
6.	Grey, No. 1	20
	—— No. 2	22
	Saxon gray	24
	———— No. 2	26
	Pale white and half-white shades	28
	Saxon blues; pale pink, dark blue, velvet	32

It is considered to be much better to bleach the fine rags with liquid chloride of lime, and not with chlorine gas, because they are less injured by the former, and afford a paper of more nerve, less apt to break, and more easily sized. But the coarse or gray rags are much more economically bleached with the gaseous chlorine, without any risk of weakening the fibre too much. Bleaching by the gas is performed always upon the sorted rags, which have been boiled in an alkaline ley, and torn into the fibrous state. They are subjected to the press, in order to form them into damp cakes, which are broken in pieces and placed in large rectangular wooden cisterns. The chlorine gas is introduced by tubes in the lid of the cistern, which falls down by its superior gravity, acting always more strongly upon the rags at the bottom than those above.

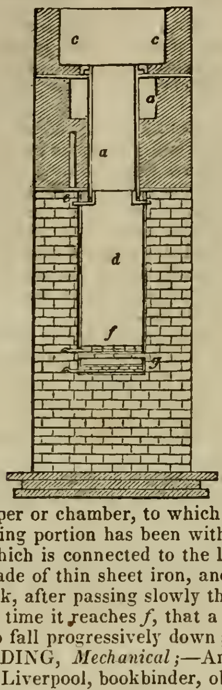
When the chlorine, disengaged from 150 kilogrammes (330 lbs.) of manganese and 500 kilos. of muriatic acid, is made to act upon 2,500 kilos. of the stuff (supposed dry), it will have completed its effect in the course of a few hours. The quantity of gaseous chlorine is equal to what is contained in the quantity of chloride of lime requisite to produce a like bleaching result. The bleached stuff should be forthwith carefully washed, to remove all the muriatic acid produced from the chlorine; for if any of this remain in the paper, it destroys lithographic stones, and weakens common ink.

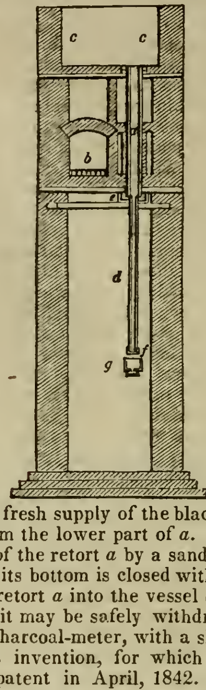
BONE BLACK, or animal charcoal *restored*. A process for this purpose was made the subject of a patent by Messrs. Bancroft and Mac Innes of Liverpool, which consists in washing the granular charcoal, or digesting it when finely ground, with a weak solution of potash or soda, of specific gravity 1·06. The bone black which has been used in sugar refining may be thus restored, but it should be first cleared from all the soluble filth by means of water.

Mr. F. Parker's method, patented in June, 1839, for effecting a like purpose, is, by a fresh calcination, as follows:—

Fig. 8 represents a front section of the furnace and retort; and *fig.* 9 is a trans verse vertical section of the same. *a* is a retort, surrounded by the flues of the furnace

9





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b; *c* is a hopper or chamber, to which a constant fresh supply of the black is furnished, as the preceding portion has been withdrawn, from the lower part of *a*. *d* is the cooling vessel, which is connected to the lower part of the retort *a* by a sand joint *e*. The cooler *d* is made of thin sheet iron, and is large; its bottom is closed with a slide plate, *f*. The black, after passing slowly through the retort *a* into the vessel *d*, gets so much cooled by the time it reaches *f*, that a portion of it may be safely withdrawn, so as to allow more to fall progressively down; *g* is the charcoal-meter, with a slide door.

BOOKBINDING, *Mechanical;*—An ingenious invention, for which Mr. Thomas Richards, of Liverpool, bookbinder, obtained a patent in April, 1842. He employs, 1st., a mechanism to sew, weave, or bind a number of sheets together to form a book, instead of stitching them by hand; 2d, a table which slides to and fro to feed or supply each sheet of paper separately into his machine; also needle-bars, or holders, to present needles with the requisite threads, for stitching such sheets as they are supplied with in succession. He has, moreover, a series of holding fingers, or pincers, suitably provided with motions, to enable them to advance and clasp the needles, draw them through the sheets of paper, and return them into their respective holders, after threading or stitching the sheet; lastly, there are arms or levers for delivering each sheet regularly upon the top of the preceding sheets, in order to form a collection or book of such sheets, ready for boarding and finishing. A minute description of the whole apparatus, with plates, is given in *Newton's Journal*, C. S., xxiii. 157.

BORACIC ACID. Imported for consumption in 1839, 1,243,868 lbs.; in 1840, 524,205 lbs.

BORAX. Imported for home consumption in 1839, 498,079 lbs.; in 1840 319,126 lbs.

BRANDY. Imported for consumption in 1839, 167,756 galls.; in 1840, 1,108,578 galls.; duty. 1*l.* 2*s.* 10*d.* per imperial proof gallon.

BRASS, YELLOW. The following table exhibits the composition of several varieties of this species of brass. No. 1 is a cast brass of uncertain origin; 2, the brass of Jemappes; 3, the sheet brass of Stolberg, near Aix-la-Chapelle; 4 and 5, the brass for gilding, according to D'Arcet; 6. the sheet brass of Romilly; 7, English brass wire; 8, Augsburg brass wire; 9, brass wire of Neustadt-Eberswald, in the neighborhood of Berlin.

	1.	2.	3.	4.	5.	6.	7.	8.	9.
Copper -	61·6	64·6	64·8	63·70	64·45	70·1	70·29	71 89	70·16
Zinc - -	35·3	33·7	32·8	33·55	32·44	29·9	29·26	27·63	27·45
Lead - -	2·9	1·4	2·0	0·25	2·86	- -	0·28	-	0 20
Tin - -	0·2	0·2	0 4	2·50	0·25	- -	0·17	0 85	0·79
	100·0	99 9	100·0	100·00	100·00	- -	100·00	100·37	98 60

The mean proportion of the metals in yellow brass is 30 zinc to 70 copper.

Tombak, or red brass, in the cast state, is an alloy of copper and zinc, containing not more than 20 per cent. of the latter constituent. The following varieties are distinguished: 1, 2, 3, tombak for making gilt articles; 4, French tombak for sword-handles, &c.; 5, tombak of the Okar, near Goslar, in the Hartz; 6, yellow tombak of Paris for gilt ornaments; 7, tombak for the same purpose from a factory in Hanover; 8, chrysochalk; 9, red tombak from Paris; 10, red tombak of Vienna.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Copper -	82·0	82	82·3	80	85	85·3	86	90·0	92	97·8
Zinc - -	18·0	18	17·5	17	15	14·7	14	7·9	8	2·2
Lead - -	1·5	3	- -	- -	- -	- -	- -	1·6		
Tin - -	3·0	1	0·2	3	trace.					
	104·5	104	100·0	100	100	100·0	100	99·5	100	100·0

Pinchbeck is made of 2 parts copper and 1 yellow brass;
Prince's metal - 3 ——— - 1 zinc.
Mannheim gold (semilor), 28 copper, 12 yellow brass, 3 tin.

Cast white metal buttons are made of an alloy of 32 parts brass (yellow), 4 parts zinc, and 2 tin.

The specific gravity of brass is greater than the mean density of its constituents; varying from 7·82 to 8·73, according to the proportion of zinc to copper. Sheet brass varies from 8·52 to 8·62; brass wire from 8·49 to 8·73. Brass heated and quickly cooled becomes somewhat less dense. The specific gravity of sheet tombak (81·25 copper + 18·75 zinc) is 8·788; of tombak wire (87·5 copper + 12·5 zinc) has been found so great as 9·00.

BREAD. I believe it may be safely asserted that the art of baking bread, pastry, and confectionary, is carried in Paris to a pitch of refinement which it has never reached in London. I have never seen here any bread which, in flavor, color, and texture, rivalled the French *pain de gruau*. In fact, our corn monopoly laws prevent us from getting the proper wheat for preparing, at a moderate price, the genuine *semoule* out of which that bread is baked. Hence, the plebeian *bourgeois* can daily grace his table with a more beautiful piece of bread than the most affluent English nobleman. The French process of baking has been recently described, with some minuteness, by their distinguished chemist, M. Dumas,* and it merits to be known in this country.

At each operation, the workman (*pétrisseur*) pours into the kneading-trough the residuary leaven of a former kneading, adding the proportion of water which practice enjoins, and diffuses the leaven through it with his hands. He then introduces into the liquid mass the quantity of flour destined to form the sponge (*pâte*). This flour is let down from a chamber above, through a linen hose (*manche*), which may be shut by folding it up at the end.

The workman now introduces the rest of the flour by degrees, diffusing and mingling it, in a direction from the right to the left end of the trough. When he has thus treated the whole mass successively, he repeats the same manipulation from left to right. These operations require no little art for their dexterous performance; hence they have the proper name assigned respectively to each, of *frasage* and *contre-frasage*. The workman next subjects the dough to three different kinds of movement, in the kneading process. He malaxates it; that is, works it with his hands and fingers, in order to mix very exactly its component parts, while he adds the requisite quantity of flour. He divides it into six or seven lumps (*pâtons*), each of which he works successively in the same manner. Then he seizes portions of each, to draw them out, taking only as much as he can readily grasp in his hands. When he has thus kneaded the different lumps, he unites them into one mass, which he extends and folds repeatedly back upon itself. He then lifts up the whole at several times, and dashes it forcibly against the kneading-trough, collecting it finally at its left end. The object of these operations is to effect an intimate mixture of the flour, the water, and the leaven. No dry powdery spots, called *marrons*, should be left in any part of the dough.

The kneader has now completed his work; and after leaving the dough for some time at rest, he turns it upside down. He lays the lumps, of a proper weight, upon a table, rolls them out, and dusts them with a little flour. He next turns over each lump, and puts it in its *panneton*, where he leaves it to swell. If the flour be of good

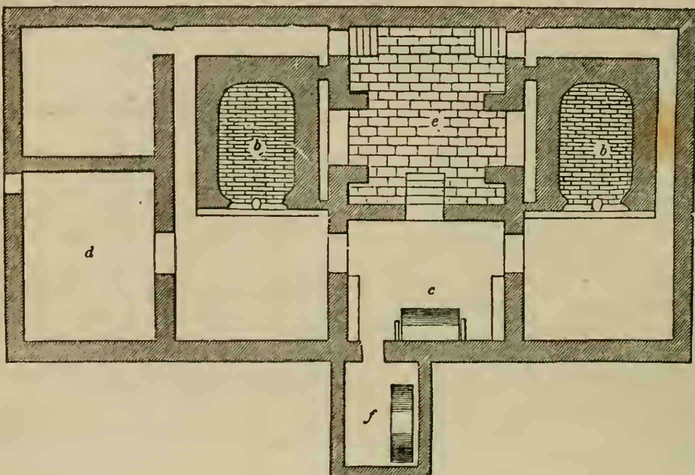
* Traité de Chimie appliquée aux Arts, vi., p. 409.

quality, the dough be well made, and the temperature be suitable, the lumps will swell much and uniformly. If after the surface has risen, it falls to a considerable extent, the flour must be bad, or it must contain other substances, as potato-starch, bean-meal, &c.

Whenever the oven is hot enough, and the dough sufficiently fermented, it is subjected to the baking process. Ovens, as at present constructed, are not equably heated throughout, and are particularly liable to be chilled near the door, in consequence of its being occasionally opened and shut. To this cause M. Dumas ascribes many of the defects of ordinary bread; but he adds, that by adopting the patent invention of M. Mouchot these may be obviated. This is called the *improved bakery, boulangerie perfectionnée.*

Fig. 10 is a ground plan of the aerothermal bakehouse, the granaries being in the

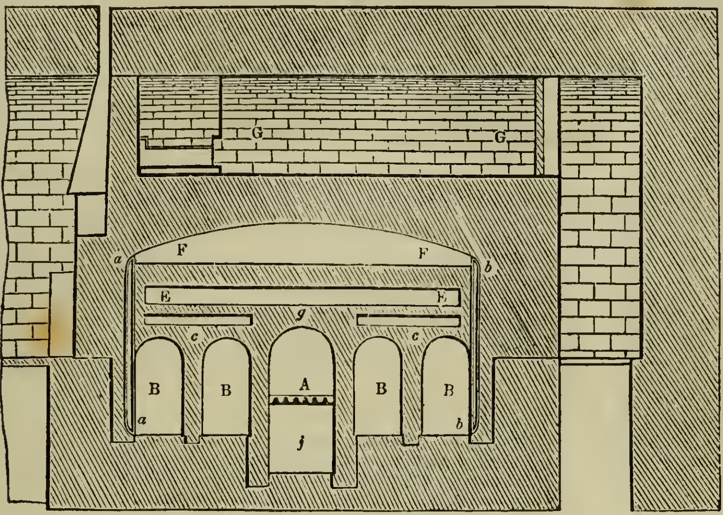
10



upper stories, and not shown here. *b, b* are the ovens; *c*, the kneading-machine; *d*, the place where the machinery is mounted for hoisting up the bread into the store-room above; *e*, a space common to the two ovens, into which the hot air passes; *f*, the place of a wheel driven by dogs, for giving motion to the kneading-machine.

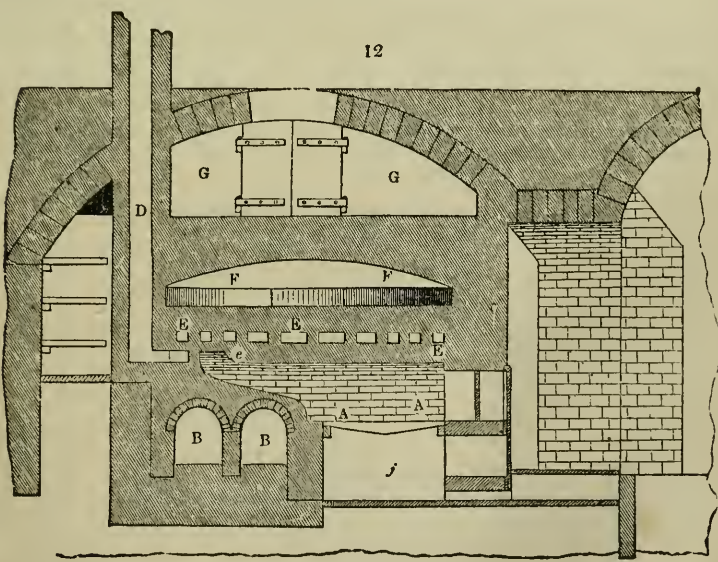
Fig. 11 is a longitudinal section of the oven; A, the grate where coke or even pit-coals may be burned; B, B, void spaces which, becoming heated, serve for warming small pieces of dough in; *c, c*, are flues for conducting the smoke, &c., from the fire-place; D, seen in *fig.* 12, is the chimney for carrying off the smoke transmitted by the flues; E, E, void spaces immediately over the flues, and beneath the sole, F, F, of the oven. By this arrangement the air, previously heated, which arrives from the void spaces B through the flues *c, c*, gets the benefit of the heat of the flame which circulates in these flues, and, after getting more heated in the spaces E, E, ascends through channels into the oven F, F, upon the sole of which the loaves to be baked are laid. The hot air is admitted into it through the passages *a, a*, being drawn from the reservoirs B, B, B, and also by the passage *d, d*, drawn from the reservoirs E, E. The sole is likewise heated by contact with the hot air contained in the space E, E, placed immediately below it. The hot air, loaded with moisture, issues by the passage *b, b*, and returns directly into the reservoir B, B. G, G, an enclosed space directly over the oven, to obstruct the dissipation of its heat; *g*, vault of the fireplace. *Fig.* 12, a transverse section through the middle of the oven. *Fig.* 13, the kneading-machine, a longitudinal section passing through its axis; P, P, the contour of the machine, made of wood, and divided into three compartments for the reception of the dough. The wooden bars *o, o*, are so placed in the interior of the compartments, as to divide the dough whenever the cylinder is made to revolve. One portion, D, of the cylinder may be opened and laid over upon the other by means of a hinge joint, when the dough and flour are introduced. A, B, C, the three compartments of the machine, two for making the dough, and one for preparing the sponge, called *levain*, or leaven, by the French. *a, a*, is the pulley which receives its motion from the engine, and transmits it to the cylinder through the pinion *b*, and the spur-wheel *e*; *d*, *d*, the fly-wheel to regulate the motion; *g*, a brake to act upon the fly *d*, by means of a lever *h*; *i*, the pillar of the fly-wheel.

11.



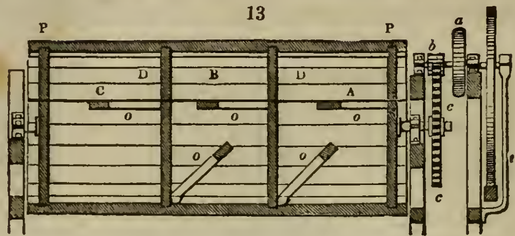
There is a rachet wheel counter for numbering the turns of the kneading machine, but it can not be shown in this view; *n*, cross bars of wood, which are easily removed when the cylinder is opened; they divide the dough.

12



Each of the three compartments of the *kneader* (*fig.* 13) is furnished at pleasure with two bars fixed crosswise, but which may be easily removed, whenever the cylinder is opened. These bars constitute the sole agents for drawing out the dough.

13



In a continuous operation, the leaven is constantly prepared in the compartment A; with which view there is put into it—

	125	kilogrammes of ordinary leaven or yeast.
	67	- - - - - - - flour.
	33	- - - - - - - water.
In all	225	kilogrammes.

The person in charge of the mechanical kneader shuts down its lid, and sets it a-going. At the end of about seven minutes he hears the bell of the counter sound, announcing that the number of revolutions has been sufficient to call for an inspection of the sponge, in regard to its consistence. The cylinder is therefore opened, and after verifying the right state of the leaven, and adding water to soften, or flour to stiffen it, he closes the lid, and sets the machine once more in motion. In ten minutes more the counter sounds again, and the kneading is completed. The 450 kilogrammes of leaven obtained from the two compartments are adequate to prepare dough enough to supply alternately each of the two ovens. For this purpose 75 kilogrammes of leaven are taken from each of the two compartments A and A′, and placed in the intermediate compartment B. The whole leaven is then 75+75=150 kilogrammes; to which are added 100 kilogs. of flour and 50 of water=150, so that the chest contains 300 kilogrammes. There is now replaced in each of the cavities A and A′ the primitive quantity, by adding 50 kilogrammes of flour and 25 of water=75.

The cylinder is again set a-going; and from the nature of the apparatus, it is obvious that the kneading takes place at once on the leavens A and A′ and on the paste B; which last is examined after 7 minutes, and completed in 10 more=17, at the second sound of the counter-bell.

The kneader is opened, the paste on the side and on the bars is gathered to the bottom by means of a scraper. The whole paste of the chest B being removed, 150 kilogs. of the leaven are taken, to which 150 kilogs. of flour and water are added to prepare the 300 kilogs. of paste destined for the supply of the oven No. 2. These 75 kilogs. of leaven from each compartment are replaced as before, and so on in succession.

The water used in this operation is raised to the proper temperature, viz. 25° or 30° C. (77° or 86° F.) in cold weather, and to about 68° F. in the hot season, by mixing common cold water with the due proportion of water maintained at the temperature of about 160° F., in the basin F placed above the ovens.

Through the water poured at each operation upon the flour in the compartment B, there is previously diffused from 200 to 250 grammes of fresh leaven, as obtained from the brewery, after being drained and pressed (*German yeast*). This quantity is sufficient to raise preperly 300 kilogs. of dough. As soon as this dough is taken out of the kneader, as stated above, and while the machine goes on to work, the quantity requisite for each loaf is weighed, turned about on the table D, to give it its round or oblong form, and there is impressed upon it with the fore-arm or roller, the cavity which characterizes cleft loaves. All the lots of dough of the size of one kilog., called cleft loaves (*pains fendus*) are placed upon a cloth a fold of which is raised between two loaves, the cloth being first spread upon a board; which thus charged with 10 or 15 loaves is transferred to the wooden shelves G G in front of the oven.

The whole of them rise easily under the influence of the gentle temperature of this antechamber or *fournil*. Whenever the dough loaves are sufficiently raised here, they are put into the oven, a process called *enfournement* in France; which consists in setting each loaf on a wooden shovel dusted with coarse flour, and placing it thereby on the sole of the oven, close to its fellow, without touching it. This operation is made easy, in consequence of the introduction of a long jointed gas-pipe and burner into the interior of the oven, by the light of which all parts of it may be minutely examined. The oven is first kept moderately hot, by shutting the dampers; but whenever the thermometer attached to it indicates a temperature of from 300° to 290° C. (572° to 554° F.), the dampers or registers are opened, to restore the heat to its original degree, by allowing of the circulation of the hot air, which rises from the lower cavities around the fireplace into the interior of the oven. When the baking is completed the gas-light, which had been withdrawn, is again introduced into the oven, and the bread is taken out; called the process of *défournement.* If the temperature had been maintained at about 300° C., the 300 kilogs. of dough divided into loaves of one kilog. (2¼ lbs. avoirdupois) will be baked in 27 minutes. The charging having lasted 10 minutes, and the discharging as long, the baking of each batch will take up 47 minutes. But on account of accidental interruptions, an hour may be assigned for each charge of 260 loaves of 1 kilog. each; being at the rate of 6240 kilogs. (or 6·75 tons) of bread in 24 hours.

Although the outer parts of the loaves be exposed to the radiation of the walls, heated to 280° or 300° C., and undergo therefore that kind of caramelization (charring) which produces the color, the taste, and the other special characters of the crust, yet the inner substance of the loaves, or the crumb, never attains to nearly so high a temperature; for a thermometer, whose bulb is inserted into the heart of a loaf, does not indicate more than 100° C. (212° F.)

The theory of *panification* (bread-baking) is easy of comprehension. The flour owes this valuable quality to the gluten, which it contains in greater abundance than any of the other *cerealia* (kinds of corn). This substance does not constitute, as had been heretofore imagined, the membranes of the tissue of the perisperm of the wheat; but is enclosed in cells of that tissue under the epidermic coats, even to the centre of the grain. In this respect the gluten lies in a situation analogous to that of the starch, and of most of the immediate principles of vegetables. The other immediate principles which play a part in *panification* are particularly the starch and the sugar; and they all operate as follows:—

The diffusion of the flour through the water, *hydrates* the starch and dissolves the sugar, the albumen, and some other soluble matters. The kneading of the dough, by completing these reactions through a more intimate union, favors also the fermentation of the sugar, by bringing its particles into close contact with those of the leaven or yeast; and the drawing out and malaxating the dough softens and stratifies it, introducing at the same time oxygen to aid the fermentation. The dough, when distributed and formed into loaves, is kept some time in a gentle warmth, in the folds of the cloth, pans, &c., a circumstance propitious to the development of their volume by fermentation. The dimensions of all the lumps of dough now gradually enlarge, from the disengagement of carbonic acid in the decomposition of the sugar; which gas is imprisoned by the glutinous paste. Were these phenomena to continue too long, the dough would become too vesicular; they must, therefore, be stopped at the proper point of sponginess, by placing the loaf lumps in the oven. Though this causes a sudden expansion of the enclosed gaseous globules, it puts an end to the fermentation, and to their growth; as also evaporates a portion of the water.

The fermentation of a small dose of sugar is, therefore, essential to true bread-baking; but the quantity actually fermented is so small as to be almost inappreciable. It seems probable that in well-made dough the whole carbonic acid that is generated remains in it; amounting to one half the volume of the loaf itself at its baking temperature, or 212°. It thence results that less than one hundredth part of the weight of the flour is all the sugar requisite to produce well-raised bread. What egregious folly was it, therefore, to mount the bakery in Chelsea, twelve years ago, at an expense of 20,000*l.*, for the purpose of *catching the volatile spirits* in their escape from the loaves in the oven—or, as it was vulgarly termed, "taking the gin out of the bread!" whereas it was nothing but taking the cash out of the pockets of the pseudo-chemical visionaries who swarm in this metropolis.

The richness or nutritive powers of sound flour and also of bread are proportional to the quantity of gluten they contain. It is of great importance to determine this point, for both of these objects are of enormous value and consumption; and it may be accomplished most easily and exactly by digesting in a water-bath, at the temperature of 167° F., 1,000 grains of bread (or flour) with 1,000 grains of bruised barley-malt, in 5,000 grains, or in a little more than half a pint, of water. When this mixture ceases to take a blue color from iodine (that is, when all the starch is converted into soluble dextrine) the gluten left unchanged may be collected on a filter cloth, washed, dried at a heat of 212°, and weighed. The color, texture, and taste of the gluten, ought also to be examined, in forming a judgment of good flour, or bread.

Independently of the skill of the baker, bread varies in quality according to the quantity of water and gluten it contains. A patent of German or French origin was obtained here a few years ago, for manufacturing loaf-bread by using thin boiled flour-paste instead of water for setting the sponge, that is, for the preliminary dough fermentation. By this artifice, 104 loaves of 4 lbs. each could be made out of a sack of flour, instead of 94, as in ordinary baking; because the boiled paste gave a water-keeping faculty to the bread in that proportion. But this *hydrated* bread was apt to spoil in warm weather, and became an unprofitable speculation to all concerned.

Bread and flour are often adulterated in France with potato-starch, but almost never, I believe, in this country. This sophistication is easily detected by the microscope, on account of the peculiar ovoid shape and the large size of the particles of the potato fecula. Horse-bean flour gives to wheaten bread a pinkish tint. In spoiled flour (such as is too often used, partially at least, by our inferior bakers) the gluten sometimes disappears altogether, and is replaced by ammoniacal salts.* In this case quicklime separates ammonia from the flour without heat; in flour slightly damaged, or ground from damaged wheat, the gluten present is deprived of its elasticity, and is softer than in the natural state. On this account the gluten test of M. Boland is valuable. It consists in putting some gluten into the bottom of a copper tube, and heating that tube in an oven, or in oil, at a temperature of 284° F. The length to which the cylinder of gluten expands is proportional to and indicates its quality.

It appears that a French sack of flour, which weighs 159 kilogrammes, affords from 102 to 106 loaves of 2 kilogrammes each: and therefore,

159 : 52·0 : : 280 : 91·6 : that is, if 159 kilogs. or lbs. afford 52 loaves of 4 kilogs. or lbs., 280 lbs., a sack English, should afford 91·6 loaves of 4 lbs. each; but our bakers usually make out 94 loaves, which are rated at 4 pounds, though they seldom weigh so much. The loaves of a baker in my neighborhood, who supplied by family with bread for some time, were found on trial to be from 6 to 8 oz. deficient in weight; when challenged for this fraud, he had the effrontery to palliate it by alleging that all his neighbor bakers did the same. It must be borne in mind that a Paris loaf of 2 lbs. or 2 kilogs. contains more dry farina than a London loaf of like weight; for it contains, from its form and texture, more crust. The crumb is to the crust in the Paris long loaves, as 25 to 75, or 1 to 3: in our quartern loaves it is as 18 or 20 to 100.

M. Dumas gives the following table:—

Weight of a sack of flour.	Number of loaves.	Weight of the bread.	Increase of weight of flour.	Ratio of dry flour = 1, to bread.
159 Kilogs.	102	202 Kilogs.	1·283	
159 do.	104	208 do.	1·300	1 : 1·60
159 do.	106	212 do.	1·333	

Thus it would appear that the mean yield would correspond to 130 kilogs. of bread for 100 of the flour employed; and admitting that common flour contains 0·17 of water, the product would be equivalent to 150 of bread for 100 of flour absolutely dry. The whole loaf contains 66 per cent. of dry substance, and the crumb only 44.

BRICKS. Mr. F. W. Simms, C. E., communicated to the Institution of Civil Engineers, in April and May, 1843, an account of the process of brick-making for the Dover railway. The plan adopted is called slop-moulding, because the mould is dipped into water before receiving the clay, instead of being sanded as in making sand-stock bricks. The workman throws the proper lump of clay with some force into the mould, presses it down with his hands to fill the cavities, and then strikes off the surplus clay with a stick. An attendant boy, who has previously placed another mould in a water trough by the side of the moulding-table, takes the mould just filled, and carries it to the floor, where he carefully drops the brick from the mould on its flat side, and leaves it to dry; by the time he has returned to the moulding-table, and deposited the empty mould in the water-trough, the brickmaker will have filled the other mould, for the boy to convey to the floor, where they are allowed to dry, and are then stacked in readiness for being burned in clamps or kilns. The average product is shown in the following table:—

Force employed.	Area of land.		Duration of season.	Produce per week.	Produce per season.
	Roods.	Perches.	Weeks.	Bricks.	Bricks.
1 moulder - 1 temperer - 1 wheeler - 1 carrier boy - 1 picker boy -	2	14½	22	16,100	354,200

* Dumas, Chimie Appliquée, vi. 425.

It appears that while the produce in sand-stock bricks is to that of slop-bricks in the same time as 30 to 16, the amount of labor is as 7 to 4; while the quantity of land, and the cost of labor per thousand, is nearly the same in both processes. The quantity of coal consumed in the kiln was at the rate of 10 cwt. 8lbs. per thousand bricks. The cost of the bricks was 2*l.* 1*s.* 6*d.* per thousand. The slop-made bricks are fully 1 pound heavier than the sand-stock. Mr. Bennett stated to the meeting, that at his brick-field at Cowley, the average number of sand-stock bricks moulded was 32,000; but that frequently so many as 37,000, or even 50,000, were formed. The total amount in the shrinkage of his bricks was $\frac{13}{16}$ of an inch upon 10 inches in length; but this differed with the different clays. Mr. Simms objected to the use of machinery in brick-making, because it caused economy only in the moulding, which constituted no more than about one eighth of the total expense.

The principal varieties of bricks are called *malm, paviors, stocks, grizzles, places,* and *shuffs*. For the first and best kind, the clay was washed and selected with care; stocks were good enough for ordinary building purposes; the rest are inferior. The difference in price between malms, paviors, and stocks, was 15*s.* or 20*s.* per 1,000; between stocks and places, 10*s.* The average weight of a sand-stock brick is fully 5 pounds, that of a slop is 1 pound more.

I believe that the siliceous sand on the surface of the sand-stocks is useful in favoring adhesion of mortar, by the production of a silicate of lime. To smooth aluminous bricks, mortar sometimes forms no stony adhesion.

Mr. Prosser, of Birmingham, makes bricks by pressure. The clay is first ground upon a slip kiln, as if for making pottery, then ground to a fine powder, and in that dry state it is subjected to the heavy pressure of about 250 tons, in strong metal moulds, by which means it is reduced to about one third of its original thickness. The clay seems to have retained sufficient moisture to give it cohesion, and the tiles are perfectly sharp at the edges. They being then baked within seggars by the heat of a kiln, seldom crack in the baking. The bricks thus formed are denser than usual, and weigh $6\frac{3}{4}$ lbs., with a specific gravity of 2·5.

Fig. 14., represents Mr. Hunt's brick-making machine. The principal working

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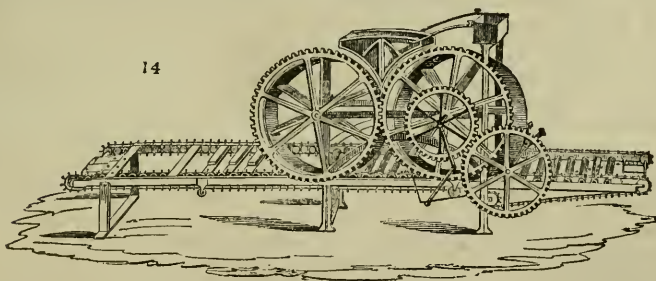
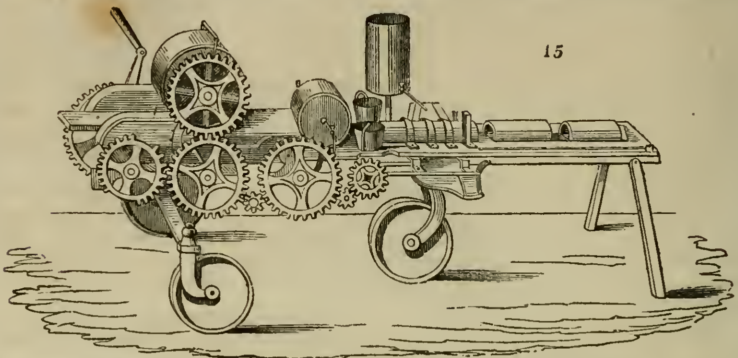


parts consist of 2 cylinders, each covered by an endless web, and so placed as to form the front and back of a hopper, the two sides being iron plates, placed so that when the hopper is filled with tempered clay from the pug-mill, the lower part of the hopper, and consequently the mass of clay within it, has exactly the dimensions of a brick. Beneath the hopper an endless chain traverses simultaneously with the movement of the cylinders. The pallet-boards are laid at given intervals upon the chain, and being thus placed under the hopper, while the clay is brought down with a slight pressure, a frame with a wire stretched across it, is projected through the mass of clay, cutting off exactly the thickness of the brick, which is removed at the same moment by the forward movement of the endless chain. This operation is repeated each time that a pallet-board comes under the hopper.

The chief object of this machine, which is worked by hand, is to produce good square compact bricks of uniform quality, using only a slight pressure. It has been found to be very difficult to dry bricks made by machinery, where a considerable pressure has been employed, because, before the evaporation from the centre of the clay is completed, the surfaces have become hard and peel off. The present machine is in operation in several parts of England, producing usually about 1,200 bricks per hour, while each machine requires only 2 men and 3 boys to tend it, and to take off the bricks. The clot-moulders are dispensed with, and the workmen are common laborers, so that professed brick-makers at higher wages are not needed.

Fig. 15 shows Mr. Hunt's machine for making tiles, and it is on the same principle. It consists of two iron cylinders, round which webs or bands of cloth revolve, whereby the clay is pressed 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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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.

The method of making bricks in the vicinity of London differed from that of almost all other places, because the material there employed is not pure clay, but a loam of a slightly cohesive nature, which will not admit of its being used in the natural state and burned in close kilns with coal; but with an admixture of ashes it becomes sufficiently tenacious to be formed into bricks, by inducing a slight semi-fusion. But the coal-ashes are also of advantage in the process of burning, because they enable the fire to spread gradually from the lower tiers, through the whole mass in the kiln or clamp, and thus obviate the effect of an intense partial heat, where distinct coal fires are trusted to alone, whereby the bricks nearest it get vitrified and glazed.

The brick kilns and clamps round London, and other large cities, which are fired with the breeze-rubbish collected from dust holes, that contain the refuse of kitchens, &c., emit, in consequence, most unpleasant effluvia; but brick-kilns fired with clean coke or coals, give out no gases of a more noxious nature than common household fires. The consideration of this subject was closely pressed upon my attention on being consulted concerning an injunction issued by the chancellor against a brick clamp in the Isle of Wight, fired with clean coke cinders from the steam-engine furnace at Portsmouth Dock Yard. The bricks being of the description called sand-stock, were of course made in moulds very slightly dusted with sand, to make them fall freely out. The sand was brought from Portsmouth harbor, and on being subjected to a degree of heat, more intense certainly than it would suffer in the clamp, was discovered by two chemical witnesses to give out traces of hydrochloric acid. Not content with this trivial indication, the said chemists, in their evidence before the courts of law, paraded a train of goblin gases, as the probable products of the pre-adjudicated clamp.

As it is well known to the chemist that common salt strongly ignited in contact with moist sand will emit hydrochloric acid, there was nothing remarkable in the above observation, but I ascertained that the sand with which the moulds were strewed would give out no hydrochloric acid, at a heat equal at least to what the bricks were exposed to in a clamp 10 or 12 feet high, and fired at its bottom only with a layer of cinders 3 or 4 inches thick. But I further demonstrated that the entire substance of the brick with its scanty film of sand, on being exposed to ignition in a suitable apparatus, gave out, not hydrochloric or any other corrosive acid, but ammonia gas. Hence, the allegations that the clamp sent forth a host of acid gases to blight the neighboring trees, were shown to be utterly groundless; on the contrary, the ammonia evolved from the heated clay would act beneficially upon vegetation, while it was too small in quantity to annoy any human being. A few yards to leeward of a similar clamp, in full activity, I could perceive no offensive odor. All ferruginous clay, when exposed to the atmosphere, absorbs ammonia from it, and of course emits it again on being gently ignited. It is a reproach to science when, as in the above case, it lends itself to judicial prejudice and oppression.

BRONZING (*of Objects in Imitation of Metallic Bronze*). Plaster of Paris, paper, wood, and pasteboard, may be made to resemble pretty closely the appearance of articles of real bronze, modern or antique. The simplest way of giving a brilliant aspect of this kind is with a varnish made of the waste gold leaf of the beater, ground up on a porphyry slab with honey or gum-water. A coat of drying linseed-oil should be first applied, and then the metallic powder is put on with a linen dossil. Mosaic gold ground up with six parts of bone-ashes has been used in the same way. When it is to be put on paper, it should be ground up alone with white of eggs or spirit varnish, applied with a brush and burnished when dry. When a plate of iron is plunged into a hot solution of sulphate of copper, it throws down fine scales of copper, which being repeatedly washed with water, and ground along with six times its weight of bone-ashes, forms a tolerable bronzing.

Powdered and sifted tin may be mixed with a clear solution of isinglass, applied with a brush, and burnished or not, according as a bright or dead surface is desired. Gypsum casts are commonly bronzed by rubbing brilliant black-lead, *graphite*, upon them with a cloth or brush. Real bronze long exposed the air gets covered with a thin film of carbonate of copper, called by virtuosi antique *ærugo* (*patine antique*, Fr.) This may be imitated in a certain degree by several applications skilfully made. The new bronze being turned or filed into a bright surface, and rubbed over with dilute aquafortis by a linen rag or brush, will become at first grayish, and afterward take a greenish blue tint; or we may pass repeatedly over the surface a liquor composed of 1 part of sal ammoniac, three parts of carbonate of potash, and 6 of sea salt, dissolved in 12 parts of boiling water, to which 8 parts of nitrate of copper are to be added; the tint thereby produced is at first unequal and crude, but it becomes more uniform and softer by time. A fine *green-blue* bronze may be obtained with very strong water of ammonia alone, rubbing it at intervals several times upon the metal.

The base of most of the secret compositions for giving the antique appearance is vinegar with sal ammoniac. Skilful workmen use a solution of 2 ounces of that salt in an English quart of French vinegar. Another compound which gives good results is made with an ounce of sal ammoniac, and a quarter of an ounce of salt of sorrel (binoxalate of potash), dissolved in vinegar. One eminent Parisian sculptor makes use of a mixture of half an ounce of sal ammoniac, half an ounce of common salt, an ounce of spirits of hartshorn, and an English quart of vinegar. A good result will also be obtained by adding half an ounce of sal ammoniac, instead of the spirits of hartshorn. The piece of metal being well cleaned, is to be rubbed with one of these solutions, and then dried by friction with a fresh brush. If the hue be found too pale at the end of two or three days, the operation may be repeated. It is found to be more advantageous to operate in the sunshine than in the shade.

BUDE LIGHT. See Gas light.

BUTTER is the fatty matter of milk, usually of that of the cow. Milk is composed of butter, caseine, sugar of milk, several salts, and water. The butter exists in the form of very small globules of nearly uniform size, quite transparent, and strongly refractive of light. Milk left in repose throws up the lighter particles of butter to the surface as cream. It was imagined that the butter was separated in the process of churning, in consequence of the milk becoming sour; but this is not the case; for milk rendered alkaline by bi-carbonate of potash affords its butter fully more readily than acidulous milk. The best temperature for churning milk or cream is 53° F.; that of 60° is too high; and under 50° it is too low. By the churning action the heat rises from 3 to 4 degrees F. All the particles of butter are never separated by churning; many remain diffused through the butter-milk, and are easily discoverable by the microscope. These are more numerous in proportion to the bulk of the liquid; and hence it is more economical to churn cream than the whole milk which affords it. It is computed that a cow which gives 1,800 quarts (old English) of milk per annum, eats in that time 8,000 lbs. of hay, and produces 140 lbs. of butter.* Analysis shows that this weight of hay contains 168 pounds of fat. The finest flavored butter is obtained from milk churned not long after it is drawn; but the largest proportion is derived from the cream thrown up by milk after standing 24 hours, in a temperature of about 50° F. The butter-milk which contains the very fermentable substance, caseine, should be well separated from the butter by washing with cold water, and by beating with the hands, or preferably, without water, for the sake of fine flavor, by the action of a press.

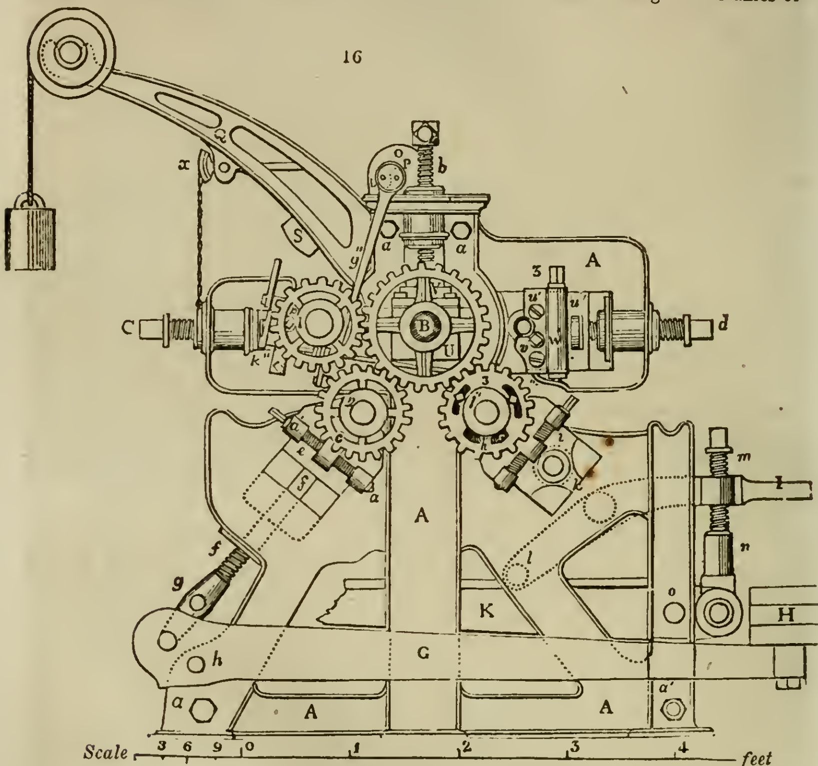
The French purify their butter by melting it in pots, plunged into water heated to 200° or 212°; and sometimes they mix a pure brine with the melting butter, whereby they favor the subsidence of the coagulated caseine and other impurities. The supernatant clear butter should be drawn or poured off, and rapidly cooled, to prevent the crystallization of its stearine and separation of its oleine, which injure its flavor and appearance.

* Two pounds and a quarter of hay correspond to one quart of good milk; and a cow which eats 16,500 lbs. of hay will produce 300 lbs. of butter per annum.

C.

CALCIUM. The atomic weight of this element being an important point, both as to pure chemistry and the chemical arts, has been the subject of innumerable researches. Very lately Berzelius, in the *Annalen der Chemie und Pharmacie*, XLVI. p. 241, has collated the most recent results of the analysis of other philosophers with his own; and while Dumas, Marchand, and Erdmann estimate the weight at 20, that of hydrogen = 1, or 250 oxygen = 100, he finds it ought to be, as compared with the latter, 251·9; and to the former, 20·152.

CALICO PRINTING (4-*color machine*). Of this beautiful and effective mechanism an accurate section is exhibited at p. 220 of the Dictionary. The outside working gear is shown in *fig.* 16., where A, A, is a part of the two strong iron frames or



cheeks in which the various rollers are mounted. They are bound together by the rods and bolts *a*, *a*, *a*. B, is the large iron pressure cylinder, which rests with its gudgeons in bearings or bushes, which can be shifted up and down in slots of the side cheeks A, A. These bushes are suspended from powerful screws, *b*, which turn in brass nuts, made fast to the top of the frame A, as is plainly shown in the *figure*. These screws serve to counteract the strong pressure applied beneath that cylinder by the engraved cylinders D, E.

C, D, E, F, are four printing cylinders, named in the order of their operation. They consist of strong tubes of copper or gun metal, forcibly thrust by a screw press upon the iron mandrels, round which as shafts they revolve. The first and last cylinders, C and F, are mounted in brass bearings, which may be shifted in horizontal slots of the frame A. The pressure roller B, against whose surface they bear with a very little obliquity downward, may be nicely adjusted to that pressure by its elevating and depressing screws. By this means C and F can be adjusted to B with geometrical precision, and made to press it in truly opposite directions.

The bearings of the cylinders D and E are lodged also in slots of the frame A, which point obliquely upward toward the centre of B. The pressure of these two print cylinders, C and F, is produced by two screws, *c* and *d*, which work in brass nuts made fast to the frame, and very visible in the figure. The framework in which these bearings and screws are placed has a curvilinear form, in order to permit the cylinders to be readily removed and replaced, and also to introduce a certain degree of elasticity Hence the pressure applied to the cylinders C and F partakes of the nature of a spring, a circumstance essential to their working smoothly, notwithstanding the occasional inequalities in the thickness of the felt web and the calico.

The pressure upon the other two print cylinders, D and E, is produced by weights acting with levers against the bearings. The bearings of D are, at each of their ends, acted upon by cylindrical rods, which slide in long tubular bosses of the frame, and press with their nuts *g*, at their under end upon the smaller arms of two strong levers G, which lie on each side of the machine, and whose fulcrum is at *h* (in the lower corner at the left hand). The longer arms, of these levers, G, are loaded with weights, H, whereby they are made to press up against the bearings of the roller D, with any desired degree of force, by screwing up the nut *g*, and hanging on the requisite weights.

The manner in which the cylinder E is pressed up against B is by a similar construction to that just described. With each of its bearings there is connected, by the link *k*, a curved lever, I, whose fulcrum or centre of motion is at *o*. By turning, therefore, the screw *m*, the weight L, laid upon the end of the longer arm of the lever K (of which there is one on each side of the machine), may be made to act or not at pleasure upon the bearings of the cylinder E. The operation of this exquisite machine is minutely described in the Dictionary, pp. 220, 221.

A patent was obtained in August, 1839, by Mr. J. C. Miller of Manchester, for certain improvements in printing calicoes, consisting of a modified mechanism, by which the same effect can be produced as by block printing.

Figs. 17, 18, 19, are several views of this machine, calculated to print two pieces, or two different patterns (on the same block) of calico, side by side, or four pieces, the carriage printing both ways, the intended device consisting of four colors to be printed from blocks.

17

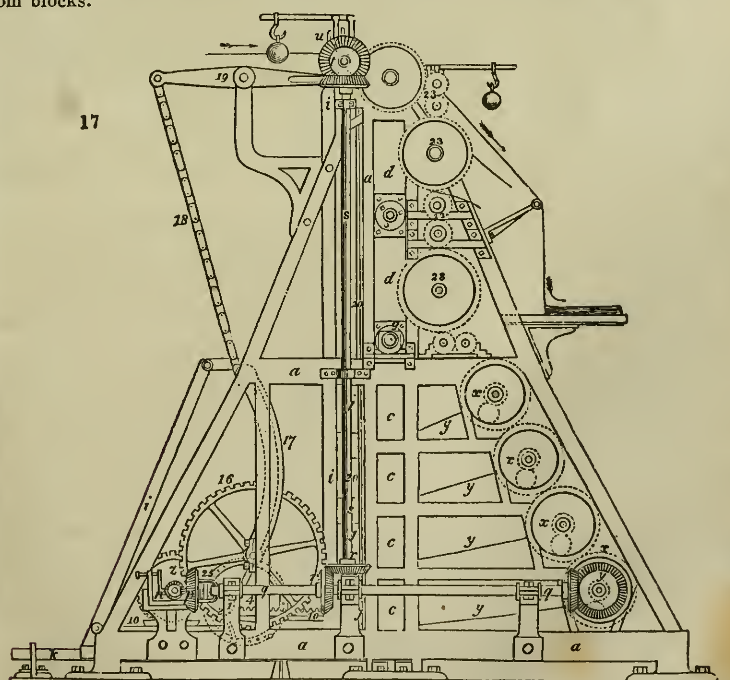
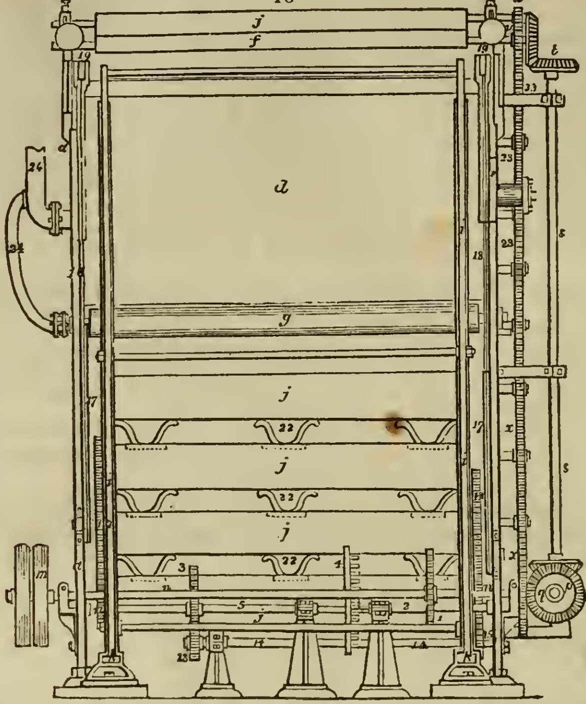


Fig. 17 represents a side elevation, *fig*. 18 a front view, and *fig*. 19 a transverse section, taken nearly through the middle of the machine.

The side or main framing is shown at *a, a,* supporting the color boxes *b, b, b,* with their *doctors;* the furnishing tables or beds, *c, c, c* (substitutes for the sieves in ordinary block printing); the printing table, *d, d*; and the feeding drying and coloring rollers, *f, f, g, g, h, h.*

18



The machine is also provided with a carriage, *i, i,* for the printing blocks, *j, j, j.* This carriage, *i, i,* travels in and out at suitable ihtervals upon rails, *k, k,* attached to the main framing.

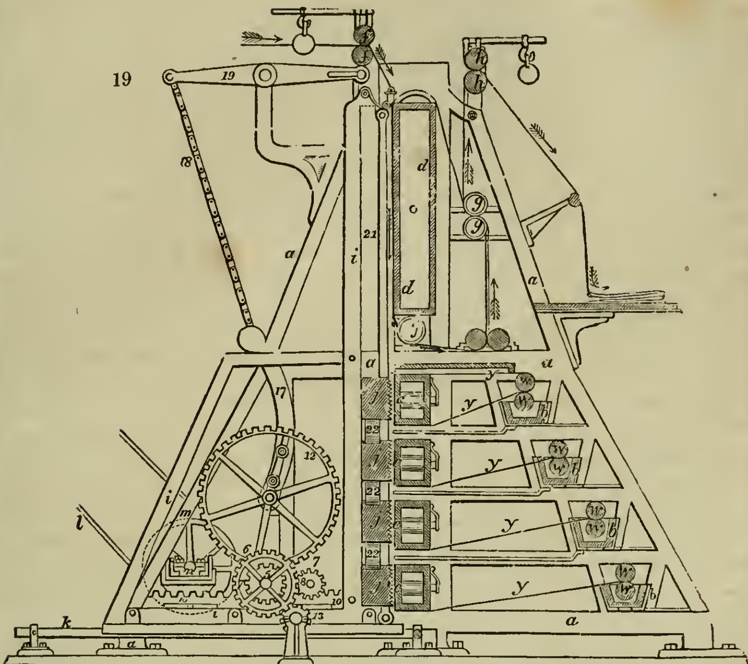
The operation of the machine is effected by passing a driving strap, *l,* round the driving pulley *m,* fixed at the extremity of the main driving shaft, *n, n.* At the other end of this shaft, the bevil pinion, *o,* is keyed, gearing at suitable intervals with the bevil wheel *p,* which is mounted upon the end of the cross shaft *q*; at about the middle of this shaft, the mitre wheels *r, r,* driving the upright shaft *s, s,* and mitre wheels *t, t,* above, actuate, by means of the spur pinions *u, u,* the feeding rollers *f, f,* and thus draw the pieces of goods into the machine.

Simultaneously with the progress of the cloth, the mitre wheels *v, v,* at the other end of the cross shaft *q,* drive the furnishing rollers *w, w, w,* by means of the spur gearing *x, x, x.* The furnishing rollers, revolving in their respective color-boxes, spread or apply the colors upon the travelling endless blankets, *y, y, y,* which pass round the top roller and the furnishing tables or beds, *c, c, c,* in order to supply the colors to the surfaces of the printing blocks, *j, j, j.* Either beds or the backs of the printing blocks may be made slightly elastic, to insure the perfect taking up of the colors.

Supposing the carriage, *i, i,* to be run out upon its railways, at the farthest point from the beds *c, c,* it is drawn inward toward the furnishing beds *c, c,* by means of the spur-wheel *x,* upon the driving-shaft *n,* taking into a small pinion, 1 (shown by dots in *fig.* 17), upon the shaft, 2. On the end of this shaft is also keyed the mangle pinion, 3, gearing in the mangle wheel, 4, which is keyed upon the end of the shaft, 5 This shaft drives the spur-wheel, 6, in gear with the pinion, 7, made fast to the shaft, *s* (see *fig.* 19).

Upon either end of the shaft, 5, is a rack pinion, 9, taking into the horizontal rack 10, made fast to the carriage-frame, *i, i*; and thus the blocks, *j, j,* are presented to the furnishing blankets *y, y, y,* and take a supply of color ready for printing. The travelling-carriage and blocks now retire, by the agency of the mangle-wheel and pinion, 3 and 4, the pinion being fixed upon the end of the shaft, 2, and the wheel upon the other shaft in a line with the shaft, 2. At this time another operation of the machine takes place.

19



Upon the reverse end of the shaft, 5, is a pinion, 11, gearing with the spur-wheel, 12; and by means of the spur gearing, 6 and 13, and counter-shaft, 14, the pinion, 15, drives the spur-wheel, 16, which corresponds to the wheel, 12, on the other side of the machine. To one of these spur-wheels are attached by bolts two quadrant levers, 17, 17; and as these wheels revolve by means of the gearing just described, the levers, 17, 17, draw down the chains, 18, 18, actuate the levers, 19 and 20, and thus elevate the whole series of printing blocks in the parallel grooves, 21, 21; at the same time pressing or closing them into one mass or block by expanding the springs 22, 22; and at the nest of the carriage caused at a proper interval by the agency of the mangle-wheel, the blocks are made to impress the patterns upon the surface of the goods at once, in four or more different colors, and in one, two, or more widths of cloth at one operation.

The cloth is now drawn forward for the space of the exact width of one of the blocks, or sketch of the design, by means of the spur-wheels and pinions, 23, 23, and passed around heated cylinders, g, g, if necessary, and between the delivering rollers out of the machine. These operations are to be repeated by the continuous rotation of the main driving-shaft, until the printing is completed; the colors making a single advance upon the pattern at every presentation of the blocks, until the whole number of blocks has been presented to the same space or portion of the goods successively.

The steam pipes, 24, are to be in connexion with the printing table and drying cylinders, in order to supply a degree of heat during the operation, which may be regulated at pleasure.

To give suitable intervals of rest and motion to the various parts of the driving-gear, an ordinary clutched box, 25 (shown in *fig.* 19), and regulated by suitable stops fixed to the travelling carriage, is used for throwing the wheel, *p*, in and out of gear with the pinion, *o*; this is to prevent clots of color from being dragged upon the blocks or cloth. —*Newton's Journal*, xxi. C. S. p. 242.

CALOMEL. A patent was obtained in September, 1841, by Anthony Todd Thomson, M. D., for an improved method of manufacturing calomel and corrosive sublimate, as follows:—

This invention consists in combining chlorine in the state of gas with the vapor of mercury or quicksilver, in order to produce calomel and corrosive sublimate.

The apparatus employed consists of a glass, earthenware, or other suitable vessel, mounted in brick-work, and communicating at one end with a large air-tight chamber, and at the other end, by means of a bent tube, with an alembic, such as is generally used for generating chlorine gas. The alembic is charged with a mixture of common salt, binoxide of manganese and sulphuric acid, or of binoxide of manganese and muriatic acid, in order to produce chlorine gas.

The mode of operating with this apparatus is as follows: A quantity of mercury or quicksilver is placed in the glass vessel, and the temperature of the same is raised to between 350° and 660° Fahr., by means of an open fire beneath. The chlorine gas, as it is generated, passes from the alembic through the bent tube into the glass vessel, and there combining with the vapor of the mercury, forms either corrosive sublimate or calomel, according to the quantity of chlorine gas employed.

The product is found at the bottom of the air-tight chamber, and may be removed from the same through a door, when the operation is finished.

According to the patent of Mr. Josiah Jewel, the vapor of calomel was to be transmitted into a vessel containing water, in order to condense it at once into an impalpable powder. But this process was beset with many difficulties. The vapor of the calomel was afterward introduced into a large receiver, into which steam was simultaneously admitted; but this plan has also been found to be precarious in the execution. The best way is to sublime the calomel into a very large chamber from an iron pot, in the same way as the flowers of sulphur are formed. The great body of cool air serves to cause the precipitation of the calomel in a finely comminuted state. It is afterward washed with water, till it is no longer colored by sulphuretted hydrogen.

CALOTYPE is the name given by Mr. Fox Talbot to the art invented by him, of making pictures or paper or other such surfaces by the agency of light. It is merely an improved kind of *photography*. The process is as follows: Dissolve 100 grains of crystallized nitrate of silver in 6 ounces of distilled water, and brush over the paper (Whatman's sized post answers well) with a soft brush on one side only, with this solution, and mark the side. When nearly dry, dip it into a solution of iodide of potassium (for only a few minutes), containing 500 grains of that salt dissolved in a pint of water. As soon as the paper is completed imbued with this solution, it should be immediately washed in distilled water, drained, and hung up to dry. This paper is to be kept for subsequent use in a portfolio, and carefully secluded from light.

Next dissolve 100 grains of silver-nitrate in 2 ounces of distilled water, and add to the solution one sixth of its volume of strong acetic acid. Keep this solution in the dark. Make a saturated solution of gallic acid in distilled water. When it is required to make a calotype picture, the two liquids last described are to be mixed in equal quantities, but only so much as is needed for the operation. With this gallo-nitrate of silver, a sheet of the silver iodide paper is to be washed over upon its marked side with a soft brush, an operation to be performed by candle-light. After half a minute, the paper being dipped in water, and dried lightly by pressure between folds of blotting paper, becomes so exceedingly sensitive to light, as to take a pictorial impression in the camera in a space varying from one second to five minutes, according to the brightness of illumination. The camera should be mounted with a meniscus lens, in an adjustible tube, so as to throw the image of the object to be calotyped upon a vertical plate of roughened glass, in the posterior side or wall of the wooden box. Whenever the focus is correctly adjusted, the glass is withdrawn, and replaced by sliding in a groove a frame with the prepared sheet of paper fixed flat upon it, the prepared side toward the lens, but screened from light by a card or thin board. The screen being now removed, the light acts upon the paper, and produces a picture. A camera made entirely of metal, in a conical form, and mounted on a stand like a telescope, which has been invented for calotype purposes, by Dr. Petzval and M. Voigtlander, of Vienna, is recommended in preference to all others, by Mr. Talbot, especially for taking portraits.

The paper, after exposure for the due time in the camera, is to be again covered from the light, taken out, and subjected to another process; for as yet it has no pictoral appearance. To bring out this effect, it must be washed with the gallo-nitrate of silver, and then be gently warmed. In a few seconds the portions of the paper upon which the light has acted will begin to darken, and eventually grown quite black, while the rest of the paper retains its original hue. Even though the pictorial impression be very faint, it may be brought out by a second application of the same solution. The operator should watch the gradual development of the tints; and when it is sufficient, he should fix them by dipping the paper in water, drying it slightly with blotting paper, then washing it over with a solution of bromide of potassium, containing 100 grains of that salt, dissolved in 8 or 10 ounces of water. Strong brine will also answer, but not so well. Similar calotype pictures may be made by using the bright light emitted from lime ignited by the oxy-hydrogen flame; as is practised in making the Daguerrotype portraits at night.

In all the photographic pictures the lights and shades of the object are reversed; but they may be made conformable to nature by rendering the paper transparent with white wax scraped upon its back, melting this in by rubbing it with a hot smoothing-iron, after it is placed between two sheets of common paper, then laying it upon paper imbued with bromide of potassium, and exposing it to sunshine. Portraits are best taken by means of a lens, whose focal length is three or four times only greater than the diameter of the aperture.

CANDLES. Messrs. Hempel and Blundell have given a very minute account of the process for making palm-oil, stearic and margaric acids, in the specification of their patent for this mode of manufacturing candles :—

1. Their first process is called *crystallization*, which consists in pouring the melted palm-oil into iron pans, and allowing it to cool slowly, whereby, at about 75° F., the elaine separates from the crystalline stearine and margarine.

2. The concreted oil is subjected to the action of an hydraulic press, in order to separate the elaine from the solid fats.

3. This process is called *oxidation*. To 104 lbs. of the stearine and margarine, melted in an iron pan, about 12 lbs. of slaked and sifted quicklime are added, with diligent stirring, during which the temperature is to be slowly raised to 240° F., and so maintained for about three hours, till a perfect chemical combination takes place. This is shown by the mass becoming thin, transparent, and assuming a glassy appearance when it cools. The fire being now withdrawn, cold water is added very gradually at first, with brisk stirring till the whole mass falls into a state of powdery granulation, when it is passed through a wire sieve to break down any lumps that may remain.

4. *Separation of the stearic and margaric acids* from the lime. For this purpose, as much muriate of lime (chlorcalcium) is taken as will, with its equivalent quantity of sulphuric acid (8 lbs. of dry chlorcalcium require 7 lbs. of the strongest sulphuric acid), produce as much muriatic acid as will dissolve the lime combined with the fat acids; and therefore that quantity of muriate of lime dissolved in water must be treated with as much sulphuric acid as will saturate its lime and throw it down in the state of sulphate of lime. Add the supernatant solution of muriatic acid in such proportion to the stearate and margarate of lime as will rather more than saturate the lime. Three pounds of muriatic acid diluted with 9 lbs. of water are stated as enough for 1 lb. of lime. This mixture is to be let alone for 3 or 4 days, in order to insure the complete separation of the lime from the fat acids; and then the mixture is heated so as to melt and cause them to separate in a stratum on the top of the liquid. The resulting muriate of lime is drawn off into another tub, and decomposed by its dose of sulphuric acid, so as to liberate its muriatic acid for a fresh operation.

5. The fat acids, being well washed by agitation with hot water, are then set to cool and crystallize, in which state they are subjected to the action of the hydraulic press, at a temperature of 75° F., whereat the margaric acid runs off from the solid stearic acid.

6. *Bleaching*. The stearic acid is taken from the press, and exposed upon water in large shallow vessels placed in the open air, where it is kept at the melting temperature from 8 to 12 hours, stirring meanwhile, in order to promote the blanching action of the atmosphere. The margaric acid is bleached in a similar manner in separate vessels.

7. *Refining process*. The fat is warmed again, and poured in a liquid state into an agitating tub; where, for every 1,000 lbs. of the stearic acid, about 2½ lbs. of common black oxide of manganese, and 40 lbs. of concentrated sulphuric acid, diluted with 200 lbs. of pure water, are to be used. This solution ("mixture"), while warm from the heat evolved in diluting the acid, is placed in a suitable vessel above the agitating tub. The stearic acid being at the melting point, in the vessel below, agitation is to be given with a revolving shaft, while the mixed manganese and acid are run slowly down into it, till the whole be well mixed, which generally requires about two hours. The mass is allowed to lie in this state for 48 hours; after which it may be boiled by steam for 2 or 3 hours, when it will be sufficiently refined. The sulphuric acid, which is at the bottom, is now run off, and the stearic acid which remains is well washed with pure water. It is then put into large conical vessels of stoneware, enclosed in a box or jacket, kept warm by steam-heat, and lined with conical bags of suitable strong filtering paper, through which, being warm, it finds its way; and when the stearic acid has been thus filtered, it is run into blocks, when it will be found to be a beautiful stearic acid or palm-wax, and is ready to be made into candles in the usual way.

On the above process with manganese and diluted sulphuric acid, it may be observed, that no solution or chemical action takes place between them, and their joint use seems therefore most problematical. The patentees proceed to describe other processes of refining, in which sulphate of manganese, with common salt, phosphoric acid (highly concentrated), and oxalic acid, are used, and in my opinion either ignorantly or for the purpose of mystification; for, as prescribed, they can serve no possible purpose of purifying the stearine.

The chief solid constituent of palm-oil is margaric acid. This they direct to be melted with tallow, in the proportion of from 10 to 20 lbs. of the former to 100 lbs. of the latter. See *Newton's Journal, C. S.*, xi. 207.

I was told by M. Runge, at Berlin, that he was the inventer of the process for making white margaric acid from palm-oil, and that Hempel had got it somehow from him, but most imperfectly, as it would appear. Hempel died here in the midst of the above patent operations; but the specification is, no doubt, a specimen of his manufacture of Runge's margaric acid. He gave me a splendid pearly-looking sample.

CAOUTCHOUC. Hitherto the greater part of the caoutchouc has been imported into Europe from South America, and the best from Para; but of late years a considerable quantity has been brought from Java, Penang, Sincapore, and Assam. About three years ago, Mr. William Griffith published an interesting report upon the *Ficus elastica*, the caoutchouc-tree of Assam, which he drew up at the request of Captain Jenkins, agent in that country to the governor-general of India. This remarkable species of fig-tree is either solitary, or in twofold or threefold groups. It is larger and more umbrageous than any of the other trees in the extensive forest where it abounds, and may be distinguished from the other trees, at a distance of several miles, by the picturesque appearance produced by its dense, huge, and lofty crown. The main trunk of one was carefully measured, and was found to have a circumference of no less than 74 feet; while the girth of the main trunk, along with the supports immediately round it, was 120 feet. The area covered by the expanded branches had a circumference of 610 feet. The height of the central tree was 100 feet.

It has been estimated, after an accurate survey, that there are 43,240 such noble trees within a length of 30 miles, and breadth of 8 miles of forest near Ferozepoor, in the district of Chardwar, in Assam.

Lieutenant Veitch has since discovered that the *Ficus elastica* is equally abundant in the district of Naudwar. Its geographical range in Assam seems to be between 25 deg. 10 min. and 27 deg. 20 min. of north latitude, and between 90 deg. 40 min. and 95 deg. 30 min. of east longitude. It occurs on the slopes of the hills, up to an elevation of probably 22,500 feet. This tree is of the banyan tribe, famed for "its pillared shade, where daughters grow about the mother-tree," which has furnished the motto *tot rami quot arbores*, to the Royal Asiatic Society. Species of this genus afford grateful shade, however, in the tropical regions of America, as well as Asia.

Many species of other trees yield a milky tenacious juice, of which birdlime has been frequently made; as *Artocarpas integrifolia*, and *Lakoocha*, *Ficus indica*, and *religiosa*, also *F. Tsiela*, *Roxburghii*, *glomerata*, and *oppositifolia*. From some of these an inferior kind of caoutchouc has been obtained.

The juice of the Ficus elastica of Chardwar is better when drawn from the old than from the young trees, and richer in the cold season than in the hot. It is extracted by making incisions a foot apart, across the bark down to the wood, all round the trunk, and also the large branches, up to the very top of the tree; the quantity which exudes increasing with the height of the incision. The bleeding may be safely repeated once every fortnight. The fluid, as fresh drawn, is nearly of the consistence of cream, and pure white. Somewhat more than half a *maund* (42 lbs.) is reckoned to be the average produce of each bleeding of one tree; or 20,000 trees will yield about 12,000 maunds of juice; which is composed in 10 parts, of from 4 to 6 parts of water, and, of course, from 6 to 4 parts of caoutchouc. The bleeding should be confined to the cold months, so as not to interfere with, or obstruct the vigorous vegetation of the tree in the hot months.

Mr. Griffith says that the richest juice is obtained from transverse incisions made into the wood of the larger reflex roots, which are half exposed above ground, and that it proceeds from the bark alone. Beneath the line of incision, the natives of Assam scoop out a hole in the earth, in which they place a leaf of the *Phrynium capitatum*, Lin., rudely folded up into the shape of a cup. He observes that the various species of *Tetranthera*, upon which the *Moonga* silkworm feeds, as also the castor oil plant, which is the chief food of the Eria silkworm, do not afford a milky caoutchouc juice. Hence it would appear that Dr. Royle's notion of caoutchouc forming a necessary ingredient in the food of silkworms, and being "in some way employed in giving tenacity to their silk," seems to be unfounded. If botany discountenances this idea, chemistry would seem to scout it altogether; for silk contains 11·33 per cent. of azote, and caoutchouc contains none at all; being simply a solid hydro-carburet, and, therefore, widely dissimilar in constitution to silk, which consists of oxygen 34·04, azote 11·33, carbon 50·69, and hydrogen 3·94, in 100 parts.

This hydro-carburet emulsion is of common occurrence in the ORDERS *Euphorbiacia* and *Tulicea*, which may be looked on as the main sources of caoutchouc. The American caoutchouc is said to be furnished by the *Siphonia elastica*, or the *Hevea guianensis* of Aublet, a tree which grows in Brazil, and also in Surinam.

Dr. Royle sent models of cylinders, of 1½ to 2½ inches in diameter, and 4 or 5 inches in length, to both the Asiatic and Agricultural Societies of Bengal, to serve as patterns for the natives to mould their caoutchouc by. Mr. Griffith says that this plan of forming the caoutchouc into tumblers or bottles, as recommended by the committee of the London Joint-stock Caoutchouc company, is, in his opinion, the worst than can possibly be offered; being tedious, laborious, causing the caoutchouc to be blackened in the drying, and not obviating the viscidity of the juice when it is exposed to the sun. He recommends, as a far better mode of treating the juice, to work it up with the hands, to blanch it in water, and then subject it to pressure. I shall presently describe a still better method which has recently occurred to me, in experimenting upon the caoutchouc juice. This fluid, with certain precautions, chiefly exclusion from air and much warmth, may be kept in the state of a creamy emulsion for a very long time.

NEW EXPERIMENTAL RESEARCHES ON CAOUTCHOUC.

The specific gravity of the best compact *Para* caoutchouc, taken in dilute alcohol, is - - - -	0·941567
The specific gravity of the best Assam is - - -	0·942972
" " Sincapore - - -	0·936650
" " Penang - - - -	0·919178

Having been favored by Mr. Sievier, formerly managing director of the Joint-stock Caoutchouc company, and by Mr. Beale, engineer, with two different samples of caoutchouc juice, I have subjected each to chemical examination.

That of Mr. Sievier is grayish brown, that of Mr. Beale is of a milky gray color; the deviation from whiteness in each case being due to the presence of aloetic matter, which accompanies the caoutchouc in the secretion by the tree. The former juice is of the consistence of thin cream, has a specific gravity of 1·04125, and yields, by exposure upon a porcelain capsule, in a thin layer, for a few days, or by boiling, for a few minutes, with a little water, 20 per cent. of solid caoutchouc. The latter, though it has the consistence of pretty rich cream, has a specific gravity of only 1·0175. It yields no less than 37 per cent. of white, solid, and very elastic caoutchouc.

It is interesting to observe how readily and compactly the separate little cloths or threads of caoutchouc coalesce into one spongy mass in the progress of the ebullition, particularly if the emulsive mixture be stirred; but the addition of water is necessary to prevent the coagulated caoutchouc from sticking to the sides or bottom of the vessel and becoming burnt. In order to convert the spongy mass thus formed into good caoutchouc, nothing more is requisite than to expose it to moderate pressure between the folds of a towel. By this process the whole of the aloetic extract, and other vegetable matters, which concrete into the substance of the balls and junks of caoutchouc prepared in Assam and Java, and contaminate it, are entirely separated, and an article nearly white and inodorous is obtained. Some of the cakes of American caoutchouc exhale when cut the fœtor of rotten cheese; a smell which adheres to the threads made of it, after every process of purification.

In the interior of many of the balls which come from both the Brazils and East Indies, spots are frequently found of a viscid tarry-looking matter, which, when exposed to the air, act in some manner as a ferment, and decompose the whole mass into a soft substance, which is good for nothing. Were the plan of boiling the fresh juice along with its own bulk of water, or a little more, adopted, a much purer article would be obtained, and with incomparably less trouble and delay, than has been hitherto brought into the market.

I find that neither of the above two samples of caoutchouc juice affords any appearance of coagulum when mixed in any proportions with alcohol of 0·825 specific gravity; and, therefore, I infer that albumen is not a necessary constituent of the juice, as Mr. Faraday inferred from his experiments published in the 21st vol. of the Journal of the Royal Institution.

The odor of Mr. Sievier's sample is slightly acescent, that of Mr. Beale's, which is by far the richer and purer, has no disagreeable smell whatever. The taste of the latter is at first bland and very slight, but eventually very bitter, from the aloetic impression upon the tongue. The taste of the former is bitter, from the first, in consequence of the great excess of aloes which it contains. When the brown solution which remains in the capsule, after the caoutchouc has been separated in a spongy state by ebullition, from 100 grains of the riches juice is passed through a filter and evaporated, it leaves 4 grains of concrete aloes.

Both of these emulsive juices mix readily with water, alcohol, and pyroxilic spirit, though they do not become at all clearer; they will not mix with *caoutchoucine* (the distilled spirit of caoutchouc), or with petroleum-naphtha, but remain at the bottom of these liquids as distinct as mercury does from water. Soda caustic ley does not dissolve the juice; nitric acid (double aquafortis) converts it into a red curdy magma. The filtered aloetic liquid is not affected by the nitrates of baryta and silver; it affords with oxalate of ammonia minute traces of lime.

I. CAOUTCHOUC MANUFACTURE.

This department of operative industry has, within a few years, acquired an importance equal to that of some of the older arts, and promises, ere long, to rival even the ancient textile fabrics in the variety of its designs and applications. The manufacture of caoutchouc has, at present, three principal branches :—1. The condensation of the crude lumps or shreds of caoutchouc, as imported from South America, India, &c., into compact homogeneous blocks, and the cutting of these blocks into cakes or sheets for the stationer, surgeon, shoemaker, &c. 2. The filature of either the Indian rubber bottles, or the artificial sheet caoutchouc, into tapes and threads of any requisite length and fineness, which, being clothed with silk, cotton, linen, or woollen yarns, form the basis of elastic tissues of every kind. 3. The conversion of the refuse cuttings and coarser qualities of caoutchouc into a viscid varnish, which, being applied between two surfaces of cloth, constitutes the well-known double fabrics, impervious to water and air.

I. The caoutchouc, as imported in skinny shreds, fibrous balls, twisted concretions, cheese-like cakes, and irregular masses, is, more or less, impure, and sometimes fraudulently interstratified with earthy matter. It is cleansed by being cut into small pieces, and washed in warm water. It is now dried on iron trays, heated with steam, while being carefully stirred about to separate any remaining dirt, and is then passed through, between a pair of iron rolls, under a stream of water, whereby it gets a second washing, and becomes at the same time equalized by the separate pieces being blended together. The shreds and cuttings thus laminated, if still foul or heterogeneous, are thrown back into a kind of hopper over the rolls, set one sixteenth of an inch apart, and passed several times through between them. The above method of preparation is that practised by Messrs. Keene and Co., of Lambeth, in their excellent manufactory, under a patent granted in October, 1836, to Mr. Christopher Nickels, a partner in the firm.

In the great establishment of the Joint Stock Caoutchouc company, at Tottenham, originally under the direction of Mr. Sievier, a gentleman distinguished no less by his genius and taste as a sculptor, than by his constructive talents, the preparatory rinsing and lamination are superseded by a process of washing practised in Mr. Nickels's second operation, commonly called the *grinding*, or, as it should more properly be styled, the *kneading*. The mill employed for agglutinating or incorporating the separate fragments and shreds of caoutchouc into a homogeneous elastic ball, is a cylindrical box or drum of cast iron, 8 or 9 inches in diameter, set on its side, and traversed in the line of its horizontal axis (also 8 or 9 inches long) by a shaft of wrought iron, furnished with 3 rows of projecting bars, or kneading arms, placed at angles of 120 deg. to each other. These act by rotation against 2 chisel-shaped teeth, which stand obliquely up from the front part of the bottom of the drum. The drum itself consists of 2 semi-cylinders; the under of which is made fast to a strong iron framing, and the upper is hinged to the under one behind, but bolted to it before, so as to form a cover or lid, which may be opened or laid back at pleasure, in order to examine the caoutchouc from time to time, and take it out when fully kneaded. In the centre of the lid a funnel is made fast, by which the cuttings and shreds of the Indian rubber are introduced, and a stream of water is made to trickle in, for washing away the foul matter often imbedded in it. The power required to turn the axis of one of these mills, as the drums or boxes are called, may be judged of from the fact, that if it be only 2 inches in diameter, it is readily twisted asunder, and requires to be 3 inches to withstand every strain produced by the fixed teeth holding the caoutchouc against the revolving arms. Five pounds constitute a charge of the material.

One of the most remarkable phenomena of the kneading operation, is the prodigious heat disengaged in the alternate condensation and expansion of the caoutchouc. Though the water be cold as it trickles in, it soon becomes boiling hot, and emits copious vapors. When no water is admitted, the temperature rises much higher, so that the elastic lump, though a bad conductor of heat, can not be safely touched with the hand. As we shall presently find that caoutchouc suffers no considerable or permanent diminution of its volume by the greatest pressure which can be applied, we must ascribe the heat evolved in the kneading process to the violent intestine movements excited throughout all the particles of the elastic mass.

During the steaming, much muddy water runs off through apertures in the bottom of the drum. In the course of half an hour's trituration, the various pieces become agglutinated into a soft, elastic, ovoid ball, of a reddish brown color. This ball is now transferred into another similar iron drum, where it is exposed to the pricking and kneading action of 3 sets of chisel-points, 5 in each set, that project from the revolving shaft at angles of 120 degrees to each other, and which encounter the resistance occasioned by five stationary chisel-teeth, standing obliquely upward from the bottom of the drum. Here the caoutchouc is kneaded dry along with a little quicklime. It soon gets very hot; discharges in steam through the punctures, the air and water which it had imbibed in the preceding washing operation; becomes, in consequence, more compact; and, in about an hour, assumes the dark brown color of stationers' rubber. During all this time frequent explosions take place, from the expansion and sudden extrication of the imprisoned air and steam.

From the second set of drums the ball is transferred into a third set, whose revolving shaft, being furnished both with flat pressing bars, and parallel sharp chisels, perpendicular to it, exercises the twofold operation of pricking and kneading the mass, so as to condense the caoutchouc into a homogeneous solid. Seven of these finished balls, weighing, as above stated, 5 pounds each, are then introduced into a much larger iron drum of similar construction, but of much greater strength, whose shaft is studded all round with a formidable array of blunt chisels. Here the separate balls become perfectly incorporated into one mass, free from honeycomb cells or pores, and therefore fit for being squeezed into a rectangular or cylindrical form in a suitable cast-iron mould, by the action of a screw-press. When condensed to the utmost in this box, the lid is secured in its place by screw bolts, and the mould is set aside for several days. It is a curious fact, that Mr. Sievier has tried to give this moulding force, by the hydraulic press, without effect, as the cake of caoutchouc, after being so condensed, resiles much more considerably than after the compressing action of the screw. The cake form generally preferred for the recomposed, ground, or milled caoutchouc, is a rectangular mass, about 18 inches long, 9 inches broad, and 5 inches thick.

This is sliced into cakes for the stationer, and into sheets for making tapes and threads of caoutchouc, by an ingenious self-acting machine, in which a straight steel blade, with its edge slanting downward, is made to vibrate most rapidly to and fro in a horizontal plane; while the cake of caoutchouc, clamped or embraced at each side between two strong iron bars, is slowly advanced against the blade by screw-work, like that of the slide rest of a lathe. In cutting caoutchouc by knives of every form, it is essential that either the blade or the incision be constantly moistened with water; for otherwise the tool would immediately stick fast. As the above straight vibrating knife slants obliquely downward, the sheet which it cuts off spontaneously turns up over the blade in proportion as it is detached from the bottom mass of the cake. The thicker slices are afterward cut by hand, with a wetted knife, into small parallelopipeds for the stationer, the sections being guided rectangularly by saw lines in a wooden frame. The wholesale price of these is now reduced to 2*s.* per pound. Slices may be cut off to almost any desired degree of thinness, by means of an adjusting screw—a mechanism that acts against a board which supports the bottom of the cake, and raises it by any aliquot part of an inch, the cutting-blade being caused to vibrate always in the same horizontal plane. These thin slices constitute what is called sheet-caoutchouc, and they serve tolerably for making tubes for pneumatic apparatus, and sheaths of every kind; since, if their two edges be cut obliquely with clean scissors, they may be made to coalesce, by gentle pressure, so intimately, that the line of junction can not be discovered either by the eye, or by inflation of a bag or tube thus formed.

The mode of recomposing the cuttings, shreds, and coarse lumps of caoutchouc, into a homogeneous elastic cake, specified by Mr. Nickels, for his patent, sealed October 24, 1836, is not essentially different from that above described. The cylinders of his mill are more capacious, are open at the sides like a cage, and do not require the washing-apparatus, as the caoutchouc has been cleansed by previous lamination and rinsing. He completes the kneading operation, in this open cylinder, within the space of about two hours, and afterward squeezes the large ball so formed into the cheese form, in a mould subjected to the action of an hydraulic press. As he succeeds perfectly in making compact cakes in this way, his caoutchouc must differ somewhat in its physical constitution from that recomposed by Mr. Sievier's process. He uses a press of the power of 70 tons; such pressure, however, must not be applied suddenly, but progressively, at intervals of two or three minutes between each stroke; and when the pressing is complete, he suffers the caoutchouc to remain under pressure till it is cold, when he thrusts it out of the mould entirely, or, placing his mould in the slide-rest mechanism, he gradually raises the caoutchouc out of it, while the vibrating knife cuts it into slices in the manner already described. The elegant machine by which these sheets are now so easily and accurately sliced, was, I believe, originally contrived and constructed by Mr. Beale, engineer, Church-lane, Whitechapel.

II.—FILATURE OF CAOUTCHOUC FOR MAKING ELASTIC FABRICS.

Messrs. Rattier and Guibal mounted in their factory at St. Denys, so long ago as the year 1826 or 1827, a machine for cutting a disc of caoutchouc into a continuous fillet spirally, from its circumference toward its centre. This flat disc was made by pressing the bottom part of a bottle of Indian rubber in an iron mould. I have described this machine under the article Elastic Bands, in the Dictionary. A machine on the same principle was made the subject of a patent by Mr. Joshua Proctor Westhead, of Manchester, in February 16, 1836; and, being constructed with the well-known precision of Manchester workmanship, it has been found to act perfectly well in cutting a disc of caoutchouc, from the circumference toward the centre spirally, into one continuous length of tape. For the service of this machine, the bottom of a bottle of Indian rubber of good quality being selected, is cut off and flattened by heat and pressure into a nearly round cake of uniform thickness. This cake is made fast at its centre by a screw nut and washer to the end of a horizontal shaft, which may be made to revolve with any desired velocity by means of appropriate pulleys and bands, at the same time that the edge of the disc of caoutchouc is acted on by a circular knife of cast-steel, made to revolve 3,000 times per minute, in a plane at right angles to that of the disc, and to advance upon its axis progressively, so as to pare off a continuous uniform tape or fillet from the circumference of the cake. During this cutting operation, the knife and caoutchouc are kept constantly moist with a slender stream of water. A succession of threads of any desired fineness is afterward cut out of this fillet, by drawing it in a moist state through a guide slit, against the sharp edge of a revolving steel disc. This operation is dexterously performed by the hands of young girls. MM. Rattier and Guibal employed, at the above-mentioned period, a mechanism consisting of a series of circular steel knives, fixed parallel to each other at minute distances, regulated by interposed washers upon a revolving shaft; which series of knives acted against another similar series, placed upon a parallel adjoining shaft, with the effect of cutting the tape throughout its length into eight or more threads at once. An improved modification of that apparatus is described and figured in the specification of Mr. Nickels's patent of October, 1836. He employs it for cutting into threads the tapes made from the recomposed caoutchouc.

The body of the bottle of Indian rubber, and in general any hollow cylinder of caoutchouc, is cut into tapes, by being first forced upon a mandril of soft wood of such dimensions as to keep it equally distended. This mandril is then secured to the shaft of a lathe, which has one end formed into a fine-threaded screw, that works in a fixed nut, so as to traverse from right to left by its rotation. A circular disc of steel, kept moist, revolves upon a shaft parallel to the preceding, at such a distance from it as to cut through the caoutchouc, so that, by the traverse movement of the mandril-shaft, the hollow cylinder is cut spirally into a continuous fillet of a breadth equal to the thickness of the side of the cylinder. Mr. Nickels has described two methods of forming hollow cylinders of recomposed caoutchouc, for the purpose of being cut into fillets by such a machine.

It is probable that the threads formed from the best Indian rubber bottles, as imported from Para, are considerably stronger than those made from recomposed caoutchouc, and therefore much better adapted for making Mr. Sievier's patent elastic cordage. When, however, the kneading operation has been skilfully performed, I find that the threads of the *ground* caoutchouc, as it is incorrectly called by the workmen, answer well for every ordinary purpose of elastic fabrics, and are, of course, greatly more economical, from the much lower price of the material.

Threads of caoutchouc are readily pieced by paring the broken ends obliquely with scissors, and then pressing them together with clean fingers, taking care to admit no grease or moisture within the junction line. These threads must be deprived of their elasticity before they can be made subservient to any torsile or textile manufacture. Each thread is *inelasticated* individually in the act of reeling, by the tenter boy or girl pressing it between his moist thumb and finger, so as to stretch it to at least eight times its natural length, while it is drawn rapidly through between them by the rotation of the power-driven reel. This extension is accompanied with condensation of the caoutchouc, and with very considerable disengagement of heat, as pointed out in Nicholson's Journal upward of thirty years ago, by Mr. Gough, the blind philosopher of Kendal. I attempted to stretch the thread, in the act of reeling, but found the sensation of heat too painful for my unseasoned fingers. The reels, after being completely filled with the thread, are laid aside for some days, more or fewer, according to the quality of the caoutchouc, the recomposed requiring a longer period than the bottle material. When thus rendered inelastic, it is wound off upon bobbins of various sizes, adapted to various sizes of braiding, or other machines, where it is to be clothed with cotton or other yarn.

In the process of making the ELASTIC TISSUES, the threads of caoutchouc being first of all deprived of their elasticity, are prepared for receiving a sheath upon the braiding-machine. For this purpose they are stretched by hand, in the act of winding upon the reel, to 7 or 8 times their natural length, and left two or three weeks in that state of tension upon the reels. Thread thus *inelasticated* has a specific gravity of no less than 0·948732; but when it has its elasticity restored, and its length reduced to its pristine state, by rubbing between the warm palms of the hands, the specific gravity of the same piece of thread is reduced to 0·925939. This phenomenon is akin to that exhibited in the process of wire-drawing, where the iron or brass gets condensed, hard, and brittle, while it disengages much heat: which the caoutchouc thread also does in a degree intolerable to unpractised fingers, as above mentioned.

The thread of the Joint-Stock Caoutchouc company is numbered from 1 to 8. No. 1 is the finest, and has about 5,000 yards in a pound weight; No. 4 has 2,000 in the pound weight; and No. 8, 700, being a very powerful thread. The finest is used for the finer elastic tissues, as for ladies' silver and gold elastic bracelets and bands. The ropes made by Mr. Sievier with the strongest of the above threads, clothed with hemp and worked in his gigantic braiding-machine, possess, after they are re-elasticated by heat, an extraordinary strength and elasticity; and, from the nearly rectilinear direction of all the strands, can stand, it is said, double the strain of the best patent cordage of like diameter.

In treating of the manufacture of elastic fabrics, I have great pleasure in adverting to the riband-looms at Holloway, which display to great advantage the mechanical genius of the patentee, Mr. Sievier. Their productive powers may be inferred from the following statement: 5,000 yards of 1-inch braces are woven weekly in one 18 riband-loom, whereby the female operative, who has nothing to do but watch its automatic movements, earns 10*s.* a week; 3,000 yards of 2-inch braces are woven upon a similar loom in the same time. But one of Mr. Sievier's most curious patent inventions, is that of producing, by the shrinking of the caoutchouc threads in the foundation or warp of the stuff, the appearance of raised figures, closely resembling coach-lace, in the weft. Thus, by a simple physical operation, there is produced, at an expense of one penny, an effect which could not be effected by mechanical means for less than one shilling.

III. OF THE WATER-PROOF DOUBLE FABRICS.

The parings, the waste of the kneading operations above described, and the coarsest qualities of imported caoutchouc, such as the inelastic lumps from Para, are worked up into varnish, wherewith two surfaces of cloth are cemented, so as to form a compound fabric, impervious to air and water. The caoutchouc is dissolved either in petroleum (coal-tar) naphtha, or oil of turpentine, by being triturated with either of the solvents in a close cast-iron vessel, with a stirring apparatus, moved by mechanical power. The heat generated during the attrition of the caoutchouc, is sufficient to favor the solution, without the application of fuel in any way. These triturating cylinders have been called pug mills by the workmen, because they are furnished with obliquely pressing and revolving arms, but in other respects they differ in construction. They are 4 feet in diameter and depth, receive 13 cwt. at a time, have a vertical revolving-shaft of wrought iron 4 inches in diameter, and make one turn in a second. Three days are required to complete the solution of one charge of the varnish materials. The proportion of the solvent oils varies with the object in view, being always much less in weight than the caoutchouc.

When the varnish is to be applied to very nice purposes, as bookbinding, &c., it must be rubbed into a homogeneous smooth paste, by putting it in a hopper, and letting it fall between a couple of parallel iron rolls, set almost in contact.

The wooden framework of the gallery in which the water-proof cloth is manufactured, should be at least 50 yards long, to give ample room for extending, airing, and drying, the pieces; it should be 2 yards wide, and not less than 5 high. It is formed of upright standards of wood, bound with three or four horizontal rails at the sides and the ends. At the end of the gallery, where the varnish is applied, the web which is to be smeared must be wound upon a beam, resembling in size and situation the cloth-beam of the weaver's loom. The piece is thence drawn up and stretched in a horizontal direction over a bar, like the breast-beam of a loom, whence it is extended in a somewhat slanting direction downward, and passed over the edge of a horizontal bar. Above this bar, and parallel to it, a steel-armed edge of wood is adjusted, so closely as to leave but a narrow slit for the passage of the varnish and the cloth. This horizontal slit may be widened or narrowed at pleasure by thumb-screws, which lower or raise the moveable upper board. The caoutchouc paste being plastered thickly with a long spatula of wood upon the down-sloped part of the web, which lies between the breast-beam and the above-described slit, the cloth is then drawn through the slit by means of cords in a horizontal direction along the lowest rails of the gallery, whereby it gets uniformly besmeared. As soon as the whole web, consisting of about 40 yards, is thus coated with the viscid varnish, it is extended horizontally upon rollers, in the upper part of the gallery, and left for a day or two to dry. A second and third coat are then applied in succession. Two such webs, or pieces, are next cemented face to face, by passing them, at the instant of their being brought into contact, through between a pair of wooden rollers, care being taken by the operator to prevent the formation of any creases, or twisting of the twofold web. The under one of the two pieces being intended for the lining, should be a couple of inches broader than the upper one, to insure the uniform covering of the latter, which is destined to form the outside of the garment. The double cloth is finally suspended in a well-ventilated stove-room, till it becomes dry, and nearly free from smell. The parings cut from the broader edges of the under piece, are reserved for cementing the seams of cloaks and other articles of dress. The tape-like shreds of the double cloth are in great request among gardeners, for nailing up the twigs of wall shrubs.

Mr. Walton, of Sowerby-bridge, has recently substituted sheet Indian rubber for leather, in the construction of fillet-cards for the cotton and tow manufactures. The superior elasticity of this article is said to prove advantageous in several respects.

Mr. Charles Keene, proprietor of the extensive and well-organized Indian rubber factory in Lambeth, obtained a patent in March, 1840, for applying a coat of caoutchouc to the outer surface of flexible leather. The varnish of caoutchouc, made with oil of turpentine, has so much lampblack incorporated with it, as to bring it to the consistence of dough. The edge of the doe-skin, buck-skin, or wash-leather, being introduced between a pair of wetted iron rollers, as much of the India rubber compound, softened by a gentle heat, and rolled into a proper length as will cover the leather, is laid in the hollow between the leather and the moist cylinders. By their rotation, the coating is evenly affected. When the surface has become dry, it may be embossed or gilt, and varnished over with a solution of shellac, with a little Venice turpentine, in alcohol. After two or three applications of this kind, the leather is passed through a pair of rollers, either smooth or embossed. When made-up articles, such as shoes or portmanteaus, &c., are to be covered, the Indian rubber varnish is used in a thinner state.—*Newton's Journal*, xxiii. 357.

CARMINE. This valuable pigment is often adulterated with starch. Water of ammonia enables us to detect this fraud by dissolving the pure carmine, and leaving the starchy matter, as well as most other sophisticating substances. Such debased carmine is apt to spoil with damp.

CASSAVA, or *Tapioca*, is obtained principally from the *Jatropha Manioc.* Its extraction is remarkable for the large quantity of hydrocyanic acid which the juice of that plant contains. When distilled it affords, as a first product, a liquor which, in the dose of 30 drops, will cause the death of a man in the course of six minutes; and it is well known that this acid does not pre-exist in the plant, but that it is generated in it, after it is grated down into a pulp. It would be interesting to discover in what state the substance exists, from which it proceeds. After the grating of the root, and washing of the pulp, this is dried upon hot plates, to agglutinate it into the form of concretions, constituting the tapioca of commerce. But the starch of the washed root floated in water, is spontaneously deposited, and, when dried in the sun, forms *Cassava*, flour, called *moussache* by the French.

CASTOR OIL. Imported for consumption in 1839, 710,344 lbs.; in 1840, 807,175 lbs.: duty, 1*s.* 3*d.* per cwt.

CEMENTS. See MORTAR, HYDRAULIC.

An excellent cement for resisting moisture is made by incorporating thoroughly eight parts of melted glue, of the consistence used by carpenters, with four parts of linseed oil, boiled into varnish with litharge. This cement hardens in about forty-eight hours, and renders the joints of wooden cisterns and casks air and water tight. A compound of glue with one fourth its weight of Venice turpentine, made as above, serves to cement glass, metal, and wood, to one another. Fresh made cheese-curd, and old skim-milk cheese, boiled in water to a slimy consistence, dissolved in a solution of bicarbonate of potash, are said to form a good cement for glass and porcelain. The gluten of wheat, well prepared, is also a good cement. White of eggs, with flour and water well mixed, and smeared over linen cloth, forms a ready lute for steam joints in small apparatus.

White lead ground upon a slab with linseed oil varnish, and kept out of contact of air, affords a cement capable of repairing fractured bodies of all kinds. It requires a few weeks to harden. When stone and iron are to be cemented together, a compound of equal parts of sulphur with pitch answers very well.

CHALYBEATE is the name given in medicine to preparations of iron. The most agreeable, and one of the most powerful, forms of such medicines, is the improved chalybeate water, for which Mr. Henry Bewley, apothecary in Dublin, obtained a patent in June, 1842. The following is his valuable recipe:—Eight ounces of crystallized citric acid being dissolved in about four times their weight of water heated to 170° F., are saturated with pure peroxide of iron, in the washed state, after being precipitated by ammonia from the ferric sulphate. The solution is sweetened, flavored, and charged highly with carbonic acid gas, so as to make a very palatable potion, agreeable also to the stomach.

I find by analysis that 100 parts of Mr. Bewley's brilliant citrate of iron contain 28·5 of peroxide, 48·5 of citric acid, and 23 of water; and that a six ounce phial of his chalybeate water contains of that citrate a quantity equivalent to nearly 8 grains of peroxide of iron.

Similar compounds are also specified to be made with other organic salts, as the tartrate or lactate of iron.—*Newton's Journal*, xxii. 470.

CHAMELEON MINERAL. As this compound—so long known in chemistry as a mere curiosity, on account of the surprising changes of color which it spontaneously assumes—has of late been largely employed for whitening tallow, palm oil, and decoloring other organic matters, it merits description in this dictionary. It exists in two states; one of which is called by chemists the manganate of potash, and the other the oxymanganate; denoting that the first is a compound of manganic acid with potash, and that the second is a compound of oxymanganic acid with the same base. They are both prepared in nearly the same way; the former by calcining together, at a red heat in a covered crucible, a mixture of one part of the black peroxide of manganese with three parts of the hydrate of potash (the fused potash of the apothecary). The mass is of a green color when cold. It is to be dissolved in cold water, and the solution allowed to settle, and become clear, but by no means filtered for fear of the decomposition to which it is very prone. When the decanted liquid is evaporated under the exhausted receiver of an air-pump, over a surface of sulphuric acid, it affords crystals of a beautiful green color, which should be laid on a clean porous brick to drain and dry. They may be preserved in dry air, but should be kept in a well-corked bottle. They are decomposed by water, but dissolve in weak water of potash. On diluting this much, decomposition of the salt ensues, with all the chameleon changes of tint; red, blue, and violet. Sometimes a green solution of this salt becomes red on being heated, and preserves this color even when cold, but resumes its green hue the moment it is shaken: it might, therefore, furnish the crafty votaries of St. Januarius with an admirable means of mystifying the worshippers at his shrine. The original calcined mass, in being dissolved, always deposites a considerable quantity of a brown powder, which is a compound of the acid and peroxide of manganese combined with water. Much of the potash remains unchanged, which may be recovered.

The oxymanganate of potash is made by fusing, with a strong heat, a mixture of equal parts of peroxide of manganese and hydrate of potash, or one part of peroxide and two parts of nitre. The mass is to be dissolved in water, and, if the solution be green, it should be reddened by the cautious addition of a few drops of nitric acid. The clarified liquor is to be evaporated to the point of crystallization. Even the smallest crystals of this salt have such an intense red color, that they appear black with a green metallic reflection. In the air they gradually assume a steel gray hue, without undergoing any essential change of nature. A very little of the salt reddens a large body of water. The least portion of any organic matter added to the solution of this salt reduces the oxymanganic acid to the state of peroxide, which precipitates combined with water; and the liquor becomes green or colorless, according to circumstances.

A more permanent oxymanganic salt may be made as follows:—Melt chlorate of potash over a spirit lamp, and throw into it a few pieces of hydrate of potash, which immediately dissolve, and form a limpid liquid. When peroxide of manganese in fine powder is gradually introduced into that melted mixture, it immediately dissolves, with the production of a rich green color. After adding the manganese in excess, the whole is to be exposed to a gentle red heat, in order to decompose the residuary chlorate of potash. It is now a mixture of manganate of potash, chloride of potassium and peroxide of manganese. It forms with water a deep green-colored solution; which when boiled assumes a fine red color, in consequence of its becoming an oxymanganate, and it ought to be decanted off the sediment while hot. By cooling, and still more after further evaporation, the oxymanganate of potash separates in crystals possessed of great lustre; but toward the end colorless crystals of chloride of potassium.

Both the above salts are readily decomposed by organic bodies and other combustibles, whereby they have their acid converted into an oxide, with the disengagement of oxygen, and the destruction of many vegetable and animal colors. In this respect they resemble the nitrates and chlorates.

CHINA INK. (*Encre de Chine*, Fr.; *Chinesischer Tusch*, Germ.) The finest kind of this useful pigment is seldom met with in our markets. According to a description in a Japanese book, it is made from the condensed smoke or soot of burned camphor; and hence, when of the best quality, it has this odor. Most of the China ink is made from oil-lampblack occasionally disguised, as to smell, with musk, or with a little camphor black. The binding substance is gelatine, commonly made from parchment or ass's skin; but isinglass answers equally well. A good imitation may be made by dissolving isinglass in warm water, with the addition of a very little alkali (soda), to destroy its gelatinizing power; and incorporating with that solution, by levigation on a porphyry slab, as much of the finest lampblack as to produce a mass of the proper consistence. The minute quantity of alkali serves also to saponify the oil which usually adheres to lampblack; and thereby to make a pigment readily miscible with water.

CHLORATE OF POTASH. The following ingenious and easy way of making this valuable compound has been lately suggested by Professor Graham:—Mix equal atomic weights of carbonate of potash and hydrate of lime (70 of the former, if pure, and 37 of slaked lime in powder), diffuse them through cold water, and transmit chloride gas through the mixture. The gas is absorbed with great avidity, and the production of a boiling heat. When the saturation is complete, carbonate of lime remains, and a mixture of muriate and chlorate of potash, which latter salts are to be separated, as usual, by the difference of their solubility in water.

It has been remarked on the above process, that it effects no saving of potassa, and therefore is far inferior to the one long practised in several parts of Germany, especially at Giessen, and introduced into this country a good many years ago by Dr. Wagenmann, from Berlin. The chlorine is passed into a mixture of one equivalent of chloride of potassium (76), and 6 equivalents of hydrate of lime (222), previously stirred with water, to the consistence of a thin paste. Thus the calcium of the lime unites with the chlorine to form chloride of calcium, while the chloride of potassium is converted into chlorate of potassa, which salt is easily separated in crystals by its sparing solubility.

Chlorate of potash may also be made by saturating with chlorine a mixture of 74 parts of chloride of potassium (muriate of potash) and 168 parts of quicklime, brought to the consistence of a thin pap by the cautious addition of water. The mass being dissolved in warm water, and evaporated and cooled, yields crystals of chlorate of potash, while a mother water of chloride of calcium (muriate of lime), remains. The following process has likewise been prescribed:—Mix 10 parts of good chloride of lime with water into a pap, and evaporate to dryness, whereby it is converted into a mixture of chloride of calcium and chlorate of lime devoid of bleaching power: dissolve it in water, filter, concentrate the solution by evaporation, then add to it 1 part of chloride of potassium, and cool for crystallization. The salt which may thereby be separated from the chloride of calcium will afford 0·83 of pure chlorate of potash. By this process of Professor Liebig five sixths of the potash are saved, but much oxygen is wasted in the evaporation to dryness of the chloride of lime, and, consequently, much chloric acid is lost toward the production of the salt. Vée mixes the chloride of lime pap, before heating it, with the chloride of potassium, boils the mixture smartly, whereby much oxygen is undoubtedly thrown off, and then sets the liquor aside to crystallize. L. Gmelin suggests that saturation of the liquor with chlorine before boiling might be advantageous. Gay Lussac has suggested to make this valuable salt by precipitating a solution of chloride of lime with carbonate (or sulphate) of potash, saturating the liquor after filtration with chlorine gas, evaporating, and crystallizing.

Professor Juch's process is to pass chlorine gas into a mixture of 1 pound caustic lime and 1 pound carbonate of potash, with 8 pounds of water. The resulting chloride of potash readily separates in the filtered liquid by crystallization, from the very soluble chloride of calcium. By this method, potash is not wasted in the useless production of chloride of potassium.

CHOCOLATE. About eighteen months ago, samples of chocolate were sent to me for analysis, by order of the lords of the admiralty. It was made at the victualling-yard, Deptford, for the use of the Royal Navy, by the government chocolate-mills, where about 400 tons are annually prepared, to be distributed to the sailors and convicts at the rate of an ounce daily, and to be used at their breakfast. After taking the said chocolate for some time, men in several ships complained of its occasioning sickness, vomiting, purging, and more serious maladies, terminating in a few cases fatally. I examined it with great care, but could find no injurious ingredient in it, and no chemical alteration from the beans of the Guyaquil coco from which it was manufactured. But I observed that it consisted of gritty grains, from very imperfect trituration or milling; that these grains were quite immiscible with water, like so much fine gravel; that they contained many sharp spiculæ of the coco-bean husks, and that hence, when swallowed, they were calculated to form mechanically irritating lodgements in the villous coats of the stomach and bowels, whereby they could produce the morbid effects certified by several naval surgeons. It was, moreover obvious that, from the insoluble condition of the chocolate, it could be of little use as an article of food, or as a demulcent substitute for milk, and that, in fact, three fourths of it were, on this account, an ineffective article of diet; or were wasted.

Having reported these results and opinions to the Lords of the Admiralty, they were pleased, after a few weeks' consideration, to request me to go down to the victualling yard at Deptford, and superintend the preparation of a quantity of chocolate in the best manner I could with the means there provided. I accordingly repaired thither on the 13th of September, 1842, and experienced the utmost courtesy and co-operation from Sir John Hill, the Captain Superintendent, and his subordinate officers. The coco-beans had been heretofore milled, after a slight roasting upon the sole of an oat-kiln, along with their husks. As I was satisfied, from analysis, that the husks were no better food than sawdust, and that they might cause irritation by their minute spiculæ left after grinding between rotating millstones, I set about a plan for shelling them, but could find no piece of apparatus destined for the purpose. There was however, a pea-shelling mill, which had been used only for one day some years before, and had stood ever since idle,* which, on being cleaned and having its millstones placed at a proper distance, was found to answer pretty well. The beans for experiment, to the amount of 6 cwt., had been previously roasted, under my care, at a well-regulated heat, with much stirring, in the oat-kiln; and, on being cold, were run through the shelling mill, which was put in communication with the fanners of the flour mill. By this arrangement, the coco-beans were tolerably shelled, and the kernels separated from their scaly husks. The weighings were accurately made.

6 cwt. of the Guyaquil coco - - -		672 lbs.
Lost in roasting - -	43	
shells - -	54	117
waste - -	20	
Remained for milling -		555

On the 14th September I made a report to the Lords of the Admiralty upon the experiments of the 13th, of which the following is an outline. After describing the pains taken to regulate the roasting temperature, and to equalize the effect upon the beans by moving them occasionly by a rake, I stated that the oat-kiln was not well adapted to the purpose of roasting the coco, because it was impossible to turn the beans regularly and continuously during the process, so that they could not be equally roasted, and because it was an unwholesome operation for the workmen, who must go into a chamber filled with noxious gases and fumes, to use the rakes. When the door of the kiln was shut, to allow the burned air from the fire below to draw up through it, mischief might be done to the stratum of coco on the sole, and when the door was again opened, to permit a person to go in and stir, time and heat were wasted in replenishing the chamber with fresh air. I understand that a revolving-cylinder-roasting machine had been made by Messrs. Rennie for the chocolate process at Deptford; but, for reasons unknown to me, it had never been employed.

The diminution of weight by roasting and shelling may be estimated at about 17 per cent. A part of this loss is moisture, which should be completely expelled, to prevent its causing the chocolate to become mouldy at sea. But a part of the defalcation was also due to some of the coco remaining in the crevices of the pea-splitting mill and the fanners, which would not be observable if these were in constant employment. I think, therefore, that the roasted kernels may be estimated in general at 85 per cent. of the raw beans.

Fig. 20 represents the chocolate mills at the victualling-yard, Deptford, as mounted by the celebrated engineers, Messrs. Rennie. There are four double millstones, A, B, C, D, each three feet in diameter, of which the nether rests upon a bed of cast iron, like a drum-head, kept at the temperature of about 220° by the admission of steam to the case below. Over each mill there is a feeding-hopper 1, 2, 3, 4, in communication by the pipes 5, 6, 7, 8, with the general reservoir E, charged upon the floor above with coco through the funnel placed over it. The vertical shafts which turn these mills are marked F, G, H, L; they are moved by the train of bevil wheels above, which are driven by an arm from the main shaft of the steam engine. Each mill can, of course, be thrown in and out of gear at pleasure. At I, I, I, I, the discharge-spout is shown, which pours out the semi-fluid hot chocolate into shallow cylindrical tin pans,

* It was found that peas in their skin kept better at sea than the split peas, and they were also preferred by the sailors in their natural state.

capable of containing about nine pounds of chocolate each. These four mills are capable of converting upward of a ton of coco into good chocolate in a day, on the system of double trituration which I adopted, and two tons on the former rough plan. I found that the two stones of each mill had been placed so far asunder as would allow entire

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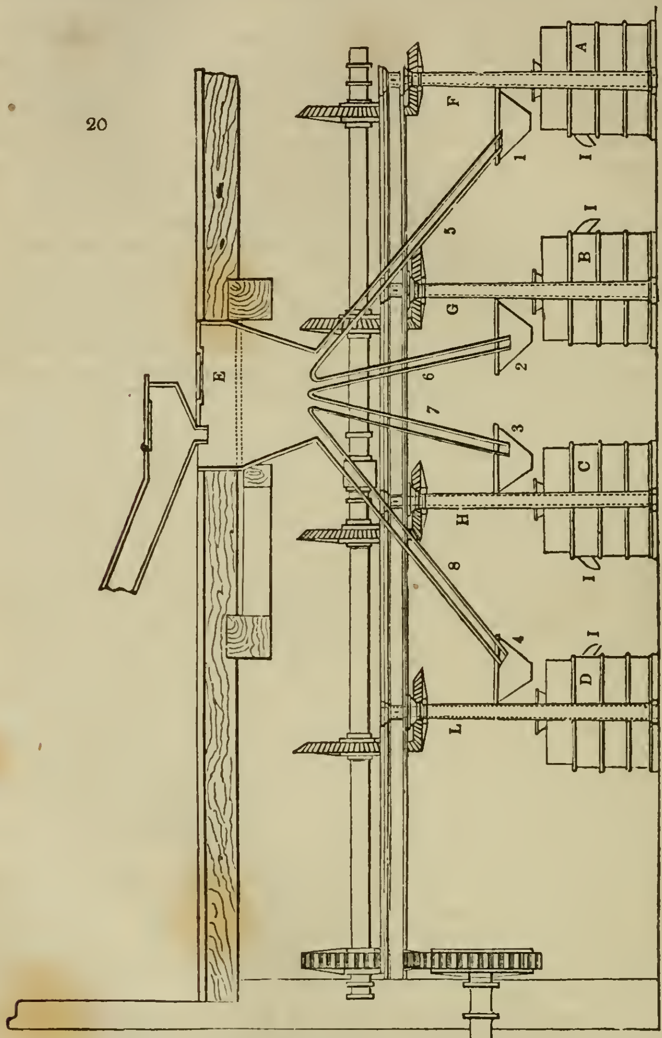

beans to pass through, as spurious chocolate, at one operation; but the chocolate thus discharged was in a very, gritty state, whereas good chocolate in the liquefied state should be smooth and plastic between the fingers, and spread upon the tongue without leaving any granular particles in the mouth. To obtain such a result, I divided the milling into two steps; for the first, two pairs of the stones, A and C, were set as close together as for a paint mill (which they closely resemble), and the other two pairs, B and D, were left at their ordinary distance. The paste obtained from the first set was transferred, while nearly liquid, into the hoppers of the second pairs, from which it issued at the spouts as thin and smooth as honey from the comb. In subservience to these experiments, I made an analysis of the Guyaquil coco, which I found to be composed as follows :—

Concrete fat or butter of coco, dissolved out by ether - - -	37
Brown extractive, extractible by hot water, after the operation of ether -	10
Ligneous matter, with some albumine - - - - - -	30
Shells - - - - - - - - -	14
Water - - - - - - - - -	6
Loss - - - - - - - - -	3
	100

The solid fat of the coco should be most intimately combined by milling with the extractive, albumine, and ligneous matter, in order to render it capable of forming an emulsion with water; and, indeed, on account of the large proportion of concrete fat in the beans, some additional substance should be introduced to facilitate this emulsive union of the fat and water. Sugar, gum, and starch or flour, are well adapted for this purpose.

Under this conviction I employed in the first of these trials at Deptford, made with one half of the above roasted kernels = 277½ lbs. 5 per cent. of sugar, which was first mixed upon a board with shovels, and the mixture was then put progressively into the hoppers of the two mills B and D. The paste which ran out of their spouts, was immediately poured into the hoppers of A and C, from which it flowed smooth and very thin into the concreting pans. The sugar supplied to me was exceedingly moist, whereas it ought to be dry, like the bag sugar of the Mauritius. The other half of the coco kernels was milled alone once by the ordinary mills B and D. I subjected next day samples of these two varieties of chocolate to the following examination, and compared them with the sample of chocolate as usually made at Deptford, as also with a sample of chocolate sold by a respectable grocer in London. A like quantity of these four samples was treated with eight times its weight of boiling water, the diffusion well stirred, and then left to settle in a conical wineglass. Of the ordinary Deptford coco, four fifths rapidly subsided in coarse grains, incapable of forming anything like an emulsion with water, and therefore of little or no avail in making a breakfast beverage.

1. The single-milled chocolate made under my direction formed a smoother emulsion than the last, on account of the absence of the coco husks; but its particles were gritty, and subsided very soon.

2. The sugared double-milled chocolate, on the contrary, formed a milky-looking emulsion, which remained nearly uniform for some time, and then let fall a soft mucilaginous deposite, free from grittiness.

3. The shop chocolate formed a very indifferent emulsion, though it was well milled, because it contained evidently a large admixture of a coarse branny flour, as is too generally the case.

I have given small samples of the above No. 2 chocolate to various persons, and they have considered it superior to what is usually sold by our grocers. The presence of dry sugar in chocolate would also give it a conservative quality at sea, and prevent it from getting musty.

The lords of the admiralty, after seeing the above two samples of chocolate, and my report thereupon, were, about six weeks afterward, pleased to request me to make at their victually-yard further experiments in the preparation of chocolate; and they indicated two modes, one of milling twice with the husks, and another of milling twice without the husks; permitting me, at the same time, to mill a portion of the kernels with 10 per cent. of sugar, and a second portion of the kernels with 5 per cent. of sugar and 5 per cent. of the excellent flour used in making the biscuits for the royal navy. On the 24th October, 1842, I accordingly performed these experiments upon 12 cwts. of Guyaquil coco as carefully roasted as possible on the kiln.

The loss in drying and slightly roasting the 1,344 lbs. of beans was 5 per cent.

1st experiment, 212 lbs. of roasted coco, milled twice with the husks, produced, of chocolate - - - - - - -	209 lbs.
2d experiment, 191 lbs. ditto, milled twice without husks - -	189
3d experiment, 191 lbs. kernels, milled once along with 19 lbs. of sugar = 210 lbs. - - - - - - - -	212*
4th experiment, 573 lbs. kernels, milled twice along with 68 lbs. of flour and 34 of sugar = 675 - - - - - -	669

Sample cakes of these four varieties of chocolate were subsequently sent to me for examination and report. I found that the chocolate milled twice with the flour and

* This small excess proceeded from a residue of the last experiment.

sugar formed a complete emulsion with hot water, bland and rich, like the best milk, but the other three were much inferior in this respect. Sugar alone, with proper milling, would serve to give the kernels of well-roasted coco a perfect emulsive property. Instead of merely milling with rotatory stones, I would prefer, for the second or finishing operation, a levigating mill, in which rollers would be rolled either backward and forward, or, when slightly conical, in a circular direction, over a plane metallic, marble, or porphyry slab, as is now, indeed, very generally practised by the trade. The coco-beans should be well selected, without musty taint, and possessed of a fine aroma, like the best of that imported from Trinidad. There is a great deal of very coarse coco and chocolate on sale in London and in the provincial towns of the United Kingdom.

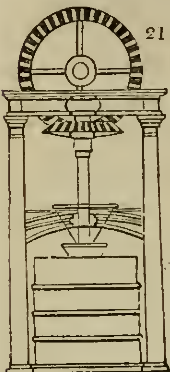
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Fig. 21 is an end view of one of the chocolate mills with its mitre-gearing. I consider the gritty chocolate hitherto made at Deptford as a very bad substitute for the chocolate which was made from coco by the sailors themselves with a pestle and mortar.

In 1840 the coco cleared for consumption in the United Kingdom was—

		Rate of Duty.
British plantation - -	2,041,492 lbs.	2*d.* per lb.
Foreign - - -	186	6*d.*
Coco-nut husks and shells -	753,580	1*d.*
Chocolate and coco paste -	2,067	4*d.*

Of the coco-nut shells, 612,122 lbs. were consumed in Ireland! and less than 4,000 lbs. of coco.

Of coco, 726,116 lbs. were consumed in her majesty's navy.

How scurvily are the people of Ireland treated by their own grocers! Upward of 600,000 lbs. of worthless coco husks served out to them along with only 4,000 lbs. of coco-beans!

CHROMIUM, OXIDE OF. Mix intimately 45 parts of gunpowder with 240 parts of perfectly dry chromate of potash, and 35 parts of hydrochlorate of ammonia (sal ammoniac), reduce to powder, and pass through a fine sieve; fill a conical glass or other mould with this powder, gently pressed, and invert so as to leave the powder on a porcelain slab of any kind. When set on fire at its apex with a lighted match, it will burn down to the bottom with brilliant coruscations. The black residuum, being elutriated with warm water, affords a fine bright green oxide of chromium.

CLOVES. Imported for home consumption in 1840, 85,769 cwts.

COAL. Under PITCOAL, the composition of several excellent coals, is stated, with their peculiar qualities, as analyzed by me; such as the Llangennoek, Powell's Duffryn steam coal, the Blackley Hurst coal, Lancashire, the Varley Rock vein coal, near Pontypool, &c.

COCHINEAL. Imported for consumption in 1839, 396,902 lbs.; in 1840, 325,744; duty, 1*s.* per cwt.

COFFEE. If tannin exist in roasted coffee, as maintained long ago by Chenevix, and generally admitted since, it must be very different from the tannin present in tea, catechu, kino, oak-bark, willow-bark, and other astringent vegetables; for I find that it is not, like them, precipitated by either gelatine, albumen, or sulphate of quinine. With regard to the action, upon the animal economy, of coffee, tea, and coco, which contain one common chemical principle called caffeine or theine, Liebig has lately advanced some ingenious views, and has, in particular, endeavored to show that to persons of sedentary habits in the present refined state of society, they afford eminently useful beverages, which contribute to the formation of the characteristic principle of *bile.* This important secreted fluid, deemed by Liebig to be subservient to the function of respiration, requires for its formation much azotised matter, and that in a state of combination analogous to what exists in caffeine. The quantity of this principle in tea and coffee being only from 2 to 5 per cent., might lead one to suppose that it could have little effect upon the system even of regular drinkers of their infusions; but if the bile contains only one tenth of solid matter, called choleic acid, which contains less than 4 per cent. of azote, then it may be shown that three grains of caffeine would impart to 500 grains of bile the azote which occurs in that crystalline precipitate of bile called *taurine,* which is thrown down from it by mineral acids.

One atom of caffeine, 9 atoms of oxygen, and 9 of water, being added together, produce the composition of 2 atoms of taurine. Now this is a very simple combination for the living organism to effect; one already paralleled in the generation of hippuric acid in urine, by the introduction of benzoic acid into the stomach; a physiological discovery made by my son, which is likely to lead to a more successful treatment of some of the most formidable diseases of man, particularly gout and gravel.

If the preceding views be established, they will justify the instinctive love of mankind for tea, coffee, and cocoa, in spite of the denunciations and vetoes of *neuropathic*, *homœopathic*, and *hydropathic* doctors; sorry pathologists—*hoc genus omne*. See TEA.

Coffee imported for consumption in 1839, 26,789,945 lbs.; in 1840, 28,664,341. Net revenue in 1839, 779,115*l.*; in 1840, 921,551*l.*

COPAL and ANIME. Imported for consumption in 1839, 193,066 lbs.; in 1840, 181,388 lbs.: duty, 6*s.* per cwt., as upon gum arabic and tragacanth.

COPPER. Quantity of copper ore raised in Cornwall in the year 1838–1839, 159,214 tons; value of, 932,090*l.* 15*s.* 6*d.*

Quantity raised in the year 1839–1840, 147,049 tons; value of, 792,750*l.* 14*s.*

Quantity of metallic copper produced in the former year, 12,469 tons; standard, 111*l.*: in the latter, 11,056; standard, 108*l.* 5*s.*

Produce per cent., 7¾ and 7½ respectively. Average price per ton, 5*l.* 17*s.* in the first; and 5*l.* 7*s.* 9*d.* in the second year.

Quantity of unwrought copper imported for home consumption in 1840, only 2½ cwts. *See* METALLIC STATISTICS.

COPPER MEDALS AND MEDALLIONS may be readily made in the following way: Let black oxide of copper, in a fine powder, be reduced to the metallic state, by exposing it to a stream of hydrogen, in a gun-barrel, heated barely to redness. The metallic powder thus obtained is to be sifted through crape, upon the surface of the mould, to the thickness of ¼ or ⅓ of an inch, and is then to be strongly pressed upon it, first by the hand, and lastly by percussion with a hammer. The impression thus formed is beautiful; but it acquires much more solidity by exposure to a red heat, out of contact with air. Such medals are said to have more tenacity than melted copper, and to be sharply defined.

M. Bœttger proposes the following improvement upon the above plan of Mr. Osann: He prepares the powder of copper easier and of better quality, by precipitating a boiling-hot solution of sulphate of copper, with pieces of zinc, boiling the metallic powder thus obtained with dilute sulphuric acid for a little, to remove all traces of the zinc or oxide, washing it next with water, and drying it in a tubulated retort by the heat of a water bath, while a stream of hydrogen is passed over it. This cupreous precipitate possesses so energetic an affinity for oxygen, that it is difficult to prevent its passing into the state of orange oxide. If it be mixed with one half its atomic weight of precipitated sulphur, and the two be ground together, they combine very soon into sulphuret of copper with the evolution of light.

COPPER, *Purifying*.—Copper may be purified by melting 100 parts of it with 10 parts of copper scales (black oxide), along with 10 parts of ground bottle-glass or other flux. Mr. Lewis Thompson, who received a gold medal from the Society of Arts for this invention, says that after the copper has been kept in fusion for half an hour, it will be found at the bottom of the crucible perfectly pure; while the iron, lead, arsenic, &c., with which this metal is usually contaminated, will be oxidized by the scales, and will dissolve in the flux, or be volatilized. Thus he has obtained perfectly pure copper from brass, bell-metal, gun-metal, and several other alloys, containing from 4 up to 50 per cent. of iron, lead, antimony, bismuth, arsenic, &c. The scales of copper are cheap, being the product of every large manufactory where that metal is worked.

CORK. Unmanufactured, imported in 1840 for home consumption, 59,793 cwts.

CORTEX PERUVIANUS, or CINCHONA. Imported for home consumption in 1840, 43,705 lbs.

COTTON may be distinguished from linen in a cloth fabric by means of a good microscope; the former fibres being flat, riband-like, and more or less contorted or shrivelled, and the latter straight, round, and with cross knots at certain distances. These two fibrous matters may be also distinguished by the action at a boiling heat of a strong caustic ley, made by dissolving fused potash in its own weight of water. By digestion in this liquor, linen yarn becomes immediately yellow, while the cotton yarn remains white. The best way of operating is to immerse a square inch of the cloth to be tested for two minutes in the above boiling-hot caustic ley, to lift it out on a glass rod, press it dry between folds of blotting-paper, and then to pull out a few of the warp and weft threads—when the linen ones will be found of a deep yellow tint, but the cotton, white or very pale yellow.

COTTON WOOL. Imported for home consumption in 1839, 352,000,277 lbs.; in 1840, 528,142,743 lbs.

CREOSOTE. Having been employed by a chemical manufacturer to examine his creosote, and compare it with others with a view to the improvement of his process, I found that the article, as made by eminent houses, differed considerably in its properties.

The specific gravities varied in the several specimens as follows: 1, a specimen given me by Messrs. Zimmer and Sell, at their factory in Sachsenhausen, by Frankfort-on-the-Maine, had a specific gravity of 1·0524; 2, a sample made in the north of England, sp. gr. 1·057, and its boiling point varied from 370° to 380° Fahr. Mr. Morson's creosote, which is much esteemed, has a sp. gr. of 1·070, and boils first at 280°, but progressively rises in temperature up to 420°, when it remains stationary. The German creosote was distilled from the tar of the pyrolignous acid manufacture. Creosote, I believe, is often made from Stockholm tar. Berzelius gives the sp. gr. of creosote at 1·037, and its boiling point at 203° C.=397·4° F. I deemed it useless to subject to ultimate analysis products differing so considerably in their physical properties. They were all very soluble in potash ley.

CROSS-FLUCKANS or FLOOKANS. The name given by the Cornish miners to clay veins of more ancient formation.

CYANIDE OF POTASSIUM. This salt, so much used now in the electrotype processes, is prepared, according to Liebig's formula, by mixing 8 parts of pounded prussiate of potash, sharply dried, with 3 parts of pure carbonate of potash, fusing the mixture in an iron crucible, by a moderate red heat, and keeping it so, till the glass or iron rod with which the fluid mass should be occasionally stirred, comes out covered with a white crust. The crucible is then to be removed from the fire; and after the disengaged iron has fallen to the bottom, the supernatant fluid, still obscurely red hot, is to be poured off upon a clean surface of iron or platinum. After concretion and cooling, the white saline mass is to be pounded while hot, and then kept in a well-stopped bottle. It consists of about 5 parts of cyanide of potassium, and 1 of cyanate of potash. For most purposes, and the analysis of ores, the latter ingredient is no ways detrimental.

CYDER. The value of apples to produce this beverage of good quality is proportionate to the specific gravity of their juice. M. Couverchel has given the following table, illustrative of that proposition :—

Juice of the green renette, queen apple (*reinette verte*)	1,084
English renette	1,080
Red renette	1,072
Musk renette	1,069
Fouillet rayé	1,064
Orange apple	1,063
Renette of Caux	1,060
Water	1,000

Cyder-apples may be distributed into three classes, the sweet, the bitter, and the sour. The second are the best; they afford a denser juice, richer in sugar, which clarifies well, and when fermented keeps a long time; the juice of sweet apples is difficult to clarify; but that of the sour ones makes bad cyder. Late apples are in general to be preferred. With regard to the proper soil for raising apple-trees, the reader may consult with advantage an able essay upon "The Cultivation of Orchards, and the making of Cyder and Perry," by Frederick Falkner, Esq., in the fourth volume of the Royal Agricultural Journal. He adverts judiciously to the necessity of the presence of alkaline and earthy bases, in the soils of all deciduous trees, and especially of such as produce acid fruits.

In November, 2,340 kilogrammes of apples ($2\frac{1}{3}$ tons English, nearly) are supposed to afford 1,000 litres ($220\frac{1}{2}$ gallons) of pure cyder; and 600 litres of a small cyder made with the marc mixed with water and pressed. But many persons mix all together, and thus manufacture 1,600 litres out of the above weight of fruit. In France, the fermented liquor, as soon as it is clear, is often racked off into casks containing the fumes of burning sulphur, whereby it ceases to ferment, and preserves much of its sugar undecomposed. It is soon afterward bottled. Average cyder should yield 6 per cent. of alcohol on distillation.

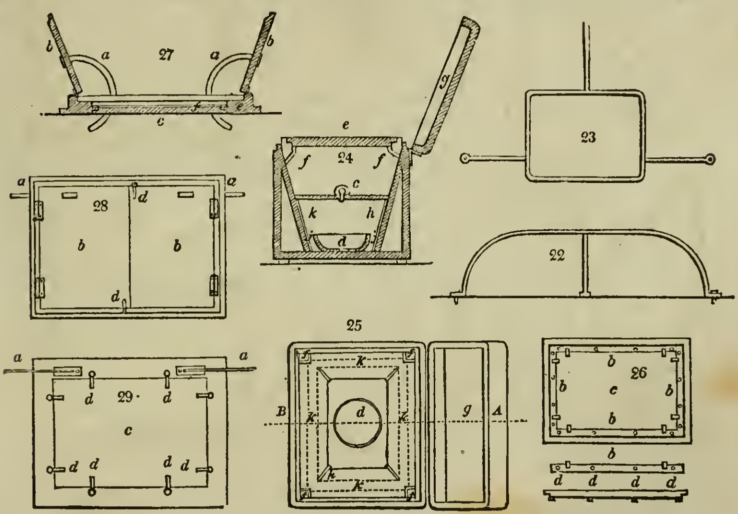
D.

DAGUERROTYPE. This new and most ingenious invention for producing pictures by the action of light, is due to M. Daguerre and M. Niepce, two Frenchmen. It was purchased from them by the French government for the benefit of the nation at large; but was made the subject of an exclusive patent in England by M. Daguerre, as that government never purchases any scientific invention.

The fixation of the images, formed in the focus of the camera obscura, is made on very smooth surfaces of pure silver plated on copper. The process is divided into five operations. 1. The first consists in polishing and cleaning the silver surface, by friction with cotton fleece imbued with olive oil, upon the plate, previously dusted over with very finely-ground dry pumice-stone out of a muslin bag. The hand of the operator should be moved round in circles, of various dimensions. The plates should be laid upon a sheet of paper solidly supported. The pumice must be ground to an impalpable powder upon a porphyry slab with water, and then dried. The surface is next to be rubbed with a dossil of cotton, slightly moistened with nitric acid, diluted with sixteen parts of water, by applying the tuft to the mouth of the phial of acid, and inverting it for a moment. Two or three such dossils should be used in succession. The plate is lastly to be sprinkled with pumice powder or Venetian tripoli, and rubbed clean with cotton.

The next step is to heat the plate by placing it in a wire frame (*fig.* 23), with the silver surface uppermost, over a spirit lamp, meanwhile moving it so as to act equally on every part of the plate. In about five minutes a whitish coating will indicate that this operation is completed. The plate must now be laid upon a flat metal or marble slab to cool it quickly. The white surface is to be brightened by rubbing it with cotton and pumice powder. It must be once more rubbed with the cotton imbued with acid, and afterward dried by friction with cotton and pumice; avoiding to touch the plate with the fingers, or with the part of the cotton held in them, or to breathe upon the plate, since spots would thereby be produced. After cleaning with cotton alone, the plate is ready for the next operation.

2. Here the following implements are required: 1, the box represented in *figs.* 24 and 25; 2, the thin board or frame, *fig.* 26; four small metallic bands of the same

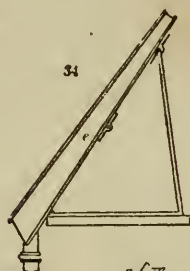


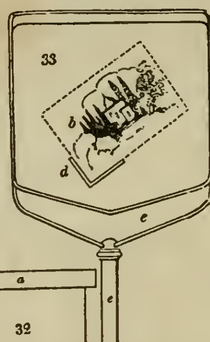
metals as the plates, also shown in *fig*, 26, a small handle and a box of small nails or tacks, and a phial of iodine.

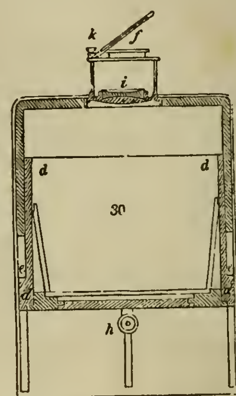
After fixing, by the metallic bands and the small nails, the plate upon the thin board, with the silver uppermost, several particles of iodine are then to be spread in the dish *d*, at the bottom of the box, *figs.* 24, and 25. The thin board with the plate, is next placed, with the silver *beneath*, upon small supports at the four corners of the box, and its cover is applied. The plate must be left in this position till the surface of the silver acquires a fine golden hue, caused by the vapors of the iodine rising through the gauze cover of the dish, and condensing upon it; but it should not be allowed to assume a violet tint. The room should be darkened, and no heat should be employed. When the box is in constant use it gets impregnated with iodine, and acts more uniformly and rapidly; but in general states of the atmospheric temperature this operation will be effected in about twenty minutes. If the purple color be produced, the plate must be repolished, and the whole process repeated.

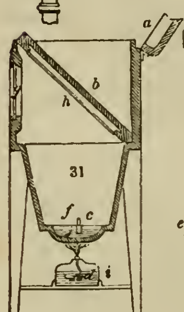
The plate with its golden hue is to be introduced with its board into the frame, *figs.* 27, 28, 29, which is adapted to the camera obscura. During this transfer the light must not be suffered to strike upon the surface of the plate; on which account, the camera obscura may be lighted briefly with a small wax taper.

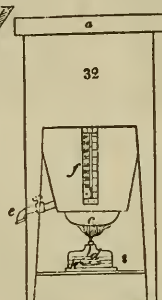
3. The plate is now submitted to the third operation, that of the camera obscura, *figs*. 30 and 22; and with the least possible delay. The action of this machine is obviously quicker the brighter the light which acts upon it; and more correct, according as the focus is previously accurately adjusted to the place of the plate, by moving backward and forward a roughened pane of glass, till the focal point be found; and the plate is to be inserted precisely there, see *figs*. 27, 28, 29. This apparatus exactly replaces the ground glass. While the prepared plate is being fastened, the camera must be closed. The darkening shutters, *b*, *b*, of the apparatus are opened by means of the two semicircles *a*, *a*. The plate is now in a proper condition to receive and retain the impression of the image of the objects presented the moment that the camera is opened. Experience alone can teach the proper length of time for submitting the plate to the concentrated rays of light; because that time varies with the climate, the seasons, and the time of day. More time should not be allowed to pass than what is necessary for fixing a distinct impression, because the parts meant to be clear would be apt to become clouded.

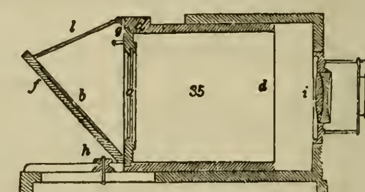


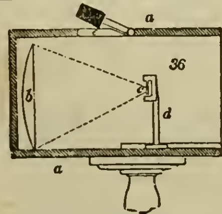












4. The fourth is the operation with quicksilver, which must follow as soon as possible the completion of the third. Here a phial of quicksilver, a spirit lamp (the apparatus represented in *figs*. 31 and 32), and a glass funnel with a long neck are required. The funnel is used for pouring the mercury into the cup *c*, placed in the bottom of the apparatus, so as to cover the bulb of the thermometer *f*. No day-light must now be admitted, but that of a small taper only should be used by the operator in conducting the process. The board with the plate is to be withdrawn from the camera, and inserted into the grooves of the blackened board, *b fig*. 31. This black board is laid back into the box at an angle of 45 degrees with the horizon; the prepared metal surface *h* being placed undermost, so that it may be viewed through the side glass, *g*; and the cover, *a*, of the box must be put down gently to prevent any par-

ticles of mercury from being thrown about by the agitation of the air. The whole being thus prepared, the spirit-lamp is lighted, and placed under the cup containing the mercury, and left there until the thermometer indicates a temperature of 140° Fahr., when the lamp is to be removed. The heat should in no case be permitted to exceed 167° F.

The impression of the image of nature is now actually made upon the plate; but it is as yet invisible; and it is only after a lapse of several minutes that faint tracings of the objects begin to be seen through the peep-glass by the momentary gleam of a taper. The plate should be left in the box till the thermometer has cooled to 113° F., when it is to be taken out.

After each operation, the interior of the apparatus, and the black-board or frame, should be carefully wiped, in order to remove every particle of mercury.

The picture may now be inspected in a feeble light, to see how far the process has succeeded. The plate, freed from the metallic bands, is to be placed in a box, provided with a cover and grooves, to exclude the light, till it is made to undergo the fifth and last operation, which may be done after any convenient interval of time without detriment, provided the plate be kept in the dark. The following articles are now required: 1, strong brine, or a weak solution of hyposulphite of soda; 2, the apparatus represented in *figs*. 33 and 34; 3, two troughs of tin-plate; 4, a jug of distilled water. The object of this process is to fix the photogenic picture. One of the troughs is to be filled with brine to the depth of an inch, and the other with pure water, both liquids being heated somewhat under the boiling pitch. The solution of hyposulphite of soda is preferable, and does not need to be warm. The plate is to be first immersed in the pure water for a moment, and transferred immediately to the saline solution, and moved to and fro in it to equalize the action of the liquor. Whenever the yellow tint of the iodine is removed, the plate is to be lifted out by the edges, and dipped straightway in the water trough. The apparatus of *figs*. 33 and 34, is then brought into use, with a vessel filled with distilled water, hot, but not boiling. The plate, when lifted out of the water-trough, is to be placed immediately on the inclined plane *e;* and without allowing it time to dry, is to be flooded over with the hot distilled water from the top, so as to carry off all the saline matter. As the quicksilver which traces the images will not bear touching, the silvered plate should be secured by a cover of glass, made tight at the edges by pasting paper round them.

In *fig*. 25, which is a plan-view of the iodine-box apparatus, *c* is an interior cover; *d* is the iodine-dish; *e* is the thin board to which the silvered plate is fixed, as shown at *fig*. 24; *g* is the cover of the box; *h h* are small rods, at the four corners of the inclined lining, *k*, of the box, to support the lid *c; j* is a gauze of wire-cloth cover, to diffuse the iodine vapor; *k* is the wooden lining, sloping like a hopper; *d d*, in *fig*. 27, are buttons to fasten the board on the doors; *e* shows the thickness of the frame; *f* is the silvered plate. In *fig*. 35, *a* is the ground glass of the camera; *b* is a mirror inclined about 45° to the horizon, by means of the rod *l*. The image of the object is easily brought into focus by moving forward or backward the sliding box *d*, in laying hold of it with both hands by the projections *a*, *fig*. 28. When the focus is adjusted, the thumb-screw, *h*, fixes the whole. The mirror is kept closed by two hooks at *f*, which take into small eyes at *g*. The frame and ground glass plate are withdrawn and replaced by the frame carrying the prepared plate, as represented in *fig*. 22, with the shading doors, *b*, open in the camera. These doors and the sliding-box *d* are lined with black velvet. The object-glass is achromatic and periscopic, the concave being outside in the camera; its diameter is about 3½ inches, and focus about 13 inches. A diaphragm is placed before the object-glass, at 3½ inches from it, and its aperture may be closed by a plate moving in a pivot. This camera reverses the objects from left to right; but this may be obviated by placing a plane mirror on the outside beyond the aperture of the diaphragm, as at *f*, *fig*. 30, where it is fixed by means of a screw, *k*. Loss of light is thereby occasioned.

Fig. 31, is an upright section, and *fig*. 32, a front elevation of the mercurial apparatus: *a*, the cover; *b*, the black-board, with grooves to receive the board *h; c* the cup of quicksilver; *d*, the spirit-lamp: *e*, a small cock, through which the quicksilver may be run off, if the apparatus be laid to one side; *f*, the thermometer; *g*, a glass window; *h*, the board bearing the metallic plate; *l*, a stand for the spirit-lamp, which is held by the ring *k*, so that its flame may strike the bottom of the cup. The whole of the inside of the apparatus should be blackened and varnished.

Fig. 33, is a front view of the washing apparatus made of tin plate, varnished. The plates to be washed, are laid on the angular ledge, *d; e* is a ledge to conduct the water to the receptacle *c*. *Fig*. 34 is a side view of the washing apparatus. The patent was enrolled in February, 1840. (See *Newton's Journal*, C. S. xvi. 1.)

Mr. Richard Beard having purchased from M. Daguerre a license to practise his invention above described, received from a foreigner a communication of certain improvements for which he obtained a patent in June, 1840. The first of these is the substitution of a concave reflecting mirror for the lens in the camera obscura. *Fig.* 36 represents in section a slight wooden box, *a a*, open at the front, opposite to the person sitting for the portrait. In the back part of the box a concave mirror, *b*, is placed, to reflect the rays coming from the person. A small frame, *c*, is fixed to an adjustable pedestal, *d*, which slides in grooves in the bottom of the box, for the purpose of being set at the focal point of the mirror. In this frame, *c*, a polished surface is first to be placed for trial, to receive the image correctly, as observed by the operator, by looking through the opening, *e*, in the top of the box. The prepared silvered plate is now substituted in the exact place for the trial one. The luminous impression being made, the slide, *d*, is withdrawn, and the plate removed; carefully shut up in a box from the light.

The second object of this patent is making the prepared surface more uniform, by passing two plates, with their silvered faces in contact, several times between hardened rollers, annealing them at a low red heat after each passage.

His third object is to use a compound of bromine and iodine, instead of the latter alone, for coating the silver; which increases its sensibility to light, thereby shortening and improving the operation of taking likenesses. He also recommends to use a combination of iodine with nitric acid. Finally, Mr. Beard finds that by placing a screen of any desired color behind the sitter, the appearance of his Daguerrotype portrait is improved. (*Newton's Journal*, xxiii. 112.)

M. A. J. F. Claudet, who had also purchased a license from M. Daguerre, obtained a patent in December, 1841, for certain improvements upon the original process. His first object is to give the front of the camera obscura such an aperture as to admit the largest object-glass intended to be used; and of such he provides a series of different dimensions, each attached to its board, that may be fitted by a slide to the front of the camera.

One of the greatest difficulties in the Daguerrotype process was the impossibility of ascertaining the precise moment at which the light had produced, on the prepared plate, the effect requisite for the vapor of mercury to bring out the image. By applying that vapor to the plate while the silver surface is being acted upon by the light, the operator is enabled to see when his picture is complete. Another advantage of this joint operation is, that the effect of the mercury upon those parts of the plate which have been acted upon by the light, are more perfect when caused to take place immediately under the luminous influence. Hence, instead of using the distinct box with the cup of quicksilver, he places a cup containing that metal in the camera obscura, with its spirit-lamp, and exhales the vapors there. When the mercury has risen to the proper temperature, the aperture of the object-glass is thrown open, and the light, reflected from the object to be delineated, is allowed to operate.

He watches the effect through an opening in the side of the camera, where he views the prepared plate by the light of a lantern passing through a piece of red or orange-colored glass in the (other) side of the camera. Whenever the light and mercury, by their simultaneous action, have produced a good image, the object-glass is covered, and the silver plate, with its picture, removed, in order to be washed and finished. M. Claudet embellishes his Daguerrotype portraits by placing behind the sitter screens of painted scenery, which furnish pleasing back grounds. He specifies also various kinds of artificial illumination, to be used in the absence of solar light. (*Newton's Journal*, C. S. xx. 430.)

According to M. Barnard, Daguerre's iodized plate should be exposed for half a minute to the action of chlorine, mixed with a large proportion of common air; whereby it becomes so sensitive, that the pictorial impression is produced in the short space of time necessary for removing and replacing the screen of the camera. The mercury is afterward employed; as also the hyposulphite wash. Daguerrotype pictures are colored by dusting over them powders of proper hues, which are immediately washed by passing the plate through water. What remains of the color after this ablution does not seem in the least to injure the appearance or alter the form of the image. It would seem that those parts of the picture which were at first black, retain, after being washed, a larger proportion of the coloring matter than the lighter parts.

Several valuable improvements seem to have been made in Vienna upon the Daguerrotype process; and among others, the mode of using *chloriodine*.

The best form of box for applying the chloriodic vapor is square, with its bottom of plate glass, supported a little above the table by feet, a thumb-screw being one of them, in order to give a certain inclination to the glass plate for spreading the chloriodine over it uniformly. A sheet of white paper being laid beneath the box, enables the operator to see whether the liquid chloriodine is properly distributed. There is a groove round the top of the box, into which the ledge of the lid fits tight. A thermometer is placed in the box.

Voigtland's lenses consist of two achromatic object-glasses placed apart; the first nearest the object, having an aperture of 18 lines; the second one of 19 lines; the solar focus of the two is 5¼ inches. A system of lenses of so short a focus with so large apertures affords from 11 to 12 times more illumination than Daguerre's original apparatus did. The finest portraits can be produced in the course of from 10 to 30 seconds with this arrangement. Such an apparatus, elegantly made in brass, costs only 120 gulden, or about 10 guineas.

Voigtland has recently made a camera with two object-glasses, as above arranged, each having an aperture of 37 lines, and a combined focus of 12 inches. By means of this instrument, portraits 5¼ inches in size can be made. The landscapes produced in them are very beautiful. Its price is 144 gulden, about 12 guineas. Along with the above apparatus, a box with a bottom of amalgamated copper is used for applying the vapor of mercury.

By peculiar methods of polishing the silvered copper plate, peculiar tones and tints may be given to the picture. The olive-oil and pumice-powder are indispensable for removing the scratches from the plate and to render its surface uniform. If a delicate blue tone be desired, the plate should be a second time polished with sulphuric ether and washed tripoli; and a third time with dilute nitric acid and Paris red, rubbing the plate lastly with a peace of washleather and crocus. But if a brownish black tone be wished for, a like series of operations is to be gone through, only instead of the ether and tripoli, spirit of ammonia and Vienna lime is to be used.

To give the plate the utmost sensibility to light, a film of iodine should be given in the first place. If with dry iodine, this should be strewed, then covered with cotton, and lastly with a sheet of paper, and the plate above the last, but not so as to touch it. This may be done also with a solution of 1 part of iodine in 6 of spirits of wine, put into a saucer, which is laid on the bottom of the box, and covered with gauze. The plate is to be removed whenever it has acquired a faint brazen tint. By this means the plate receives the impressions of light so well as to produce good contrasts between the white and the dark places. The application of bromine afterward causes a rapid reception of the image, and occasions the deep black shades of an object. The best form is *brome* water, made by dissolving the bromine in a little distilled water, and then adding more, when it is wanted, till the solution acquires a straw-yellow color. A delicate thermometer being put into the box, the solution is to be spread uniformly on its glass bottom, the plate being laid on above and covered up, while the time of exposure must be counted by seconds, with a clock or watch. If the temperature be

41° F.,	the time should be	258 seconds.
50°	———	230 —
59°	———	201 —
68°	———	158 —
77°	———	113 —

By attending to these instructions, exact results may be always obtained.

A second mode of experimenting is with bromiodine; prepared by dissolving 1 part of bromine in an alcoholic solution of 5 parts of iodine; and diluting this mixture with water, till it acquires the color of Bavarian beer. The action of this application upon the plate is so rapid as hardly to leave time for consideration. It must be watched every instant till the dark gold yellow tint appear, when it is ready for the camera.

The best time of day for Daguerrotype operations is from an hour after the sun rises till he comes within 45° of the meridian, and not again till he has passed the meridian by 45°. When the sitting is too long, the parts which should be pure white become of a dirty blue tint, and the dark parts become brown. The picture is burnt, so to speak.

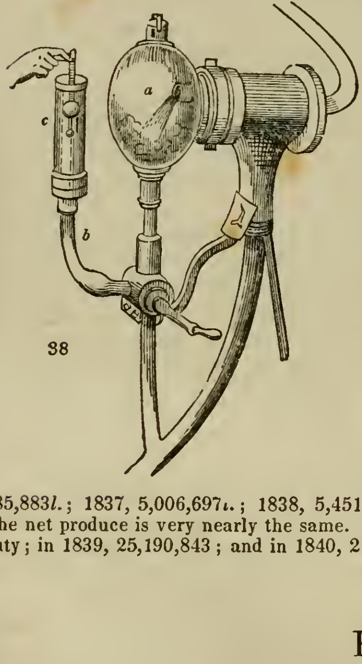
Chloride of gold applied to the picture has the effect of fixing and enlivening the tints. A small grate being fixed by a clamp to the edge of a table, the plate is laid upon it with the image uppermost, and overspread evenly with solution of chloride of gold, by means of a fine broad camel-hair brush, without letting any drop over the edge. A spirit lamp is now brought under the plate, and moved to and fro till a number of small steam bubbles appear upon the image. The spirit lamp must be immediately withdrawn. The remainder of the chloride solution must be poured back into the phial, to be used on another occasion. It is lastly to be washed and examined. This operation has been repeated three or four times with the happiest effect, of giving fixity and force to the picture. It may then be wiped with cotton without injury.

By dusting various pigment powders from small cotton-wool dossils upon the picture, previously coated with an alcoholic solution of copal, and nearly dry, the appearance of a colored miniature has been very successfully imitated. The varnish must be applied delicately with one stroke of a broad brush of badger hair.*

* See Praktische Anweisung znm Daguerrotypiren, Leipzig, &c., 1843.

DEXTRINE. This substance has exactly the same chemical composition as starch, consisting of 24 atoms of carbon, 20 of hydrogen, and 10 of oxygen (Dumas); but it is distinguished from starch by its solubility in cold water, like gum, and not being affected by iodine. British gum, as it is called, or roasted starch, is merely dextrine somewhat discolored; a substance apparently used for the paste on the queen's head post-office letter-stamps. A process discovered by M. Payen, and patented in France by M. Henzé, for making dextrine, consists in moistening one ton of dry starch with water containing 4½ lbs. of strong nitric acid. The starch thus uniformly wetted, is made up into small bricks or loaves, and dried in a stove. It is then rubbed down into a coarse powder, and exposed in a stove-room to a stream of air heated to about 160° F. Being now triturated, sifted, and heated in a stove to about 228° F., it forms a perfect dextrine of a fair color; because the acid acts as a substitute for the higher heat, used in making the British gum. Such an article makes a fine dressing for muslin and silk goods, and is much employed in French surgery, for making a stiff paste-support to the bandages of fractured limbs.

DISTILLATION. *Fig.* 38 represents one form of the worm-safe, which is a contrivance for permitting the distiller to observe and note at any period of the distillation the alcoholic strength or the specific gravity of his spirits, without access to the still or the means of purloining the product before it has paid duty. The nose-pipe of the worm-tub terminates in, and is firmly cemented to the side of the glass globe, *a*, from whose bottom the discharge-pipe descends vertically, but has a stop-cock upon it, and a branch small pipe *b*, turned up parallel to the former. This branch is surmounted with a glass cylinder, *c*, which, when the stop-cock is opened, gets filled with the spirits, and then receives a hydrometer to show the gravity of the fluid. The stop-cock mechanism is so contrived, that only one full of the small glass cylinder can be obtained at a time.



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The following is the gross produce of the excise duties on British distilled spirits for the United Kingdom annually from 1830 to 1840 inclusive: 1831, 5,196,175*l.*; 1832, 5,163,373*l.*; 1833, 5,258,572*l.*; 1834, 5,287,032*l.*; 1835, 5,073,276*l.*; 1836, 5,485,883*l.*; 1837, 5,006,697*l.*; 1838, 5,451,792*l.*; 1839, 5,363,220*l.*; 1840, 5,208,040*l.* The net produce is very nearly the same. In 1838, 26,486,543 millions of gallons paid duty; in 1839, 25,190,843; and in 1840, 21,859,337. See Rum, Spirits, and Still.

E.

ELECTRO-METALLURGY. By this elegant art, perfectly exact copies of any object can be made in copper, silver, gold, and some other metals, through the agency of voltaic electricity. The earliest application of this kind seems to have been practised about ten years ago, by Mr. Bessemer, of Camden Town, London, who deposited a coating of copper on lead castings, so as to produce antique heads in relief, about 3 or 4 inches in size. He contented himself with forming a few such ornaments for his mantel-piece; and though he made no secret of his purpose, he published nothing upon the subject. A letter of the 22d of May, 1839, written by Mr. J. C. Jordan, which appeared in the *Mechanics' Mag*. for *June* 8, following, contains the first printed notice of the manipulation requisite for obtaining electro-metallic casts; and to this gentleman, therefore, the world is indebted for the first discovery of this new and important application of science to the uses of life. It appears that Mr. Jordan had made his experiments in the preceding summer, and having become otherwise busily occupied, did not think of publishing till he observed a vague statement in the journals, that Professor Jacobi, of St. Petersburg, had done something of the same kind. Mr. Jordan's apparatus consisted of a glass tube closed at one extremity with a plug of plaster of Paris, and nearly filled with a solution of sulphate of copper. This tube, and its contents, were immersed in a solution of common salt. A plate of copper was plunged in the cupreous solution, and was connected by means of a wire and solder, with a zinc plate dipped in the brine. A slow electric action was thus established through the moist plaster, and copper was deposited on the metal in a thin plate, corresponding to the former in smoothness and polish; so that when he used an engraved metal matrix, he obtained an impression of it by this electric agency. "On detaching the precipitated metal," says he, "the most delicate and superficial markings, from the fine particles of powder used in polishing to the deeper touches of a needle or graver, exhibited their correspondent impressions in relief with great fidelity. It is, therefore, evident that this principle will admit of improvement, and that casts and moulds may be obtained from any form of copper. This rendered it probable that impressions might be obtained from those other metals having an electro-negative relation to the zinc plate of the battery. With this view a common printing type was substituted for the copper-plate, and treated in the same manner. This, also, was successful; the reduced copper coated that portion of the type immersed in the solution. This, when removed, was found to be a perfect matrix, and might be employed for the purpose of casting, where time is not an object. Casts may probably be obtained from a plaster surface surrounding a plate of copper, &c."

On the 12th of September following the above publication, Mr. Thomas Spencer read a paper "On Voltaic Electricity applied to the purpose of working in Metal," before the Polytechnic Society of Liverpool; which he had intended to present to the British Association at Birmingham in the preceding August, but not being well received there, he exhibited merely some electro-metallic casts which he had prepared. The society published Mr. Spencer's paper, and thereby served to give rapid diffusion to the practice of electro-metallurgy.

One of the most successful cultivators of this art has been Mr. C. V. Walker, secretary to the London Electrical Society. He has published an ingenious little work in two parts, entitled *Electrotype Manipulation*, where he presents, in a lucid manner, the theory and practice of working in metals, by precipitating them from their solutions through the agency of voltaic electricity. His first part is devoted to the explanation of principles, to the preparation of moulds, to the description of the voltaic apparatus to be used, to bronzing, to coating busts with copper, to the multiplication of engraved plates, and to the deposition of other metals.

Fig. 39 represents a single cell voltaic apparatus for electro-metallurgy: *z* is a rod of amalgamated zinc, *m* is the mould on which the metal is to be deposited; *w*, is the wire joining them; *c*, is a strong solution of sulphate of copper in the large vessel; *p*, is a tube or cylinder of porous earthenware, standing in the other, and containing dilute sulphuric acid. The solution of blue vitriol is kept saturated, during the progress of its depositing copper, by piling crystals of the salt upon the shelf, shown by the dots under *p*. The mould to be coated should not be too small in reference to the surface of zinc under voltaic action. The time for the deposition to be effected depends upon the temperature; and is less the higher this is within certain limits; and at a freezing temperature it ceases almost entirely. When a mould of fusible metal is used, it should not be placed in the voltaic apparatus till everything is arranged, otherwise oxide will be deposited upon it, and spoil the effect. When the circuit is completed the mould may be immersed, but not before. Wax moulds are rendered electric conductors, and thereby depositors as follows: After breathing on the wax, rub its surface with a soft brush dipped in plumbago; breathing and rubbing alternately till the surface be uniformly covered. Attach a clean wire to the back of the mould, connecting it by plumbago with the blackened wax. Sealing-wax is coated in like manner. Casts of Paris plaster are first well imbued with melted wax or tallow, and then black-leaded. Objects in Paris plaster should be thoroughly penetrated with hot water, but not wet on the surface, before wax casts are made from them. Moulds are best taken from medals in stearine (stearic acid). For plating and gilding by electro-chemical agency, the following simple plan of apparatus is used. *Fig.* 40 is a rectangular porcelain vessel, which contains in its centre a porous cell for containing the solution of oxide of silver or gold, by means of cyanide of potassium; and this porous cell is surrounded at a little distance by a similarly formed vessel of zinc. The connexion is formed between the zinc and the suspended object to be coated, either by a pinching screw, or by the pressure of its weight upon the wire. The dilute acid which excites the zinc should, in this case, be very weak, in reference to the strength of the cyanide solution, which should be recruited occasionally by the addition of oxide.

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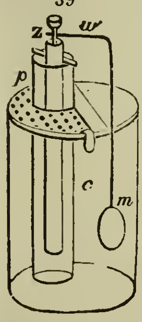
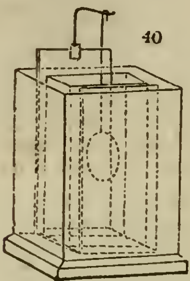
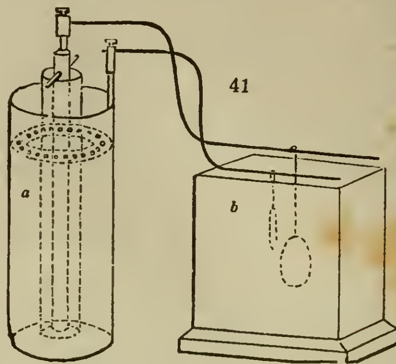


It has been found that with cyanide solutions of gold and silver in the electro-chemical apparatus, the nascent cyanogen at the positive pole or plate, in a decomposition cell, will act upon and dissolve gold and silver. Two or three of Daniell's cylindric cells, as shown at *a* in *fig*. 41, of a pint size, for acting upon solutions of





gold or silver, will in general suffice. The decomposition cell *b* is made of glass or porcelain. The zinc may be amalgamated, and excited with brine; the copper cell contains, as usual, a solution of blue vitriol. To the end of the wire attached to the copper cylinder of the battery, a plate of silver or gold is affixed; and to the end of the wire attached to the zinc cylinder is affixed the mould, or surface, to be plated or gilt. The plates of silver or gold and zinc should be placed face to face as shown in the figure in the decomposition cell; which is filled by the cyanide solution. A certain degree of heat favors the processes of electro-gilding and plating. The surface is dead as first obtained, but it may be easily polished with leather and plate-powder, and burnished in whole or in parts with a steel or agate tool.

In March, 1840, Messrs. Elkington obtained a patent for the use of *prussiate of potash*, as a solvent for the oxides of gold and silver in the electro-chemical apparatus for plating and gilding metals. They also "sometimes employ a solution of protoxide (purple of Cassius) in the muriates of potash, &c." The chemical misnomers, in their specification, are very remarkable, and do great discredit to the person employed to draw it up. Prussiate of potash is the ordinary commercial name of a salt very different from the cyanide of potassium—the substance really meant by the patentees—and the purple of Cassius is very different from protoxide of gold.

In plating or gilding great care must be bestowed in making the articles clean, bright, and perfectly free from the least film of grease. For this purpose, they should be boiled in a solution of caustic alkali, then scoured with sand and water, next dipped into a dilute acid, and finally rinsed with water. A solution of the nitrate or cyanide of mercury may also be used with advantage for cleaning surfaces. The following metals have been deposited by electro-chemistry:—

Gold, platinum, silver, copper, zinc, nickel, antimony, bismuth, cobalt, palladium, cadmium, lead, and tin; of these, the first five are the most important and valuable. The gilding solution may be prepared by placing slips or sheets of gold in a solution of cyanide of potassium, and attaching to the negative pole of a voltaic battery, a small plate of gold, but to the positive pole a much larger one; whereby the latter combines with the cyanogen, under the influence of positive electricity, and forms a solution. Or, oxide of gold, precipitated from the chloride by magnesia, may be dissolved in the solution of the cyanide.

For making copper medals, &c., a plate of amalgamated zinc is to be put into a vessel of unglazed earthenware, or of any other porous substance, filled with dilute sulphuric acid; which vessel is set into a trough of glass, glazed pottery, or pitched wood, containing blue vitriol in the state of solution, as well as in the state of crystals upon a perforated shelf, near the surface of the liquid.

The moulds to be covered with copper are to be attached by a copper wire to the zinc plate. The surface of zinc excited by the acid should be equal to that of the moulds; with which view a piece of zinc, equivalent in size to the mould, should be suspended in front of it.

For depositing copper upon iron, Messrs. Elkington use a solution of ferrocyanide of copper in cyanide of potassium in the decomposition trough, instead of sulphate of copper, neutralized from time to time with a little caustic alkali, as in the common practice of making medals, &c., of copper. I should imagine that the black oxide of copper dissolved in solution of cyanide of potassium would answer better; as the iron in the ferrocyanide might be rather injurious. The iron to be coppered being previously well cleaned from rust, &c., with the aid of a dilute acid, is to be plunged into the cyanide solution heated to 120° Fahrenheit, and connected by a wire with the negative pole of a voltaic battery, as formerly described. In from five to ten minutes, the iron will be completely coated. It is then to be scoured with sand, and plunged into solution of sulphate of copper; whereby it will show black spots wherever there are any defective places. In this case, it is to be cleaned and replaced under the cyanide solution, in the decomposition cell for a minute or two. Zinc may be deposited from a solution of its sulphate by a like arrangement.

Metallic cloth may be made as follows :—On a plate of copper attach quite smoothly a stout linen, cotton, or woollen cloth, and connect the plate, with the negative pole of a voltaic battery; then immerse it in a solution of copper or other metal, connecting a piece of the same metal as that in the solution with the positive pole; decomposition takes place, and the separated metallic particles in their progress toward the metal plate or negative pole, insinuate themselves into the pores of the tissue, and form a complete sheet of flexible metal. Lace is metallized by coating it with plumbago, and then subjecting it to the electro-metallurgic process.

The gilding solution should be used in the electric process at a temperature of 130° F. The more intense the electric power, the denser and harder is the metallic coat deposited.

Metallic silver may be combined with cyanogen by subjecting it to the joint action of a solution of cyanide of potassium and positive electricity. Or cyanide of silver may be precipitated from the nitrate by a little cyanide of potassium, and afterward dissolved by means of an excess of cyanide of potassium. The *quantity* of electric power or surface-size of the battery should in all cases be proportioned to the surface of the articles to be placed or gilt, and the electric intensity or number of sets of jars proportioned to the density of the solution. Plating is accomplished in from 4 to 6 hours. The articles should be weighed before and after this operation, to ascertain how much silver they have taken on.

Messrs. Elkington make their moulds with wax, combined with a little phosphorus, which reduces upon their surfaces a thin film of gold or silver, from solutions of these metals, which films are better than the blackleaded surfaces for receiving the copper deposite. They also recommend to add a little alkali to the solution of sulphate of copper, intended to afford a deposite of metal. The single cell, first described above, is best adapted for this purpose.

M. Ruolz employs for gilding, a solution of sulphuret of gold in sulphuret of potassium, which he prepares by precipitating a solution of gold in *aqua regia*, by sulphuretted hydrogen, and redissolving the precipitate with sulphuret of potassium. By the use of this solution of gold, he obtains a very beautiful and solid gilding, and at less expense than with cyanide of potassium. Every metal which is a negative electrode to gold may be gilded.

Platinizing is effected best by means of a solution of the potash-chloride of platinum in caustic potash. 1 milligramme (0·015 grain) covers completely a surface of 50 square centimeters (2 inches square); the film of platinum is only one hundredth of a milligramme thick.

M. Bœttger has shown that we may easily tin copper and brass in the moist way by dissolving peroxide of tin (putty) in hydrate of potash (caustic potash ley), putting at the bottom of the vessel holding that solution some turnings of tin, setting the piece of copper or brass upon the turnings, and making the liquor boil. An electric current is produced by the contact of the dissimilar metals; and as the tin is withdrawn by the copper or brass from the solution, it is restored to it by the turnings. Zinking may be done in the same way ; by putting pieces of zinc into a concentrated solution of chlorine, by setting the piece of metal to be zinked in contact with these pieces, and applying heat to the vessel containing the whole.

For certain new methods of constructing and arranging voltaic batteries for electro-metallurgic operations, a patent was obtained by Dr. Leeson in June, 1842.

Fig. 42, is a longitudinal section of the battery, and *fig.* 43, a plan view of the frame to which the metal plates are attached. *a* is a rectangular wooden trough, containing a wooden frame *b*, formed with vertical grooves in its sides, to receive a series of porous cells *c*, *c*, *c*. The plates of the battery are suspended in the fluid or fluids by brass forks *d*, *d*, fastened to a wooden frame *e*, *e*, which rests upon the trough *a*, and is connected to the other frame *b*, by two pins *f*, when they are required to be raised together out of the trough *a*, *a*.

The battery may be charged as usual with one or two fluids; one of them in the latter case being contained in the porous cells *c, c, c*; and plates of copper and zinc, or any other suitable metals, may be employed.

The second improvement consists in cleaning copper and zinc plates after they have been used in a battery, by the employment of a voltaic battery; and also in amalgamating or coating with mercury the surfaces of zinc plates, by the same means to render them suitable for being used in the construction of the voltaic apparatus.

The third improvement consists in exciting electricity by a combination of nitric, sulphuric, or muriatic acid, with any of the following substances; viz., impure ammoniacal or lime liquor of the gas works, solutions of alkaline and earthy sulphurets, the alkalies and their carbonates, or lastly the acidulous sulphate of iron generated from iron pyrites.

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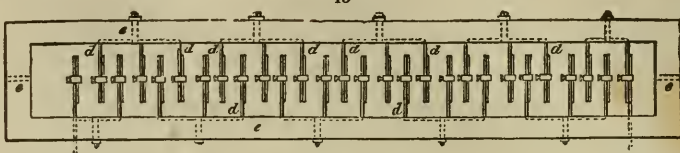

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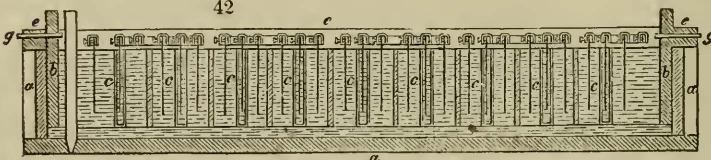

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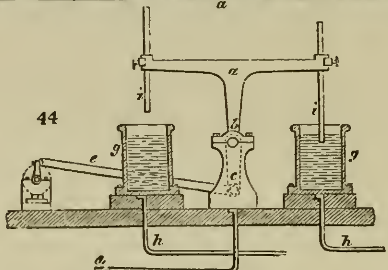


Another of Dr. Leeson's manifold improvements is for depositing metallic alloys, consists in the employment of one battery, with the "alternating cathode," represented in *fig.* 44. It is composed of a beam, *a*, mounted on the shaft, *b*, which turns in bearings carried by standards, *c;* the beam communicates with the anode of the battery by the wire, *d*, and a vibrating motion is given to it by the rod, *e*, from the shaft, *f*, which is driven by an electro-magnetic engine, or any other suitable prime mover. *g, g*, are two vessels containing mercury, connected by wires, *h, h*, with the cathode plates of the two metals composing the alloy (but if the alloy is to consist of more than two metals, then more vessels, *g*, will be required, for one each cathode plate); these plates are immersed in a solution composed of similar salts of the different metals to be deposited, together with the anode, or surface to be deposited upon, which is connected by a wire with the cathode of the battery. A communication is established between the two cathode plates, or supply metals, and the anode of the battery, by means of the rods, *i, i*, which are caused, by the vibration of the beam, *a*, to dip alternately into either the one or the other of the vessels, *g;* and thus each metal will be deposited on the article to be coated, during the time that the connexion is established between it and the battery, by the immersion of its rod into the vessel of mercury. The relative proportions of the two metals is adjusted by lengthening or shortening the rods, *i, i*, as shown in the figure, so that they may be immersed for a longer or shorter period in the mercury.

Where the electrical current enters the electrolyte, is the *anode;* where it leaves it, is the *cathode.*

The patentee describes ten other improvements, which seem to be ingenious. See *Newton's Journal*, xxii. 292.

ELEMENTS, CHEMICAL. The catalogue given in the Dictionary has been augmented by four new bodies; *Lanthanium, Didymium,* from Cerium; *Erbium* and *Terbium,* from Yttria.

ELVAN. The name given by the Cornish miners to porphyry, as also to the heterogeneous rocky masses which occur in the granite or in the clay slate, deranging the direction of their metallic veins, or even the mineral strata: but elvan generally indicates a felspar porphyry.

EMBOSSING OF LEATHER. Beautiful ornaments in basso-relievo for decorating the exteriors or interiors of buildings, medallions, picture-frames, cabinet-work, &c., have been recently made by the pressure of metallic blocks and dies, for which invention a patent was obtained in June, 1839, by M. Claude Schroth. The dies are made of type-metal, or of the fusible alloy with bismuth, called d'Arcet's. The leather is beaten soft in water, then wrung, pressed, rolled, and fulled as it were, by working it with the hands till it becomes thicker and quite supple. In this state it is laid on the mould, and forced into all its cavities by means of a wooden, bone, or copper tool. In other cases, the embossing is performed by the force of a press. The leather, when it has become dry, is easily taken off the mould, however deeply it may be inserted into its crevices, by virtue of its elasticity. A full detail of all the processes is given in *Newton's Journal*, vol. xxii., p. 122.

ENAMELLING *of Cast Iron and other Hollow Ware for Saucepans, &c.* In December, 1799, a patent was obtained for this process by Dr. Samuel Sandy Hickling. His specification is subdivided into two parts:—

1. The coating or lining of iron vessels, &c., by fusion with a vitrifiable mixture, composed of 6 parts of calcined flints, 2 parts of *composition* or Cornish stone, 9 parts of litharge, 6 parts of borax, 1 part of argillaceous earth, 1 part of nitre, 6 parts of calx of tin, and 1 part of purified potash. Or, 2dly,

8 parts of calcined flints, 8 red lead, 6 borax, 5 calx of tin, and 1 of nitre. Or, 3dly,

12 of potter's composition, 8 borax, 10 white lead, 2 nitre, 1 white marble calcined, 1 argillaceous earth, 2 purified potash, and 5 of calx of tin. Or, 4thly,

4 parts calcined flint, 1 potter's composition, 2 nitre, 8 borax, 1 white marble calcined, $\frac{1}{2}$ argillaceous earth, and 2 calx of tin.

Whichever of the above compositions is taken, must be finely powdered, mixed, fused; the vitreous mass is to be ground when cold, sifted, and levigated with water. It is then made into a pap with water or gum-water. This pap is smeared or brushed over the interior of the vessel, dried, and fused with a proper heat in a muffle.

Calcined bones are also proposed as an ingredient of the flux.

The fusibility of the vitreous compounds is to vary according to the heat to be applied to the vessel, by using various proportions of the siliceous and fluxing materials. Colors may be given, and also gilding.

The second part or process in his specification describes certain alloys of iron and nickel, which he casts into vessels, and lines or coats them with copper precipitated from its saline solutions. It also describes a mode of giving the precipitated copper a brassy surface by acting upon it with an amalgum of zinc with the aid of heat.

A factory of such enamelled hollow wares was carried on for some time, but it was given up for want of due encouragement.

A patent was granted to Thomas and Charles Clarke on the 25th of May, 1839, for a method of enamelling or coating the internal surfaces of iron pots and saucepans, in such a way as shall prevent the enamel from cracking or splitting off from the effects of fire. The specification prescribes the vessel to be first cleansed by exposing it to the action of dilute sulphuric acid (sensibly sour to the taste) for three or four hours, then boiling the vessel in pure water for a short time, and next applying the composition. This consists of 100 lbs. of calcined ground flints; 50 lbs. of borax calcined, and finely ground with the above. That mixture is to be fused and gradually cooled.

40 lbs. weight of the above product is to be taken with 5 lbs. weight of potter's clay; to be ground together in water until the mixture forms a pasty-consistenced mass, which will leave or form a coat on the inner surface of the vessel about one sixth of an inch thick. When this coat is set, by placing the vessel in a warm room, the second composition is to be applied. This consists of 125 lbs. of white glass (without lead), 25 lbs. of borax, 20 lbs. of soda (crystals), all pulverized together and vitrified by fusion, then ground, cooled in water, and dried. To 45 lbs. of that mixture, 1 lb. of soda is to be added, the whole mixed together in hot water, and when dry, pounded; then sifted finely and evenly over the internal surface of the vessel previously covered with the first coating or composition, while this is still moist. This is the glazing. The vessel thus prepared is to be put into a stove, and dried at the temperature of 212° F. It is then heated in a kiln or muffle, like that used for glazing china. The kiln being brought to its full heat, the vessel is placed first at its mouth to heat it gradually, and then put into the interior of the fusion of the glaze. In practice it has been found advantageous also to dust the glaze powder over the fused glaze, and apply a second fluxing heat in the oven. The enamel, by this double application, becomes much smoother and sounder.

Messrs. Kenrick of West Bromwich having produced in their factory and sent into the market some excellent specimens of enamelled saucepans of cast iron, were sued by Messrs. Clarke for an invasion of their patent rights; but after a long litigation in chancery, the patentees were nonsuited in the court of exchequer. The previous process of cleansing with dilute sulphuric acid appeared by the evidence on the trial to have been given up by the patentees, and it was also shown by their own principal scientific witness that a good enamelled iron saucepan could be made by Hickling's specification. In fact, the formulæ by which a good enamel may be compounded are almost innumerable; so that a patent for such a purpose seems to be untenable, or at least most easily evaded. I have exposed the finely-enamelled saucepans of Messrs. Kenrick to very severe trials, having fused even chloride of calcium in them, and have found them to stand the fire very perfectly without chipping or cracking. I consider such a manufacture to be one of the greatest improvements recently introduced into domestic economy; such vessels being remarkably clean, salubrious, and adapted to the most delicate culinary operations of boiling, stewing, making of jellies, preserves, &c. They are also admirably fitted for preparing pharmaceutical decoctions, and ordinary extracts.

The enamel of the said saucepans is quite free from lead, in consequence of the glass which enters into its composition being quite free from that metal. In several of the saucepans which were at first sent into the market by Messrs. Clarke, their enamel was found on analysis by several chemists to contain a notable proportion of oxide of lead. In consequence of the quantity of borax and soda in the glaze, this oxide was so readily acted upon by acids, that sugar of lead was formed by digesting vinegar in them with a gentle heat. The presence of this noxious metal formed, in my opinion, a legitimate ground for contesting the patent, being in direct violation of the terms of the specification. Messrs. Kenwick's wares have been always free from this deleterious metal. Messrs. Clarke, I understand, have for some time been careful to reject from their enamel-composition all glass which contains lead; and they now manufacture also wholesome enamelled ware. Thus the public have profited in a most important point by the aforesaid litigation.

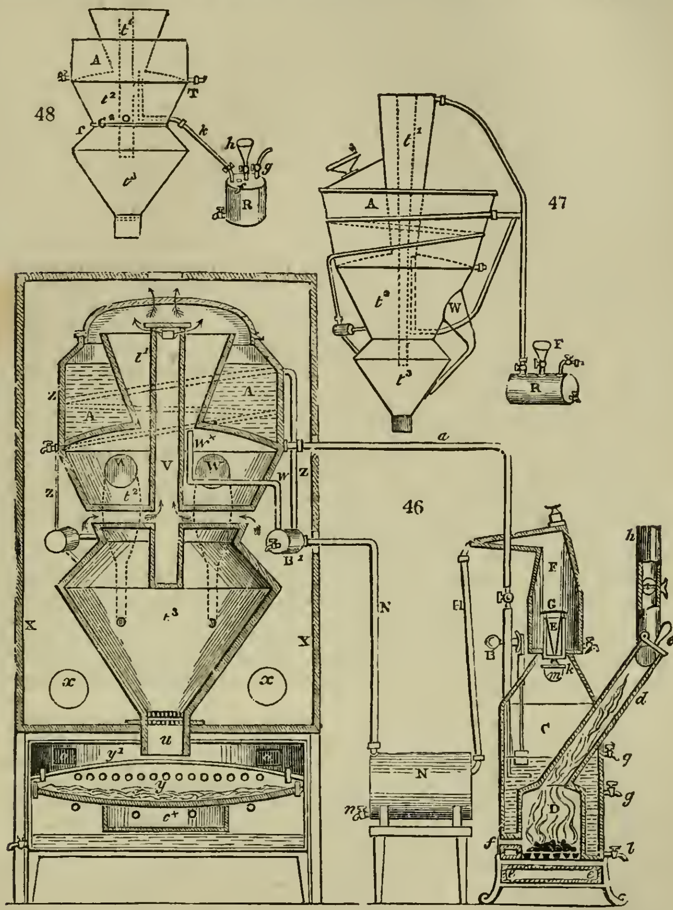
Enamelled iron saucepans had been many years ago imported from Germany, and sold in London. I had occasion to analyze their enamel, and found to my surprise that it contains abundance of litharge or oxide of lead. The Prussian government has issued an edict prohibiting the use of lead in the enamelling of saucepans, which are so extensively manufactured in Peiz, Gleiwitz, &c. Probably the German ware sent to England was fabricated for exportation, with an enamel made to flux easily by a dose of litharge. The composition of the said enamel is nearly the same with that which I found upon some of the earlier saucepans of Messrs. Clarke. Had their patent been sustained, the important legal question would have arisen, whether it gave the patentees the power of preventing dealers from continuing to sell what they had been habitually doing for a great many years.

A suitable oven or muffle for lining or coating metals with enamel may have the following dimensions:—

The outside, 8 feet square, with 14-inch walls; the interior muffle, 4 feet square at bottom, rising 6 inches at the sides, and then arched over; the crown may be 18 inches high from the floor: the muffle should be built of fire-brick, $2\frac{1}{2}$ inches thick. Another arch is turned over the first one, which second arch is 7 inches wider at the bottom, and 4 inches higher at the top. A 9-inch wall under the bottom of the muffle at its centre divides the fireplaces into two, of 16 inches width each, and 3 feet 3 inches long. The flame of the fire plays between the two arches and up through a 3-inch flue in front, and issues from the top of the arch through three holes, about 4 inches square; these open into a flue, $10 + 9$ inches, which runs into the chimney.

The materials for the enamel body (ground flint, potter's clay, and borax) are first mixed together and then put into a reverberatory furnace, 6 feet 6 inches long, by 3 feet 4 wide, and 12 inches high. The flame from an 18-inch fireplace passes over the hearth. The materials are spread over the floor of the oven, about 6 inches thick, and ignited or fritted for four or five hours, until they begin to heave and work like yeast, when another coating is put on the top, also 6 inches thick, and fired again, and so on the whole day. If it be fired too much, it becemes hard and too refractory to work in the muffles. The glaze is worked in an oven similar to the above. It may be composed of about one half borax and one half of Cornish stone in a yellowish powder procured from the potteries. This is fritted for 10 hours, and then fused into a glass which is ground up for the glaze.

EVAPORATION. For the following scheme of generating, purifying, and condensing steam, Mr. Charles Clark, merchant, London, obtained a patent in January, 1843. His apparatus for converting sea-water, &c., economically into good fresh water, is represented in *figs.* 46, 47, 48. A is the supply-cistern, which communicates with a pipe *a*, with a self-regulating eduction apparatus B. C is a strong wrought iron cylinder, fitted at bottom into a flanged ring-place, *c*, and covered with a conical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top; it is about two thirds filled with the water, to be operated upon. D is a cylindrical furnace concentric with the water cylinder C; *d* is an upward air and water-tight tube, which serves both as a feed-pipe, through which the fuel is supplied to the furnace, and as a passage for the escape of the smoke, and other gaseous products of combustion; *e* is a hinged trap door through which the fuel is passed into the tube *d*; *h* is a chimney into which the pipe *d* terminates; and *i*, a damper, by which the degree of activity given to the furnace can be regulated at pleasure; *f* is an open air pipe; which leads from the outside, through the boiler into the furnace, a little way above the fire bars, and assists in securing a good draught through the furnace into the chimney. To the water cylinder C there are attached gauge-cocks, *g g*, for ascertaining from time to time the height of the water; *l* is a cock or tap for drawing off the brine, and other residual matters which collect at the bottom of the boiler; *m* is a screw-cap and hole, through which access may be had to the interior of the water cylinder C, when it needs to be cleaned; E is a short pipe fitted into the conical top of the water cylinder C, which conveys the steam generated in it, into the steam-head or receiver F; G is a concave plate, resting upon the top of the pipe E, a little larger than that pipe, and kept steady by a weight, *k*, of one or more pounds, suspended from it by wires. This plate prevents, in a great measure, the escape water escaping into the steam-head (an accident commonly called *priming* in steam engines; because, till the steam has acquired a pressure exceeding that of the counterweight *k*, it can not raise the weight G, so as to escape freely into the steam-head F, since any particle of water must, during the rising of the cap G, strike against it, and drop back, either into the water cylinder C, through the pipe E, or into the space round that pipe at the bottom of the steam-head F; whence it may be withdrawn by the cock shown in the drawing. H is a pipe which conveys the steam from the steam-head F to the rectifier R. This consists simply of a cylinder (about one third the size of the cylinder C) laid horizontally, in the lower part of which a body of water speedily collects, and serves to retain any particle of undecomposed matter, which may come over with the steam, as it continues to flow in from the boiler; whereby only its purer portions may pass off from the rectifier R, by the pipe N. *n* is a cock or tap, at the bottom of the cylinder R for drawing off its water occasionally; R^1 is a second steam-rectifier, like R, into which the steam passes from the pipe N, and is thereby still further purified; but when the proportion of saline matter is small, R' may be dispensed with, and for very foul water, two or three more such rectifiers may be added.

The condenser for liquefying the purified steam, and *aerating* the resulting water, is shown at t^1, t^2, t^3. It is composed of conical upright compartments communicating with each other; the chamber t^1 is surrounded by the water in the cistern A (slightly heated by the steam in that chamber), while the chambers t^2 and t^3 are exposed freely to the air. The lowest of these, t^3, terminates at bottom in a tube, *u*, containing at the mouth of the cone two or three plates of perforated zinc, for admission of the atmosphere. An upright steam-tight tube of zinc, at about the middle of the lowest chamber, t^3, and is continued to the top of the uppermost chamber, t^1, having two lateral branches. This tube is closed at its lower end, but open at top, and at the ends of the two branches, to give a draught of cool air into the tube, and a rapid flow of heated air from the top of the tube. W, W, are pipes which pass externally from about the middle of the chamber t^2, to near the bottom of the chamber t^3. At their tops they are of large dimensions, as represented, but diminish gradually to small pipes at bottom. Of these pipes, there should be as many as can be conveniently applied, in order that the process of condensation may be effectually promoted.

From the second rectifier, R^1, the steam is conveyed by a pipe, *w*, of gradually increasing dimensions, to near the top of the middle chamber, *t*, whence it diffuses itself through the three chambers, where it gets condensed. The hottest steam passes into t^1, and is there most powerfully condensed. The main body of the water produced therefrom, either drops directly into the bottom of the chamber t^3, or runs down the inclined sides of the chambers t^1, t^2, t^3, thence through the outer pipes W, W, and out at the bottom of the tube, getting partially aerated in its progress, by means of the air ascending constantly through the tube *u*.

Z, Z, is an auxiliar steam-pipe from the rectifier R^1, passing twice or thrice close round the water supplying the cistern, A, and terminating in a cylinder which communicates by pipes with the chambers, t^2 and t^3; whereby all the water thus condensed may fall through the perforated zinc plates, into the general discharge tube, *u*. X is an outer casing of wood or metal, leaving a small space round the condenser, with draught-holes, *x*, *x*, for the admission of air. The refrigerator is made of protected metal (" tinned copper ?") and divided into three compartments, y^1, y^2, y^3.

In the top of y^1, the end of the discharged tube *u* is inserted; and at a little distance from this tube there are air apertures, *a*, *a*, furnished with shutters in the inside, slanting from the top downward, to prevent as much as possible the escape outward of any vapor which may occasionally be carried down with the water from the condenser. The middle compartment, y^2, is perforated, convex at top, and concave at bottom; so that the water that drops from the tube *u*, in the convex top of y^2, falls off laterally through small pipes into the chamber y^2, while its concave bottom turns the water into a central filtering-box, *c*, that projects a little into y^3, set to receive it. For aerating this water, the bottom of y^2 is covered about an inch deep with small pebbles. y^3, which is the reservoir of the purified cool water, is perforated with small holes. c^1, c^1, are small pipes for promoting a continual upward flow of cold air. y^3 is furnished with a tap to draw off its water, as required.

For redistilling or rectifying spirituous liquids, the apparatus, *fig.* 47, is employed; in which the supply cistern A is much larger, and close at top; the upper condensing chambers, t^1, t^2, are also larger, but the lowest, t^3, is narrowed. The second rectifier of *fig.* 46, is removed. The feints collect in the bottom of the rectifier R, to be drawn off by a cock; while the rectified spirit passes off at top into the condenser. The refrigerator has only two compartments, and no pebbles. F is a funnel into which the spirits may be returned for redistillation.

For extracting the soluble matter of vegetable infusions, the apparatus, shown in *fig.* 48, is used. The rectifier is vertical, has a screw-capped hand-hold, *f*, for admitting the vegetables. g is a steam-pipe; and *h* is a funnel for returning portions of the liquid extract. R is connected by a pipe, *k*, with the condenser, T, made in two portions, fitted water-tight together, but separable for the purpose of cleansing. The steam which passes from the boiler into the rectifier R disengages the soluble portion of the vegetable substances, and, if they be volatile, carries them off to the condenser; if not, it combines and falls with them to the bottom of the vessel, whence this portion of the extract is drawn off by the cock, and a fresh charge may be introduced. The steam is shut off from the rectifier R by a cock on the pipe *g*. When the steam is afterward admitted to assist the process of maceration, the supply of it is regulated by the stop-cocks in the pipes *g* and *k*.—*Newton's Journal*, xxiii. p. 247, C. S.

EXTRACTS. These preparations of vegetables for medicinal use are made either by evaporating the infusions of the dried plant in water, or in alcohol, or the expressed juice of the fresh plant; and this evaporation may be effected by a naked fire, a sand bath, an air bath, a steam heat, or a liquid *balneum* of any nature, all of which may be carried on either in the open air, or *in vacuo*. Of late years, since the vacuum-pan has been so successfully employed in concentrating syrups in sugar-houses, the same system has been adopted for making pharmaceutical extracts. An elegant apparatus of this kind, invented by Mr. Barry of Plough Court, was made the subject of a patent about 25 years ago. The use of the air-pump for evaporating such chemical substances as are readily injured by heat, has been very common since Professor Leslie's discovery of the efficacy of the combined influence of rarified air, and an absorbing surface of sulphuric acid, in evaporating water at low temperatures. It has been supposed that the virtues of narcotic plants in particular might be better obtained and preserved, by evaporation in vacuo than otherwise, as the decomposing agency of heat and atmospheric oxygen would be thereby excluded. There is no doubt that extracts thus made from the expressed juices of fresh vegetables, possess, for some time at least, the green aspect and odor of the plants in far greater perfection than those usually made in the air, with the aid of artificial heat. Dr. Meurer, in the *Archiv. der Pharmacie* for April, 1843, has endeavored to show that the color and odor are of no value in determining the value of extracts of narcotics, that the albumen left unchanged in the extracts made in vacuo, tends to cause their spontaneous decomposition, and that the extracts made with the aid of alcohol, as is the practice in Germany, are more efficacious at first, and much less apt to be injured by keeping. M. Baldenius has, in the same number of the *Archiv.*, detailed experiments to prove that the juices of recent plants mixed with alcohol, in the homœopathic fashion, are very liable to spontaneous decomposition. To the above expressed juice, the Germans add the alcoholic tincture of the residuary vegetable matter, and evaporating both together, with filtration, prepare very powerful extracts.

F.

FATS. The following statement is given on the authority of Braconnot:—

	Oleine.	Stearine.
Fresh butter in summer - -	60	40
——— in winter - -	37	63
Hog's Lard - - - -	62	38
Ox Marrow - - - -	24	76
Goose Fat - - - -	68	32
Duck Fat - - - -	72	28
Ox Tallow - - - -	25	75
Mutton Suet - - - -	26	74

M. Dumas says that butter contains no stearine. The purification and decoloration of fats has been the object of many patents. Under CANDLE, Hempel's process for refining palm-oil and extracting its *margarine* is described.

About 30 years ago, palm-oil was deprived of color to a certain degree by mixing with the melted oil, previously freed from its impurities by filtration, some dilute nitric acid, wooden vessels being used, and the oil being in a melted state. This process was both expensive and imperfect. More lately whitening has been prescribed by means of chromic acid, which, in the act of decomposition into chromic oxide, gives out oxygen, and thereby destroys vegetable colors. One pound of bichromate of potash in solution is to be mixed with two pounds of strong sulphuric acid, diluted beforehand with about two gallons of water; and this mixture is to be incorporated by diligent stirring with 2 cwt. of the filtered palm-oil, at a temperature of about 100° F., contained in a wooden vessel. The palm-oil is afterward to be washed in warm lime-water, to which some solution of chloride of lime may be advantageously added. By this process, well managed, a fat may be obtained from palm-oil fit for making white soap. Tallow may be also blanched to a considerable degree by a like operation.

Instead of sulphuric acid, the muriatic may be used to convert the chromic acid into chromic oxide in the above process, and thereby to liberate the blanching oxygen. The resulting solution of green muriate of chrome being freed from some adhering oil, is to be mixed with so much milk of lime as just to neutralize the excess of acid that may be present. The clear green muriate is then to be decomposed in a separate vessel, by the addition of well-slaked and sifted lime, in some excess. The green mixture of lime and chrome-oxide is now to be dried, and gently ignited, whereby it is converted into yellow chromate of lime, with some unsaturated lime. This compound being decomposed by dilute sulphuric acid, affords chromic acid, to be applied again in the decoloring of palm-oil, on the principles above explained.

Mr. Prynne obtained a patent in March, 1840, for purifying tallow for the candle-maker, by heating it along with a solution of carbonate of potash or soda for 8 hours, letting the whole cool, removing the tallow to another vessel, heating it by means of steam up to 206° F., along with dry carbonate of potash (pearlash): letting this mixture cool very slowly; and finally removing the tallow to a vessel enclosed in steam, so as to expel any subsidiary moisture.—*Newton's Journal*, xxi. 258.

A patent for a like purpose was obtained in June, 1842, by Mr. H. H. Watson. He avails himself of the blanching power of oxygen, as evolved from manganate of potash (chameleon mineral), in the act of its decomposition by acids, while in contact with the melted fat. He prescribes a leaden vessel (a well-joined wooden tub will also serve) for operating upon the melted tallow, with one twentieth of its weight of the manganate, dissolved in water, and acidulated to the taste. The whole are to be well mixed, and gradually heated from 150° up to 212° F., and maintained at that temperature for an hour. On account of the tendency of the dissolved manganate to spontaneous decomposition, it should be added to the dilute acid, mixed with the fat previously melted at the lowest temperature consistent with its fluidity.

Palm-oil may be well blanched in the course of 12 hours by heat alone; if it be exposed in a layer of one or two inches to the air and sunshine, upon the surface of water kept up at nearly the boiling point by a coil of steam-pipes laid in the bottom of a square cistern of lead or wood, well jointed.

Tallow imported for home consumption in 1839, 1,148,192 cwt.; in 1840, 1,131,513. Duty, 3*s.* 2*d.* per cwt.

FELTED CLOTH. This woollen fabric, made without spinning and weaving, was made the subject of a patent by Mr. T. R. Williams in February, 1840. A copious description of the process is given in *Newton's Journal*, xxii. 1.

Varnished or Japanned Felt is made by imbuing the stuff of coarse hat-bodies with drying oil, prepared by boiling 50 lbs. of linseed oil with white lead, litharge, and umber, of each one pound. The felt is to be dried in a stove, and then polished by pumice-stone. Five or six coats of oil are required. The surface is at last varnished. When the object is intended to be stiff, like visors, the fabric is to be impregnated first of all with flour-paste, then stove-dried, cut into the desired shape, next imbued with the drying-oil, and pumiced repeatedly; lastly placed, to the number of 20, in a hot iron mould, and exposed to strong pressure. Japanned hats, made in this way, are sold in France at 1*s.* 3*d.* a piece; and they will stand several years' wear.

FERMENTATION. This term has been of late extended to several chemical operations, besides those formerly included under it. The phenomena which it exhibits under these different phases, and the changes which it effects among the various subjects of its operation, are no less striking and mysterious in their principle than important in their applications to the arts of life. Fermentations are now arranged into twelve classes—1, the alcoholic; 2, the glucosic or saccharine; 3, the viscous or mucous; 4, the lactic; 5, the acetic; 6, the gallic; 7, the pectic; 8, the benzoilic; 9, the sinapic; 10, the ammoniacal; 11, the putrid; and 12, the fatty.

Fermentation, in the most general sense, may be defined to be a spontaneous reaction, a chemical metamorphosis, excited in a mass of organic matter, by the mere presence of another substance, which neither abstracts from nor gives to the matter which it decomposes anything whatever. This process requires the following conditions: 1, A temperature from 45° to 90° F.; 2, Water; 3, The contact of air; 4, The presence of a neutral organic azotised matter, in very small quantity, and of a crystallizable non-azotised substance in considerable quantity. The former is the ferment, the latter undergoes fermentation. In ordinary chemical actions we perceive one body unite to another to form a new compound; or one body turn another out of a combination, and take its place, in virtue of a superior affinity. The effects are foreseen and explained by the intervention of that molecular force which governs all chemical operations, that attractive power which unites the particles of dissimilar bodies. Thus, also, in the ordinary phenomena of decomposition, we perceive the agency of heat at one time, at another of light, or of electricity; forces of which, though we are not acquainted with the essence, yet we know the exact effect under determinate circumstances. But fermentation, on the contrary, can be explained neither by the known laws of chemical affinity nor by the intervention of the powers of light, electricity, or heat. Fermentation reduces complex organic substances to simpler compounds, thereby reducing them nearer to the constitution of mineral nature. It is an operation analogous, in some respects, to that effected by animals upon their vegetable food.

With a good microscope, any person may convince himself that ferment or yeast is an organized matter, formed entirely of globules, or of corpuscles slightly ovoid, from the three to the four thousandth part of an inch in diameter. Sometimes their surface seems to have a little tail, which has been regarded as a bud or germ attached to the mother cell. Whenever the fermentation begins, the yeast does not remain an instant idle. These small round bodies become agitated in all directions, and if the substance undergoing fermentation is mixed with an azotized matter, as in beer-worts, the corpuscles become larger, the small tails get developed, and on acquiring a certain size they separate from the parent globule, to live by themselves and give birth to new corpuscles.* In the fermentation of beer from malt, this series of multiplications produces a quantity of yeast seven times greater than what was added at the commencement. Were the above ingenious speculations demonstrated with certainty, we should be led to admit, in all these phenomena, actions truly vital, and a reproduction like that of buds in the vegetable kingdom. The existence of a vital force seems to be rendered probable by the fact that in incomplete fermentation, such as that of fine syrup with too little yeast, the ferment loses its properties and powers. If, however, we add to the solution of pure sugar an albuminous substance, a caseous or fleshy matter, the development of yeast becomes manifest, and an additional quantity of it is found at the end of the operation. Thus with nourishment, ferment engenders ferment. It is for this reason that a little fermenting must, added to a body of fresh grape-juice, excites fermentation in the whole mass. These effects are not confined to alcoholic fermentation. The smallest portions of sour milk, of sour dough, or sour juice of beet-root, of putrefied flesh or blood, occasion like alterations in fresh milk, dough, juice of beet-roots, flesh, and blood. But further, and which is a very curious circumstance, if we put into a liquid containing any fermenting substance, another in a sound state, the latter would suffer decomposition under the influence of the former. If we place urea in presence of beer-yeast, it experiences no change; while if we add to it sugar-water in a fermenting state, the urea is converted into carbonate of ammonia. We thus possess two modes of decomposition, the one direct, the other indirect.

Although yeast has all the appearances of an organized substance, it is merely by analogy that its multiplication by growth is assumed, for this is a phenomenon very difficult of experimental demonstration. When blood, cerebral substance, gall, pus, and such like substances, in a putrid state, are laid upon fresh wounds in animals, vomiting, debility, and death, soon supervene. The scratches from bones in putrid bodies have been often the causes of disease and death to anatomists. The poison in bad sausages is of the same class of ferments. In Wurtemberg, where sausages are prepared from very miscellaneous matters, as blood, livers, brains, and offal of many other kinds, with bread, meal, salt, and spices, fatal results from eating them are not uncommon. Death in these cases is preceded by the gradual wasting of the muscular fibre, and of all the like constituents of the human body; so that the patient becomes emaciated, dries into a complete mummy, and soon expires. The cadaver is stiff as if frozen, and is not subject to putrefaction. During the progress of the *sausage* disease, the saliva becomes viscid, and emits an offensive smell. No peculiar poison can be detected by analysis in the sausages; but they are rendered wholesome food for animals by the action of alcohol, or by that of boiling water, which destroy the noxious *fomes* without acquiring it themselves; and thus decompose the putrefactive ferment of the sausages. When this, however, passes unchanged through the stomach into the circulating system, it imparts its peculiar action to the constituents of the blood, operating upon it as yeast does upon wort. Poisons of a like kind are produced by the body itself in some diseases. In plague, small-pox, measles, &c., substances of a peculiar fermentative nature are generated from the blood, which are capable of inducing in the blood of a healthy person a decomposition like that of which themselves are the subjects. The morbid virus reproduces itself, and multiplies indefinitely, just as the particles of yeast do in the fermentation of beer. The temperature of boiling water, and alcohol applied to matters imbued with such poisonous secretions, render their poison inert. Many

* M. Turpin, M. Cagniard Latour, M. Quévenne, and Professor Mitscherlich.

acids, chlorine, iodine, bromine, empyreumatic oils, smoke, creosote, strong decoction of coffee, have the same salutary effect. All these agents are known to counteract fermentation, putrefaction, and that dry wasting of organic matter called *eremacausis*, or *slow combustion*. It is most deserving of remark that the poisons chemically neutral or alkaline, such as those of small-pox in man, and of *typhus ruminantium* in cows, lose their baneful power when subjected to the action of the stomach; whereas that of bad sausages, which is acid, resists the modifying power of the digestive organs.

Alcoholic fermentation has been copiously discussed in the *Dictionary*. I may here add that ammonia, being a product of that change in solution of pure sugar, proves the presence of azote in the yeast; and that sulphuretted hydrogen, being made manifest in the disengaged gaseous products, by their blackening paper imbued with acetate of lead, proves the presence of sulphur. The acid liquor accompanying yeast may be washed away, without impairing materially its fermenting power, while the acid so removed has of itself no such virtue.

Yeast, freed from all soluble matters by water, alcohol, and ether, contains, independently of ashes—carbon, 50·6; hydrogen, 7·3; azote, 15; oxygen, sulphur, and phosphorous, 27·1, in 100 parts. Viewed atomically, yeast bears a close analogy to albumen. Like albuminous matter, yeast takes a violet tint with muriatic acid, and it may be replaced as ferment by gluten. Caseum (the curd of milk) and flesh operate the same effect. All these fermentative powers have the same globular appearance in the microscope with yeast. When the activity of yeast has been destroyed by heat, &c., it can be restored by the positive energy of the voltaic battery, which causes its combination with oxygen. The best proportion of sugar and water, for exhibiting the phenomena of fermentation, is 1 of the former to 3 or 4 of the latter, and 5 parts of sugar to 1 of fresh yeast may be added; though in the course of fermentation, 100 parts of sugar do not consume 2 parts of yeast, estimated in the dry state. The quickest fermenting temperature is from 68° to 86°. A very little oil of turpentine or creosote, or of the mineral acids, prevents or stops fermentation completely; oxalic and prussic acids have the same effect, as also corrosive sublimate and verdigris. It has been known from time immemorial in Burgundy, that a little red precipitate of mercury, when added to the must-tun, stopped the fermentation. All alkalies counteract fermentation, but when they are saturated it recommences. The first person who described the microscopic globules of yeast with precision was Désmazières, who arranged them among the mycodermes (*fungus-skinned*), under the name of *mycoderma cerevisiæ*. They have not the flattened form of the globules of blood, but are rather egg-shaped. One small black point may be seen on their surface, which, after some days, is associated with 3, 4, or 5 others. Their average diameter is from $\frac{1}{5000}$ to $\frac{1}{4000}$ of an inch. Sometimes more minute globules cluster round one of ordinary size, and whirl about with it, when the liquor in which the globules float is agitated.

Fresh yeast loses, by drying, 68 parts in the 100, and becomes solid, horny-looking, and semitransparent, breaking readily into gray or reddish fragments. With water, it resumes immediately its pristine appearance. When fresh yeast is triturated with its own weight of white sugar, it forms a liquid possessing the fluidity of oil of almonds, and a yellow color. The globules continue unchanged, except perhaps becoming somewhat smaller. Yeast in the dry state retains its fermentative virtue for a long time.

Saccharine Fermentation is that by which starch and dextrine are converted into sugar, as shown remarkably in the action of diastase upon these bodies. If we mix 2 parts of starch paste with 1 part of dry gluten, and keep the mixture at a temperature of from 122° to 140° Fahr., we obtain a good deal of sugar and dextrine. Some lactic acid is also formed. Flour paste, long kept, spontaneously produces sugar by a like reaction. *See* FERMENTATION in the Dictionary.

Lactic Fermentation.—Almost all azotized organic matters, after being modified by the contact of air, become capable of giving rise to this fermentation. Oxygen does not come into play, except as the means of transforming the animal substances into a ferment. Diastase and caseum are well adapted to exhibit this change. The body that is to furnish the lactic acid may be any one of the neutral vegetable matters, possessing a like composition with lactic acid, such as cane-sugar, grape or potato sugar, dextrine, and sugar of milk. All the agents which stop the alcoholic, stop also the lactic fermentation; while diastase and caseum are its two best exciters. For producing abundance of lactic acid, we have merely to moisten malt, to expose it to the air for a few days, then to triturate it with a quantity of water, and leave the emulsion for some days more in the air, at a temperature between 67° and 86° F. We then saturate the liquor with chalk, after having filtered it, and thereby obtain the lactate of lime, which may be crystallized in alcohol, to deprive it of the dextrine and earthy phosphates; and then decomposed by sulphuric acid.

Lactic Acid, formed from curd (caseum), exhibits more remarkable phenomena. Thus when milk is left alone for some time it becomes sour, and coagulates. The coagulum is formed of caseum and butter; while the whey of it contains sugar of milk and some salts. The coagulation of the caseum has been occasioned by the lactic acid, which was generated in consequence of an action which the caseum itself exercised upon the sugar of milk. Thus with the concourse of air, the caseum becomes a ferment, and excites the conversion of the sugar of milk into lactic acid. The lactic acid in its turn coagulates the caseum, which in the consolidation of its particles attracts the butter. The caseum then ceases to act upon the sugar of milk, and consequently produces no more lactic acid.

But now, if the lactic acid already formed be saturated, the caseum will redissolve, and the phenomena will recommence in the same order. This is easily done by adding a due dose of bicarbonate of soda to the soured milk. In the course of 30 hours a fresh portion of lactic acid will be generated, and will have coagulated the milk again. We may also add some sugar of milk to the liquid, and to a certain extent convert it into lactic acid. Milk boiled, and kept from contact of air, will not coagulate, and remains fresh for many months. Animal membranes, modified by exposure to moist air for some time, form a true ferment for the lactic fermentation, and acidify solutions of sugar, dextrine, and gum, but the membranes must not be putrescent. Cane-sugar, starch-sugar, and sugar of milk, by assuming or losing a little water, acquire the constitution of lactic acid.

Viscous or Mucous Fermentation.—Every one is acquainted with this spontaneous modification of white wine and ale, which gives them a stringy or oily aspect, and is called in French *graisse*, or fat of wines, and in English the ropiness of beer. The viscous fermentation may be excited by boiling yeast with water, and dissolving sugar in the decoction, after it has been filtered. The syrup should have a specific gravity from 1·040 to 1·055, and be kept in a warm place. It soon assumes the consistence and aspect of a thick mucilage, like linseed tea, with the disengagement of a little carbonic acid and hydrogen, in the proportion of 2 or 3 of the former gas to 1 of the latter. A ferment of globular texture like that of yeast is formed, which is capable of producing viscous fermentation in any saccharine solution to which it is added, provided the temperature be suitable. The viscid matter being evaporated to dryness forms transparent plates, of a sub-nauseous taste, and soluble in water, but less easily than gum arabic. Its mucilage is, however, thicker than that of gum, and yields with nitric acid, oxalic acid, but no mucic acid. Four parts of sugar, treated as above described, furnish 2·84 of unchanged sugar, and 1·27 of the mucilage; from which it appears that water becomes fixed in the transformation. Muriatic, sulphuric, sulphurous acids, and alum, prevent the production of the viscous fermentation, by precipitating its ferment. It is probably the soluble portion of gluten which is the cause of this species of fermentation. It has been found, accordingly, that tannin, which precipitates the said glutinous ferment, completely stops the viscous fermentation, or *graisse*, of wines. It is owing to the tannin which the red wines derive from the grape-stalks, with which they are long in contact during fermentation, that they are preserved from this malady of the white wines. The gluten of must is of two kinds, the one soluble in virtue of the alcohol and tartaric acid, and producing the viscous, the other insoluble, and producing the alcoholic fermentation. The art of the wine-maker consists in precipitating the injurious ferment, without impeding the action of the beneficial one; an art of considerable delicacy with regard to sparkling wines.

Acid Fermentation has been fully discussed under acetic acid. It requires the presence of ready formed alcohol and air. The lactic fermentation, on the contrary, may take place with starchy or saccharine substances, without the intervention of alcohol or constant exposure to the atmosphere; and when once begun, it can go on without air. Acetification has a striking analogy with nitrification, as is shown by the necessity of a high temperature, and the utility of porous bodies for exposing the liquid on a great surface to the air.

Benzoic Fermentation is that which transforms the azotised neutral crystalline matter, existing in bitter almonds, which has no action upon the animal economy, into new and remarkable products, among others the hydrure of benzöile and hydrocyanic (prussic) acid, which together constitute the liquid, called oil, or essence, of bitter almonds, a compound possessed of volatility and poisonous qualities. The attentive study of this fermentation has revealed a great fact in vegetable physiology, the spontaneous production, by means of certain artifices, of certain volatile oils, not pre-existing in the plants, yet capable of being generated in the products of their decomposition. The volatile oil of bitter almonds constitutes in this respect a starting point, from which have proceeded the oil of mustard, the oil of spiræa, and which will likely lead to other discoveries of the same kind. See Almond and Amygdaline.

Sinapic Fermentation is that by which the oil of mustard is formed, and which takes place by the contact of water, under certain conditions, of too refined and scientific a nature for this practical work.

Pectic Fermentation.—Pectic acid may be obtained from the expressed juice of carrots, and it seems to be formed in the process of extraction by the reaction of albumine in the carrots upon a substance called pectine; a transformation analogous therefore with that which takes place in the formation of the essence of bitter almonds.

Gallic Fermentation.—Gallic acid does not exist ready formed in nut-galls, but is generated from their tannin when they are ground, made pasty with water, and exposed to the air. This conversion may be counteracted by the red oxide of mercury, alcohol, sulphuric, muriatic, and nitric acids, bromine, essence of turpentine, creosote, oxalic, acetic, and prussic acids. The tannin disappears in the sequel of the above metamorphosis.

Fatty Fermentation.—All fats are transformed by the action of an alkaline or other base into certain acids, the stearic, margaric, the oleic, ethalic, &c. When these acids are once formed, they can not by any means, hitherto known, be reconverted into the primitive fat. By the fixation of water in the acid and the base (called *glycerine*), a change is effected which can not be undone, because the glyceric base is incapable by itself to displace the water, once combined in the hydrated fat acid. The circumstances necessary to the fatty fermentation, are like those of other fermentations; namely, the co-operation of an albuminoid matter, along with water, and a temperature of from 60° to 86° F.; under these conditions, the matter becomes warm, and assumes speedily the character of rancidity; acid is generated, and the carbonate of soda can then form salts, while the fatty acid is liberated; a circumstance impossible when the fat was acted upon in the neutral state. This altered fat, treated with water, gives up to it *glyceric alcohol.*

Digestive Fermentation.—Digestion of food may be considered in its essential features as a peculiar fermentative process. The gastric juice is a genuine ferment. Tiedmann, Gmelin, and Prout, have shown that the gastric juice contains muriatic acid; and Eberli has made interesting experiments on the digestion of food out of the body, with water containing a few drops of the same acid. He observed that when this liquid contained none of the mucous secretion of the stomach, it did not dissolve the aliments put into it; but with a little of that mucus it acquired that property in an eminent degree. Even the mucus of the bladder had a like effect. Schwann and Vogel have produced this digestive principle in a pure state, called by them *pepsine*, as obtained most abundantly from the stomachs of swine. The glandular part of that viscus being separated from the serous, is cut into small pieces, and washed with cold distilled water. After digestion for 24 hours, that water is poured off, and fresh water is poured on. This operation is repeated for several days, till a putrid odor begins to be felt. The watery infusion thus obtained is precipitated by acetate of lead. This white flaky precipitate contains the *pepsine*, accompanied with much albumen. It is then washed, mixed with water, and subjected to a stream of sulphuretted hydrogen. The whole being now thrown on a filter, the coagulated albumen remains on the paper, along with the sulphuret of lead, while the pepsine liquor passes, associated with some acetic acid. If to this liquor a very small quantity of muriatic acid be added, it becomes capable of carrying on artificial digestion. Dry pepsine may be obtained by evaporating the above filtered liquor on a water bath, to a syrupy consistence, then adding to it absolute alcohol, which causes a bulky whitish precipitate. This dried in the air constitutes *pepsine.* It contains a minute quantity of acetic acid, which may be removed completely, by heating it some hours on the water bath. The white powder then obtained is soluble in water, and betrays the presence of no acid whatever. According to Vogel, this substance is composed of, carbon, 57·72; hydrogen, 5·67; azote, 21·09; oxygen, &c., 15.52 = 100. Vogel has proved the analogy between the action of pepsine and diastase by the following experiment:—

He dissolved two grains of pepsine in very weak muriatic acid, and put into this liquor heated to 81° F., small bits of boiled beef. In the course of a few hours the pieces became transparent on their edges, and not long after they were completely dissolved. He now added fresh morsels in succession, till those last put in remained unchanged. He found by analysis, that 1·98 grains of the pepsine were left, showing how minute a portion of this ferment was necessary to establish and effect digestion. In fact, we may infer that pepsine, like yeast, serves to accomplish digestion without any waste of its own substance whatever, or probably with its multiplication.

Rennet, with which milk is coagulated in making cheese, is somewhat of the same nature as pepsine. It has been called *chymosine.* But the simplest digesting liquor is the following:—

If 10,000 parts of water by weight be mixed with 6 parts of ordinary muriatic acid and a little rennet, a liquor is obtained capable of dissolving hard boiled white of egg, beef, gluten, &c., into a transparent jelly in a few hours.

Ammoniacal Fermentation.—Under this title may be described the conversion of urea into carbonate of ammonia under the influence of water, a ferment, and a favorable temperature. Urea is composed in atoms; reckoned

In volumes,	Carbon 4;	hydrogen 8;	azote 4;	oxygen 2;
which by fixing	—	4;	—	2;
give	4;	12;	4;	4:

which is 4 vol. of carbonic acid, and 8 of ammonia; equivalent to ordinary carbonate of ammonia. The fermentation of urea plays an important part in the reciprocal offices of vegetable and animal existence. By its conversion into carbonate of ammonia, urea becomes a food fit for plants; and by the intervention of the mucous ferment which urine contains, that conversion is effected. Thus the urea constitutes a neutral and innocuous substance while it remains in the bladder, but is changed into a volatile, alkaline, and acrid substance, when it is acted upon by the air. Yeast added to pure urea mixed with water, exercises no action on it in the course of several days; but when added to urine, it soon causes decomposition, with the formation of carbonate of ammonia, and disengagement of carbonic acid. The deposite on chamberpots ill-cleaned acts as a very powerful ferment on urine, causing the complete decomposition of fresh urine in one fifth of the time that would otherwise be requisite.

Nitrous Fermentation, as exhibited in the formation of nitric acid from the atmosphere, and consequent production of nitrates in certain soils, has been with much probability traced to the action of ammonia on oxygen, as the intermedium or ferment.

Caseous and putrid Fermentations.—Curd *is converted into cheese, when after being coagulated by rennet,* it is left to itself under certain conditions; and this constitutes the true distinctive character of caseum. In the production of cheese there is evidently the intervention of a peculiar ferment which is gradually formed, and the decomposition of the curd into new products.

For animal and vegetable matters to run into putrefaction, they must be in contact with air and water, at a certain temperature; viz., between the freezing and boiling points of water. The contact of a putrid substance acts as a ferment to fresh animal and vegetable matters. The reagents which counteract fermentation in general stop also putrefaction. In this process, myriads of microscopic animalcules make their appearance, and contribute to the destruction of the substances.

A dispute having taken place between some distillers in Ireland and officers of Excise, concerning the formation of alcohol in the vats or tuns by spontaneous fermentation, without the presence of yeast, the Commissioners of Excise thought fit to cause a series of experiments to be made upon the subject, and they were placed under my general superintendence. An experiment was made on the 6th of October, with the following mixture of corn:—

	lbs.	oz.
2 Bushels of Barley, weighing - - - -	100	5
½ Bushel of Malt, - - - - -	21	7
½ Bushel of Oats - - - - -	20	12
Total, 3 Bushels, weighing - - -	142	8

The bruised corn was wetted with 26 gallons of water at the temperature of 160° F., and, after proper stirring, had 8 gallons more of water added to it at the average temperature of 194°. The mash was again well stirred, and at the end of 45 minutes the whole was covered up, having at that time a temperature of 138° F. Three hours afterward, 16 gallons of wash only were drawn off; being considerably less than should have been obtained, had the apparatus been constructed somewhat differently, as shall be presently pointed out. The gravity of that wash was 1·060, or, in the language of the distiller, 60°. After a delay of two hours more, twenty additional gallons of water at the temperature of 200° were introduced, when the mash was well stirred, and then covered up for two hours, at which period 23 gallons of fine worts of specific gravity 1·042 were drawn off. An hour afterward 12 gallons of water at 200° were added to the residual grains, and in an hour and a half 11 gallons of wort of the density 1·033 were obtained. Next morning the several worts were collected in a new mash tun. They consisted of 48 gallons at the temperature 80°, and of a specific gravity 2·0465 when reduced to 60°. Being set at 80°, fermentation soon commenced; in two days the specific gravity had fallen to 1·0317, in three days to 1·018, in four days to 1·013, and in five days to 1.012, the temperature having at last fallen to 78° F. The total attenuation was therefore 34½°, indicating the production of 3·31 gallons of proof spirit, while the produce by distillation in low wines was 3·22; and by rectification in spirits and feints it was 3·05. The next experiment was commenced on the 12th of October, upon a similar mixture of corn to the preceding. 48 gallons of worts of 1·043 specific gravity were set at 82° in the tun, which next day was attenuated to 1·0418, in two days to 1·0202, in three days to 1·0125, and in five days to 1·0105, constituting in the whole an attenuation of 32½°, which indicates the production of 3·12 gallons of proof spirits; while the produce of the first distillation was 2·93 in low wines, and that of the second in feints and spirits was 2·66. In these experiments the wash, when fermenting most actively, seemed to simmer and boil on the surface, with the emission of a hissing noise, and the copious evolution of carbonic acid gas. They prove beyond all doubt that much alcohol may be generated in grain worts without the addition of yeast, and that, also, at an early period; but the fermentation is never so active as with yeast, nor does it continue so long, or proceed to nearly the same degree of attenuation. I was never satisfied with the construction of the mash tun used in these experiments, and had accordingly suggested another form, by which the mash mixture could be maintained at the proper temperature during the mashing period. It is known to chemists that the diastase of malt is the true saccharifying ferment which converts the fecula, or starch of barley and other corn, into sugar; but it acts beneficially only between the temperatures of 145° and 168° F. When the temperature falls below the former number, saccharification languishes; and when it rises much above the latter, it is entirely checked. The new mash tun was made of sheet zinc, somewhat wider at bottom than top; it was placed in a wooden tun, so much larger as to leave an interstitial space between the two of a couple of inches at the sides and bottom. Through this space a current of water at 160° was made to circulate slowly during the mashing period. Three bushels of malt, weighing 125 lbs. 3 oz., were wetted with 30 gallons of water at 167°, and the mixture being well agitated, the mash was left covered up at a temperature of 140° during three hours, when 19 gallons of fine worts were drawn off at the specific gravity of 1·0902 or 90·2°. Twenty gallons more water at 167° were then added to the residuum, which afforded after two hours 28 gallons of wort at the gravity 1·036; 12 gallons of water at 167° were now poured on, which yielded after other two hours 15 gallons at the gravity 1·0185. Forty gallons of fine worts at 1·058 gravity and 68° temperature were collected in the evening of the same day, and let into the tun with 5 per cent. of yeast. The attenuation amounted in six days to 54°. The third wort of this brewing, amounting to 15 gallons, being very feeble, was mixed with 7 gallons of the first and second worts, put into a copper, and concentrated by boiling to 11 gallons, which had a gravity 1·058 at 60° F. They were separately fermented with 5 per cent. of yeast, and suffered an attenuation of 48½°. The produce of spirit from both indicated by the attenuation was 5·36 gallons; the produce in low wines was actually 5·52, and that in spirits and feints was 5·33, being a perfect accordance with the Excise tables.

The next experiments were made with a view of determining at what elevation of temperature the activity or efficiency of yeast would be paralysed, and how far the attenuation of worts could be pushed within six hours, which is the time limited by law for worts to be collected into the tun, from the time of beginning to run from the coolers. When worts of the gravity 1·0898 were set at 96° Fahr., with 5 per cent. of yeast, they attenuated 26·9° in 6 hours; worts of 1·0535 gravity set at 110° with 5 per cent. of yeast, attenuated 16° in about 5 hours; but when worts of 1·0533 were set, as above, at 120°, they neither fermented then, nor when allowed to cool; showing that the activity of the yeast was destroyed. When fresh yeast was now added to the last portion of worts, the attenuation became 5·8 in 2 hours, and 28·4° in 3 days: showing that the saccharine matter of the worts still retained its fermentative faculty. Malt worts, being brewed as above specified, were set in the tun, one portion at a temperature of 70°, with a gravity of 1·0939, and 5 per cent. of yeast, which attenuated 66° in 3 days; other two portions of the same gravity were set at 120° with about 10 per cent. of yeast, which underwent no fermentative change or attenuation in 6 hours, all the yeast having fallen to the bottom of the tuns. When these two samples of worts were allowed, however, to cool to from 74° to 72°, fermentation commenced, and produced in two days an attenuation of about 79°. It would appear, from these last two experiments, that yeast to the amount of 5 per cent. is so powerfully affected by strong worts heated to 120° as to have its fermentative energy destroyed; but that when yeast is added to the amount of 10 per cent., the 5 parts of excess are not permanently decomposed, but have their activity merely suspended till the saccharine liquid falls to a temperature compatible with fermentation. Yeast, according to my observations, when viewed in a good acromatic microscope, consists altogether of translucent spherical and spheroidal particles, each of about the 6000th part of an inch in diameter. When the beer in which they float is washed away with a little water, they are seen to be colorless; their yellowish tint, when they are examined directly from the fermenting square or round of a porter brewery, being due to the infusion of the brown malt. The yeast of a square newly set seems to consist of particles smaller than those of older yeast, but the difference of size is not considerable. The researches of Schulze, Cagniard de la Tour, and Schwann, appear to show, that the vinous fermentation, and the putrefaction of animal matters, processes which have been hitherto considered as belonging entirely to the domain of chemical affinity—are essentially the results of an organic development of living beings. This position seems to be established by the following experiments: 1. A matrass or flask containing a few bits of flesh, being filled up to one third of its capacity with water, was closed with a cork, into which two slender glass tubes were cemented air-tight. Both of these tubes were passed externally through a metallic bath, kept constantly melted, at a temperature approaching to that of boiling mercury. The end of one of the tubes, on emerging from the bath, was placed in communication with a gasometer. The contents of the matrass were now made to boil briskly, so that the air contained in it and the glass tubes was expelled. The matrass being then allowed to cool, a current of atmospherical air was made constantly to pass through it from the gasometer, while the metallic bath was kept constantly hot enough to decompose the living particles in the air. In these experiments, which were many times repeated, no infusoria or fungi appeared, no putrefaction took place, the flesh underwent no change, and the liquor remained as clear as it was immediately after being boiled. As it was found very troublesome to maintain the metallic bath at the melting pitch, the following modification of the apparatus was adopted in the subsequent researches: A flask of three ounces capacity, being one fourth filled with water and flesh, was closed with a tight cork, secured in its place by wire. Two glass tubes were passed through the cork; the one of them was bent down, and dipped at its end into a small capsule containing quicksilver, covered with a layer of oil; the other was bent on leaving the cork, first into a horizontal direction, and downward for an inch and a half, afterward into a pair of spiral turns, then upward, lastly horizontal, whence it was drawn out to a point. The pores of the cork having been filled with caoutchouc varnish, the contents of the flask were boiled till steam issued copiously through both of the glass tubes, and the quicksilver and oil became as hot as boiling water. In order that no living particles could be generated in the water condensed beneath the oil, a few fragments of corrosive sublimate were laid upon the quicksilver. During the boiling, the flame of a spirit lamp was drawn up over the spiral part of the second glass tube, by means of a glass chimney placed over it, so as to soften the glass, while the further part of the tube was heated by another spirit lamp, to prevent its getting cracked by the condensation of the steam. After the ebullition had been kept up a quarter of an hour, the flask was allowed to cool, and get filled with air through the hot spiral of the second tube. When the contents were quite cold, the end of this tube was hermetically sealed, the part of it between the point and the spiral was heated strongly with the flames, and the lamps were then withdrawn. The matrass contained now nothing but boiled flesh and gently ignited air. The air was renewed occasionally through the second tube, its spiral part being first strongly heated, its point then broken off, and connected with a gasometer, which caused the air to pass onward slowly, and escape at the end of the first tube immersed in the quicksilver. The end of the second tube was again hermetically closed, while the part interjacent between it and the spiral was exposed to the spirit flame. By means of these precautions, decoctions of flesh were preserved, during a period of six weeks, in a temperature of from 14° to 20° R. (63½° to 77° F.), without any appearance of putrefaction, infusoria, or mouldiness: on opening the vessel, however, the contents fermented in a few days, as if they had been boiled in the ordinary manner. In conducting such researches, the greatest pains must be taken to render the cork and junctions of the glass tubes perfectly air-tight. The following more convenient modification of the experiment, but one equally successful and demonstrative, was arranged by F. Schulze. The glass tubes connected with the flask were furnished each with a bulb at a little distance from the cork; into one of which globes caustic alkaline ley being put, and into the other strong sulphuric acid, air was slowly sucked through the extremity of the one tube, while it entered at the other, so as to renew the atmosphere over the decoction of flesh in the flask. In another set of experiments, four flasks being filled with a solution of cane-sugar containing some beer-yeast, were corked and plunged in boiling water till they acquired its temperature. They were then taken out, inverted in a mercurial bath, uncorked, and allowed to cool in that position. From one third to one fourth of their volume of atmospherical air was now introduced into each of the flasks; into two of them through slender glass tubes kept red hot at a certain point, into the other two through glass tubes not heated. By analysis it was found that the air thus heated contained only 19·4 per cent. of oxygen, instead of 20·8; but, to compensate for this deficiency, a little more air was admitted into the two flasks connected with the heated tubes than into the two others. The flasks were now corked and placed in an inverted position, in a temperature of from 10° to 14° R. (54½° to 63½° F.). After a period of from four to six weeks, it was found that fermentation had taken place in both of the flasks which contained the non-ignited air—for, in loosening the corks, some of the contents were projected with force—but, in the other two flasks, there was no appearance of fermentation, either then, or in double the time. As the extract of nux vomica is known to be a poison to *infusoria* (animalcules), but not to vegetating mould, while arsenic is a poison to both, by these tests it was proved that the living particles instrumental to fermentation belonged to the order of plants of the confervoid family. Beer yeast, according to Schwann, consists entirely of microscopic fungi, in the shape of small oval grains of a yellowish white color, arranged in rows oblique to each other. Fresh grapes must contain none of them; but after being exposed to the air at 20° R., for 36 hours, similar grains become visible in the microscope, and may be observed to grow larger in the course of an hour, or even in half that time. A few hours after these plants are first perceived, gas begins to be disengaged. They multiply greatly in the course of fermentation, and at its conclusion subside to the bottom of the beer in the shape of a yellow white powder.

FERRIC ACID. This new compound having been prescribes as a source of supplying oxygen to persons confined in diving-bells and in mines, by M. Payerne, in a patent recently granted to him, merits notice in a practical work. M. Fremy is the discoverer of this new acid, which he obtains in the state of ferrate of potash, by projecting 10 parts of dry nitre in powder upon 5 parts of iron filings, ignited in a crucible; when a reddish mass, containing much ferrate of potash, is formed. The preparation succeeds best when a large crucible, capable of holding about a pint of water, is heated so strongly that the bottom and a couple of inches above it, appear faintly, but distinctly red, in which state the heat is just adequate to effect due deflagration without decomposition. An intimate mixture of about 200 grains of *dried* nitre with about one half its weight of the finest iron filings, is to be thrown at once upon the side of the crucible. The mixture will soon swell and deflagrate. The crucible being taken from the fire, and the ignited mass being cooled, is to be taken out with an iron spoon, pounded, immediately put into a bottle, and secluded from the air, in which it would speedily attract moisture, and be decomposed. It is resolved by the action of water, especially with heat, into oxygen gas, peroxide, and nitrate of iron.

Mr. J. D. Smith prepares the ferrate of potash by exposing to a full red heat a mixture of finely powdered peroxide of iron with four times its weight of dry nitre. It has an amethyst hue, but so deep as to appear black, except at the edges. Oxygen is rapidly evolved by the action of the sulphuric or nitric acid upon its solution. He considers the atom of iron to exist in this compound, associated with 3 atoms of oxygen, or double the proportion of that in the red oxide. Hence 52 grains of pure ferric acid should give off 12 grains of oxygen, equal to about 35 cubic inches; but how much of the ferrate of potash may be requisite to produce a like quantity of oxgyen, can not be stated, from the uncertainty of the operation by which it is produced.

FERRIC-CYANIDE OF POTASSIUM, or *Red Prussiate of Potash.* This beautiful and useful salt, discovered by L. Gmelin, is prepared by passing chlorine gas through a weak solution of the prussiate of potash (ferro-cyanide of potassium) till it ceases to affect solution of red sulphate of iron, taking care to agitate the liquid all the while, and not to add an excess of chlorine. On looking through the weak solution to the flame of a candle, one may see the period of change from the greenish to the red hue, which indicates the completion of the process. The liquor being filtered and evaporated in a dish with upright sides, will eventually afford crystalline needles, possessed of an almost metallic lustre, and a yellow color, inclining to red. These being dissolved and recrystallized, will become extremely beautiful. This salt is composed of 33·68 parts of potassium, 16·48 of iron, and 47·84 of cyanogen. It is therefore a dry salt. It dissolves in 38 parts of cold water, and as it forms then the most delicate test of the protoxide of iron, is very useful in *Clorometry*.—See APPENDIX.

The solution of this salt affords the following colored precipitates with the solutions of the respective metals :—

Titanium - - - -	Brownish yellow.
Uranium - - - -	Reddish brown.
Manganese - - - -	Brownish gray.
Cobalt - - - -	Deep reddish brown.
Nickel - - - -	Yellowish brown.
Copper - - - -	Dirty yellowish brown.
Silver - - - -	Orange yellow.
Mercury - - - -	Yellow, with both the protoxide and peroxide salts.
Tin - - - -	White.
Zinc - - - -	Orange Yellow.
Bismuth - - - -	Yellowish brown.
Lead - - - -	No precip.
Iron protoxide - - - -	Blue.
—— peroxide - - - -	No precip.

The ferric-cyanide of potassium has been introduced into dyeing and calico-printing.

In case an excess of chlorine has been used in preparing the above salt, Posselt recommends to add to its solution, when near the crystallizing point, a few drops of potash ley, in order to decompose a green substance that is present, which takes place with the precipitation of a little peroxide of iron.

FIREARMS. *Barrel-welding by Machinery.*—The barrels of musquets, birding-guns, &c., or what are called *plain*, to distinguish them from those denominated *stub* or twisted barrels, have of late years been formed by means of rolls, a process in which the welding is first effected on a short slab of thick iron, and then the barrel is brought down to its destined length, and form, by repeatedly passing it between a pair of rolls, that have been previously grooved to the exact shape of the barrel intended to be made.

This method has entirely superseded the skelp-welding by hand described in the *Dic. of Man.*, p. 471, and is conducted as follows :—

The iron being thoroughly refined, and reduced into flat bars by the process described at length at p. 705, is cut by the shears into slabs or lengths of 10 to 12 inches, and 10 to $10\frac{1}{2}$ lbs. weight, or less, according to the description of gun-barrel that is intended to be made. These slabs are then heated, and bent in their whole length, by means of conveniently grooved bending rolls, until they assume the form of rough tubes, of the kind of section shown by A, *fig.* 49. They are then placed on the hearth of the reverberatory furnace (*Dict.* p. 701), and brought to a full welding heat, and as soon as the edges of a tube come to a semi-fluid state, it is taken out and passed between rolls having grooves somewhat smaller in diameter than the exterior of the tube, by which means the tube is perfectly welded from end to end; and if care be taken in the management of the heat, and the juncture be kept clear of dirt and cinders, the iron will be found perfectly homogeneous in every part, and there will be no appearance whatever of the seam where the edges came together. These tubes are repeatedly heated, and passed between the barrel rolls, which are of sufficient diameter to admit of gradually decreasing grooves, the whole length of the intended barrel being indented on their surfaces.

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To preserve the tubular form, and insure regularity in the size of the bore during the welding process, they are taken out of the furnace, bv thrusting into them a tool called a mandril B, which consists of a long rod of iron, having a short steel treblett on its end, of the diameter that the bore of the barrel is meant to bore. This rod is so adjusted by means of a strong iron plate C, near its handle, which is of wood, and long, that when passed with the heated tube on it between two tranverse holding bars, the short steel treblett D, shall be found exactly between the point of impact of the barrel-rolls, E E.

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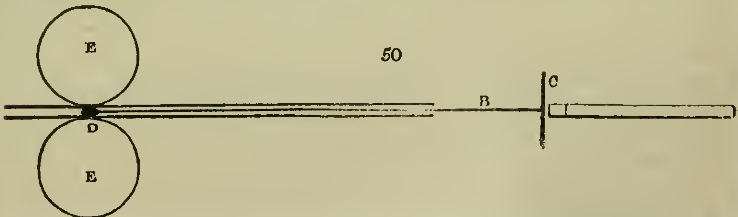

The adhesion of the hot iron to the surface of the rolls is strong enough to draw the tube off the mandril, which thus keeps the bore open from end to end, and by repeating the process through the whole series of grooves in the rolls, the barrel is gradually elongated, and brought down to the exact form required: any superfluous length at the muzzle is then cut off. The breach end is then adjusted by the hammer—a tripple-seat welded on by hand if it be intended for a percussion lock, and then the barrel is ready to go forward to the mill to be bored, turned, and finished.

Gun-barrels formed by this mechanical method are found to stand proof better than those worked by hand, because the heat is more equalized; and any imperfections in the original mass of iron are more dispersed over the whole extent of the tube.

Mr. Wells Ingram, of Bradford street, Birmingham, has lately perfected a very complete lathe for turning the exterior of gun-barrels of all descriptions, a process which is fast superseding the use of the grindstone, for equalizing the barrels of all kinds of fire-arms.

I am indebted for this article to Mr. Lovell, Director of the Royal Arms Manufactory. See MUSQUET.

FLAX and TOW, or *Codilla of Hemp and Flax*, imported for home consumption in 1839, 1,216,811 cwt.; in 1840, 1,256,322; 1*d*. per cwt.

FLOOKAN. The name given by the Cornish miners to a vein of clay-stone, often nearly vertical.

FLOOR-CLOTH MANUFACTURE has become of late years a very large branch of trade. The cloth is a strong somewhat open canvass, woven of flax with a little hemp, and from 6 to 8 yards wide, being manufactured in appropriate looms chiefly at Dundee. A piece of this canvass from 60 to 100 feet in length, is secured tight in an upright open frame of oaken bars, in which position it receives the foundation coats of paint, 2 or 3 in number, first on the black side, and then on the front; but it previously is brushed over with glue-size, and rubbed smooth with pumice-stones. The foundation paint made with linseed oil and ochre, or any cheap coloring matter, is too thick to be applied by the brush, and is therefore spread evenly by a long narrow trowel, held in the right hand, from a patch of it laid on just before with a brush in the left hand of the workman. Each foundation coat of the front surface is smoothed by pumice whenever it is hard enough to bear the operation. When both sides are dry, the painted cloth is detached from the frame, coiled round a roller, in this state transferred to the proper printing-room, where it is spread flat on a table, and variously figured and colored devices are given to it by wooden blocks, exactly as in the block-printing of calicoes, and in the wood-printing of books. The blocks of the floor-cloth manufacture are formed of two layers of white deal and one of pear-tree timber, placed with their grain crossing one another alternately. There is of course a block for each color in the pattern, and in each block those parts are cut away that correspond to the impressions given by the others; a practice now well understood in the printing of two or more colors by the press. The faces of the blocks are so indented with fine lines, that they do not take up the paint in a heavy daub from the flat cushion on which it is spread with a brush, but in minute dots, so as to lay on the paint (somewhat thicker than that of the house-painter) in a congeries of little dots or teeth, with minute interstices between. Applied in this way, the various pigments lie more evenly, are more sightly, and dry much sooner than if the prominent part of the block which takes up the color were a smooth surface. The best kinds of floor-cloth require from two to three months for their production.

FODDER, a weight of 21 cwt., by which lead is sold in the north of England.

FUEL. On the measurement of heat, and the qualities of different kinds of coal, I made an elaborate series of experiments, a few years ago, of which the following is an outline:—

The first and most celebrated, though probably not the most accurate apparatus for measuring the quantity of heat transferable from a hotter to a colder body, was the calorimeter of Lavoisier and Laplace. It consisted of three concentric cylinders of tin plate, placed at certain distances asunder; the two outer interstitial spaces being filled with ice, while the innermost cylinder received the hot body, the subject of experiment. The quantity of water discharged from the middle space by the melting of the ice in it, served to measure the quantity of heat given out by the body in the central cylinder. A simpler and better instrument on this principle would be a hollow cylinder of ice of proper thickness, into whose interior the hot body would be introduced, and which would indicate by the quantity of water found melted within it the quantity of heat absorbed by the ice. In this case, the errors occasioned by the retention of water among the fragments of ice packed into the cylindric cell of the tin calorimeter, would be avoided. One pound of water at 172° F., introduced into the hollow cylinder above described, will melt exactly one pound of ice; and one pound of oil heated to 172° will melt half a pound.

The method of refrigeration, contrived at first by Meyer, has been in modern times brought to great perfection by Dulong and Petit. It rests on the principle, that two surfaces of like size, and of equal radiating force, lose in like times the same quantity of heat when they are at the same temperature. Suppose for example, that a vessel of polished silver, of small size, and very thin in the metal, is successively filled with different pulverized substances, and that it is allowed to cool from the same elevation of temperature; the quantities of heat lost in the first instant of cooling will be always equal to each other; aud if for one of the substances, the velocity of cooling is double of that for another, we may conclude that its capacity for heat is one half, when its weight is the same; since by losing the same quantity of heat, it sinks in temperature double the number of degrees.

The method of mixtures.—In this method, two bodies are always employed; a hot body which becomes cool, and a cold body, which becomes hot, in such manner that all the caloric which goes out of the former is expended in heating the latter. Suppose for example, that we pour a pound of quicksilver at 212° F., into a pound of water at 32°; the quicksilver will cool and the water will heat, till the mixture by stirring acquires a common temperature. If this temperature was 122°, the water and mercury would have equal capacities, since the same quantity of heat would produce in an equal mass of these two substances equal changes of temperature, viz., an elevation of 90° in the water and a depression of 90° in the mercury. But in reality, the mixture is found to have a temperature of only $37\frac{1}{2}$°, showing that while the mercury loses $174\frac{1}{2}$° the water gains only $5\frac{1}{2}$°; two numbers in the ratio of about 32 to 1; whence it is concluded, that the capacity of mercury is $\frac{1}{32}$ of that of water. Corrections must be made for the influence of the vessel and for the heat dissipated during the time of the experiment.

The following calorimeter, founded upon the same principle as that of Count Rumford, but with certain improvements, may be considered as an equally correct instrument for measuring heat, with any of the preceding, but one of much more general application, since it can determine the quantity of heat disengaged in combustion, as well as the latent heat of steam and other vapors.

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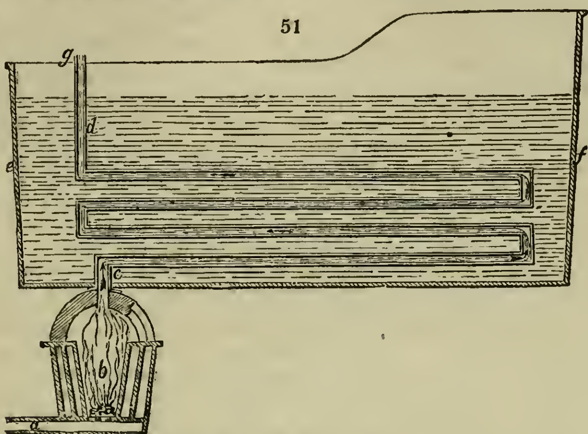

(Scale about ¼ inch to the foot.)

It consists of a large copper bath, *e, f* (*fig.* 51), capable of holding 100 gallons of water. It is traversed four times, backward and forward, in four different levels, by a zig-zag horizontal flue, or flat pipe *d, c*, nine inches broad and one deep, ending below in a round pipe at *c*, which passes through the bottom of the copper bath *e, f*, and receives there into it the top of a small black lead furnace *b*. The innermost crucible contains the fuel. It is surrounded at the distance of one inch by a second crucible, which is enclosed at the same time by the sides of the outermost furnace; the strata of stagnant air between the crucibles serving to prevent the heat from being dissipated into the atmosphere round the body of the furnace. A pipe *a*, from a pair of cylinder double bellows, enters the ash-pit of the furnace at one side, and supplies a steady but gentle blast, to carry on the combustion, kindled at first by half an ounce of red-hot charcoal. So completely is the heat which is disengaged by the burning fuel absorbed by the water in the bath, that the air discharged at the top orifice *g*, has usually the same temperature as the atmosphere.

The vessel is made of copper, weighing two pounds per square foot; it is $5\frac{1}{2}$ feet long, $1\frac{1}{2}$ wide, 2 deep, with a bottom $5\frac{1}{2}$ feet long, and $1\frac{3}{4}$ broad, upon an average. Including the zig-zag tin plate flue, and a rim of wrought iron, it weighs altogether 85 pounds. Since the specific heat of copper is to that of water as 94 to 1,000; the specific heat of the vessel is equal to that of 8 pounds of water, for which, therefore, the exact correction is made by leaving 8 pounds of water out of the 600, or 1,000 pounds used in each experiment.

In the experiments made with former calorimeters of this kind, the combustion was maintained by the current or draft of a chimney, open at bottom, which carried off at the top orifice of the flue a variable quantity of heat, very difficult to estimate.

When the object is to determine the latent heat of steam and other vapors, they may be introduced through a tube into the orifice g, the latent heat being deduced from the elevation of temperature in the water of the bath, and the volume of vapor expended from the quantity of liquid discharged into a measure glass from the bottom outlet c. In this case, the furnace is of course removed.

The heating power of the fuel is measured by the number of degrees of temperature which the combustion of one pound of it, raises 600 or 1,000 pounds of water in the bath, the copper substance of the vessel being taken into account. One pound of dry wood charcoal by its combustion causes 6,000 pounds of water to become 20° hotter. For the sake of brevity, we shall call this calorific energy 12,000 unities. In like circumstances, one pound of Llangennoek coal will yield by combustion 11,500 unities of caloric. One pound of charcoal after exposure to the air gives out in burning only 10,500 unities; but when previously deprived of the moisture which it so greedily imbibes from the atmosphere, it affords the above quantity. One pound of Lambton's Wall's-end coals, affords 8,500 unities; and one of anthracite 11,000.

It must be borne in mind that a coal which gives off much unburnt carburetted hydrogen gas, does not afford so much heat, since in the production of the gas a great deal of heat is carried off in the latent state. I have no doubt, that by this distillatory process, from one third to one fourth of the total calorific effect of many coals is dissipated in the air. But by means of such a furnace as the patent Argand invention of Mr. C. W. Williams, the whole heat produceable by the hydrogen as well as the carbon is obtained; and it should be borne in mind that a pound of hydrogen in burning generates as much heat as three pounds of carbon.

Mr. Berthier proposes to determine the proportion of carbon in coals and other kinds of fuel, by igniting in a crucible a mixture of the carbonaceous matter with litharge, both finely comminuted, and observing the quantity of lead which is reduced. For every 34 parts of lead, he estimates 1 part of carbon, apparently on the principle, that when carbon is ignited in contact with abundance of litharge, it is converted into carbonic acid. Each atom of the carbon is therefore supposed to seize two atoms of oxygen, for which it must decompose two atoms of litharge, and revive two atoms of lead. Calling the atom of carbon 6, and that of lead 104, we shall have the following ratio:—$6 : \overline{104 \times 2} :: 1 : 34.66$, being Berthier's proportion, very nearly.

On subjecting this theory to the touchstone of experiment, I have found it to be entirely fallacious. Having mixed very intimately 10 grains of recently calcined charcoal with 1,000 grains of litharge, both in fine powder, I placed the mixture in a crucible which was so carefully covered, as to be protected from all fuliginous fumes, and exposed it to distinct ignition. No less than 603 grains of lead were obtained; whereas by Berthier's rule, only 340 or 346.6 were possible. On igniting a mixture of 10 grains of pulverized anthracite from Merthyr Tydfil, with 500 grains of pure litharge (previously fused and pulverized), I obtained 380 grains of metallic lead. In a second similar experiment with the same anthracite and litharge, I obtained 450 grains of lead; and in a third only 350 grains. It is therefore obvious that this method of Berthier is altogether nugatory for ascertaining the quantity of carbon in coals, and is worse than useless for judging of the calorific qualities of different kinds of fuel.

In my researches upon coals, I have also made it one of my principal objects to determine the quantity of sulphur which they may contain; a point which has been hitherto very little investigated in this country at least, but which is of great consequence, not only in reference to their domestic combustion, but to their employment by manufacturers of iron and gas. That good iron can not be produced with a sulphureous coal, however well coked, has been proved in France by a very costly experience. The presence of a notable proportion of sulphur in a gas coal is most injurious to the gaseous products, because so much sulphuretted hydrogen is generated as to require an operose process of washing or purification, which improverishes the gas, and impairs its illuminating powers by the abstraction of its olefiant gas, or bicarburetted hydrogen. In proof of this proposition, I have only to state the fact, that I found in a specimen of coal gas as delivered from the retorts of one of the metropolitan companies, no less than 18 per cent. of olefiant gas, while in the same gas, after being passed through the purifiers, there remained only 11 per cent. of that richly-illuminating gas. By using a gas-coal, nearly free from sulphur, such as No. 4, in the subjoined list, I think it probable that 10 per cent. of more light may be realized than with the common more sulphureous coal. This is an important circumstance which the directors of gas-works have hitherto neglected to investigate with analytical precision, though it is one upon which their success and profits mainly depend.

How little attention indeed has been bestowed upon the sulphureous impregnation of pit-coal may be inferred from the fact that one of our professional chemists of note, in a public report, upon a great commercial enterprise, stated that a certain coal analyzed by him was free from sulphur, which coal I found by infallible chemical evidence to contain no less than 7 per cent. of sulphur, being about the double of what is contained in English coals of average quality. The proportion of sulphur may in general be inferred from the appearance and quantity of the ashes. If these be of a red or ochrey color, and amount to above 10 per cent., we may be sure that the coal is eminently sulphureous. The coal above referred to afforded from 15 to 16 per cent. of ferruginous ashes. I believe that sulphur exists in coal generally, though not always in the state of pyrites, either in manifest particles, or invisibly disseminated through their substance.

The readiest method of determining rigidly the quantity of sulphur in any compound, is to mix a given weight of it with a proper weight of carbonate of potassa, nitre, and common salt, each chemically pure, and to ignite the mixture in a platinum crucible. A whitish mass is obtained, in which all the sulphur has been converted into sulphate of potassa. By determining with nitrate of baryta the amount of sulphuric acid produced, that of the sulphur becomes known. By means of this process applied to different samples of coals, I obtained the following results:—

Gas Coals.	Sulphur in 100 parts.	Gas Coals.	Sulphur in 100 parts.
No. 1	3·00	No. 5	2·50
2	3·90	6	5·20
3	2·42	7	3·40
4	3·80	8	3·50

Coals for puddling cast iron, to be converted into steel,	Specific gravity	Sulphur in 100 parts.
No. 1, hard foliated or splent coal, specific gravity	1·258	0·80
2, ditto	1·290	0·96
3, ditto	1·273	3·10
4, cubical and rather soft	1·267	0·80

The last coal being rich in bitumen, would prove an excellent one for the production of a pure coal gas. See PITCOAL.

FUEL, ECONOMY OF. In the report of the Transactions of the Institution of Civil Engineers for February, 1838, the results of exact comparisons between the performance of different steam-engines exhibit this economy in a remarkable manner. It is there shown that a condensing engine of the most perfect construction, and in perfect condition, of the common low pressure crank-kind, not working expansively, performs a duty of not more than 20 or 21 millions of lbs. raised one foot high, by 90 or 94 lbs. of coal; or ten lbs. of coal per horse power per head.

The following table exhibits the relative value of different engines in lbs. of coal per horse power per hour:—

Cornish Pumping Engine	1·57
Bolton and Watt's Single Engine	4·82
Cornish Double Engine	3·25
Bolton and Watt's Double Engine	10·5

The greatest duty performed by the measured bushel of 84 lbs. was 86½ millions of lbs. There was raised by the Huel Towan engine in Cornwall 1,085 tons (of water) one foot high for one farthing. Hence the weight of a man (1½ cwt.) would be raised ten miles for one penny!

In order to raise steam with economy, the surface of water in the boiler, exposed to the fire, ought not to be less thon 10 square feet per horse power; but the usual allowance in Lancashire is only 7½; and by Messrs. Boulton and Watt, 5 square feet.

The values of the mean of the Cornish, Warwick, London, Lancashire, and locomotive experiments, as reported by Mr. Josiah Parkes, were respectively 21, 18, 13½, and 10 cubic feet of water evaporated by 112 lbs. of coals, from water heated to 212° F.

FUEL, GRANT'S PATENT. This fuel is composed of coal-dust and coal-tar pitch; these materials are mixed together, under the influence of heat, in the following proportions:—20 lbs. of pitch to 1 cwt. of coal-dust, by appropriate machinery; consisting of crushing-rollers for breaking the coal in the first instance sufficiently small, so that it may pass through a screen the meshes of which do not exceed a quarter of an inch asunder; 2dly, of mixing-pans or cylinders, heated to the temperature of 220°, either by steam or heated air; and, 3dly, of moulding machines, by which the fuel is compressed, under a pressure equal to five tons, into the size of a common brick; the fuel bricks are then whitewashed, which prevents their sticking together, either in the coal bunkers or in hot climates. The advantages of Grant's fuel over even the best coal may be stated to consist, first, in its superior efficacy in generating steam, which may be thus stated—200 tons of this fuel will perform the same work as 300 tons of coal, such as are generally used; secondly, it occupies less space; that is to say, 500 tons of it may be stowed in an area which will contain only 400 tons of coal; thirdly, it is used with much greater ease by the stokers or firemen than coal, and it creates little or no dirt or dust, considerations of some importance when the delicate machinery of a steam-engine is considered; fourthly, it produces a very small proportion of clinkers, and thus it is far less liable to choke and destroy the furnace bars and boilers than coal; fifthly, the ignition is so complete that comparatively little smoke, and only a small quantity of ashes, are produced by it; sixthly, from the mixture of the patent fuel, and the manner of its manufacture, it is not liable to enter into spontaneous ignition.

G.

GALVANO-PLASTIC is the German name of *Electro-Metallurgy.*

GARANCINE, an extract of madder by means of sulphuric acid, prepared in France.

GAS-LIGHT. Since the former edition of this work I have received from Mr. Hedley, an engineer of great eminence and experience, plans and drawings of gas works and of apparatus of the most approved and modern construction, and on the very largest scale as to extent of business or manufacture; also plans and drawings of a gas work on a smaller scale, with its corresponding apparatus. In the first, or large work, purification by wet lime, before described, is used; in the latter, by dry lime.

The large work referred to is calculated for and is arranged to contain 400 retorts, 12 wet-lime purifiers, & 2 washers; 12 large double or telescopic gas-holders, capable of storing 1,000,000 cubic feet of gas; and coal stores capable of holding 10,000 tons of coal. The smaller work is calculated for and will contain 40 retorts, 2 dry lime purifiers, and a wash vessel; 2 gasholders capable of storing 50,000 cubic feet of gas; and coal stores sufficient for 1000 tons of coal.

Fig. 52 is the side elevation (front view) of a gas work, capable of containing 400 retorts, and all their dependencies.

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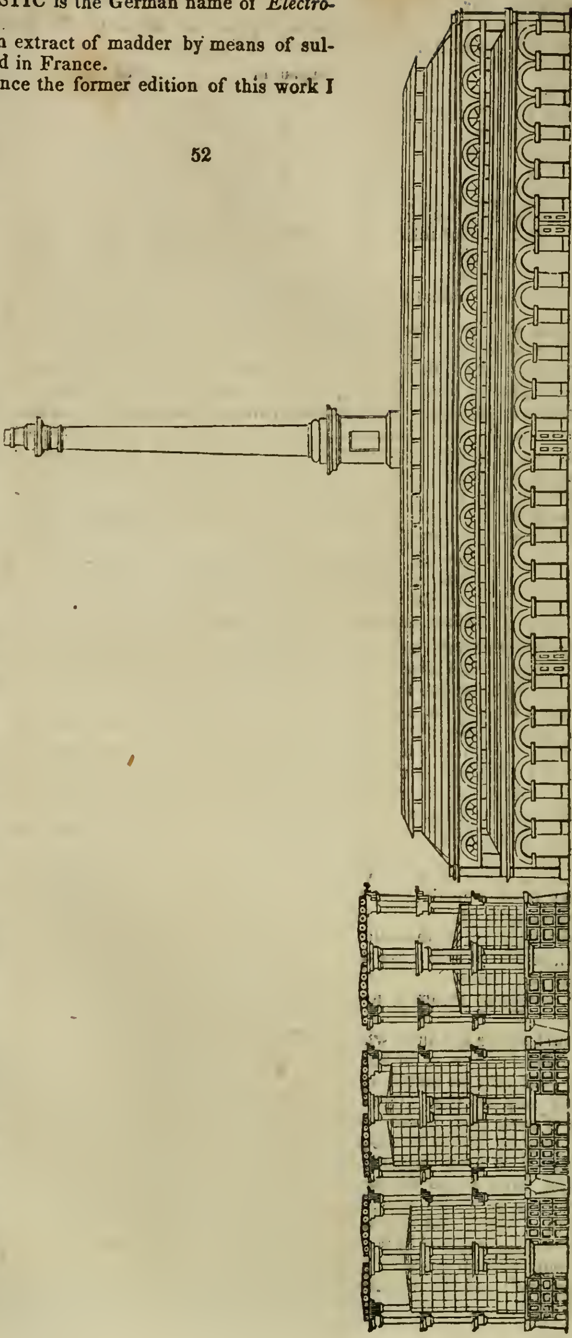

Fig. 53, is the plan of the retort house, coal stores, tanks, gas-holders, &c., on the largest scale and most approved form, viz., A, the retort house, 300 feet long, 56 feet wide; B, retort beds; C, chimney stack; D, flues; E, hydraulic mains; F, coal stores, each 300 feet long, 30 feet wide; G, condensers; H, engine houses; J, wash

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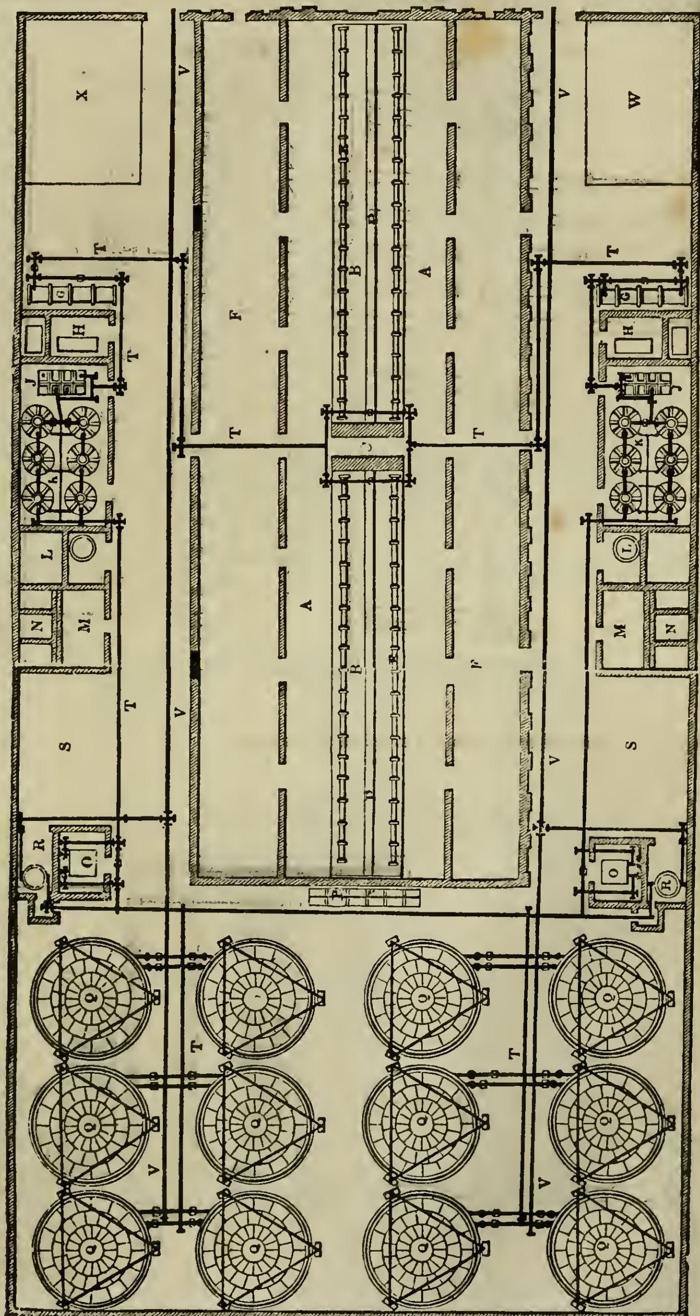

vessels; K, purifiers and connexions; L, lime store and mixing tub; M, smiths' and fitters' shop; N, refuse lime pits; O, meter-house; P, tar tank; Q, tanks, gas-holders, bridges, columns, valves, and connexions; R, governors; S, coke stores; T, inlet pipes; V, outlet pipes; W, house and offices; X, stores.

Fig. 54. Transverse section and elevation of a bed of 5 D retorts; A, transverse section; B, elevation.

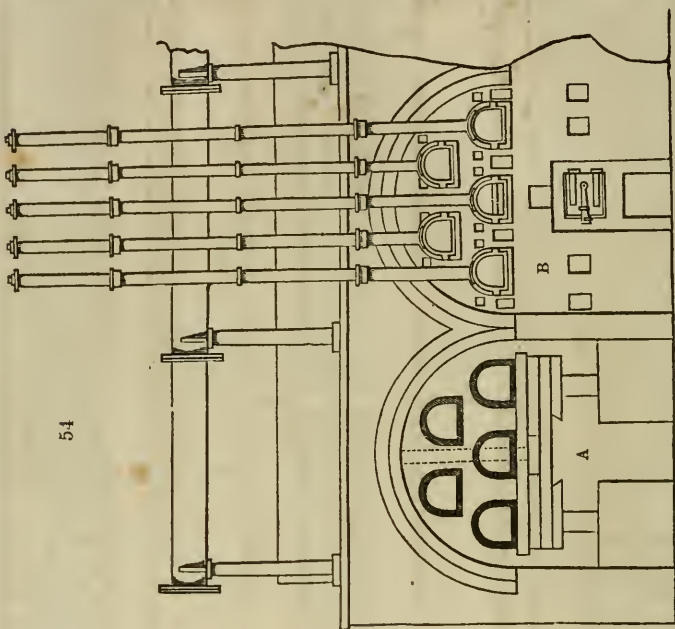

Fig. 55. Longitudinal section of a bed of 5 D retorts.

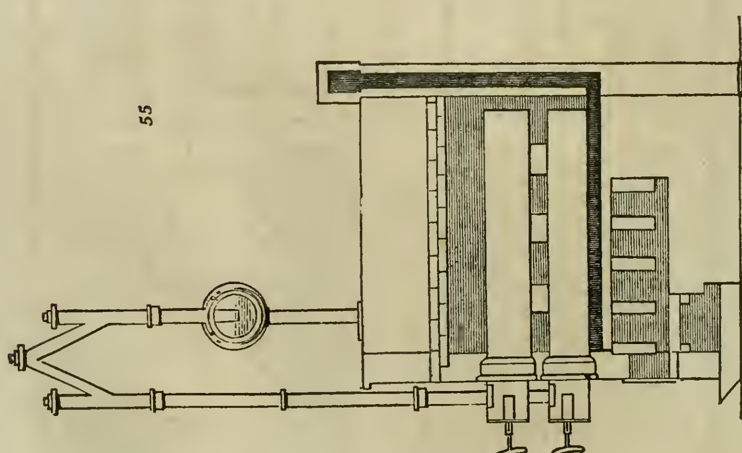

Fig. 56. Elevation of an upright air condenser, consisting of 5 chambers, with a series of 10-inch pipes.

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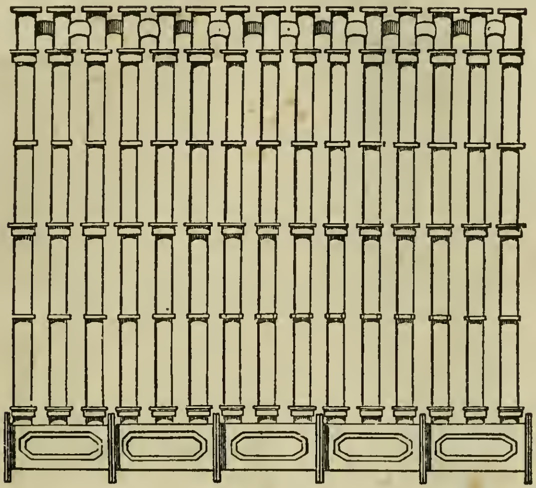

Fig. 57. Elevation of a double or telescopic gas-holder, of a modern and approved form, with part of tank.

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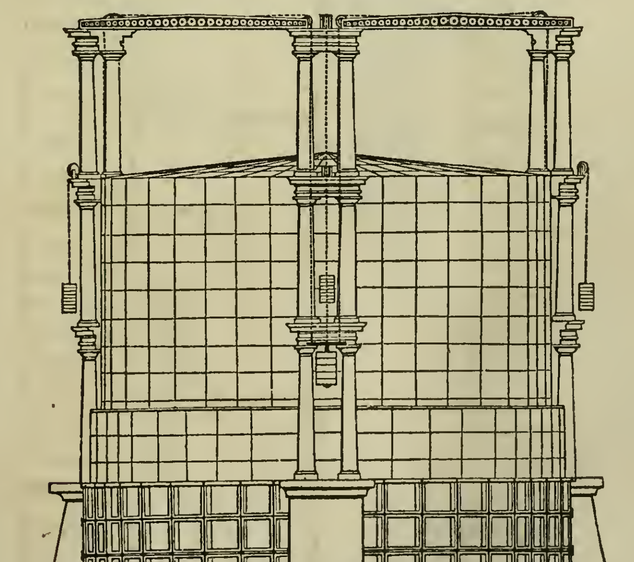

Fig. 58. End elevation and plan of air condenser; A, end elevation; B, plan.

Fig. 59. Set of 3 wet-lime purifiers and wash-vessels in elevation and section, with feed-heads, agitators, valves, and connexions, raised for the lime liquor to run from one purifier to the next below it, and ultimately into the refuse lime-pits, viz. A, section of wash vessel; B, section of purifier; C, elevation of purifier.

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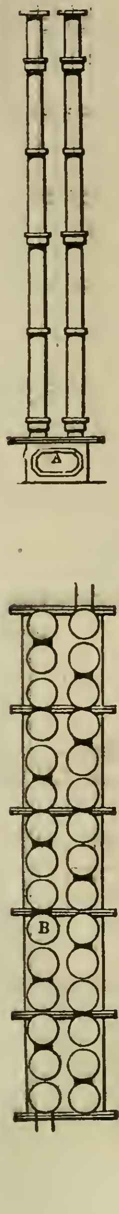

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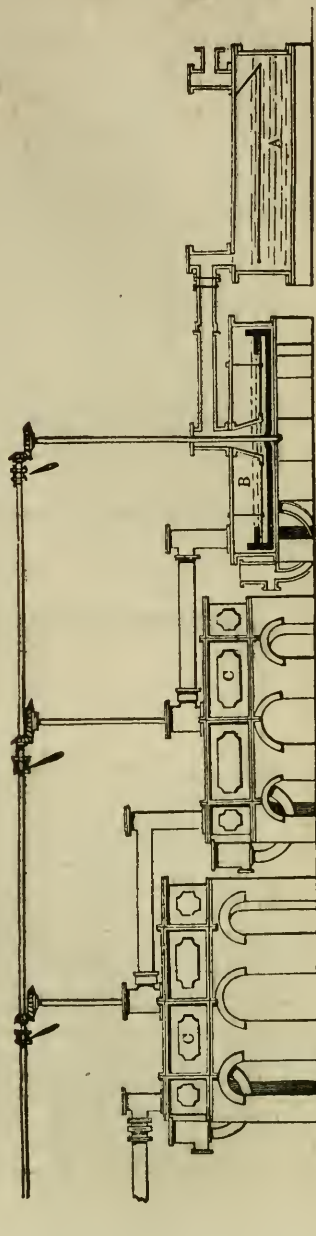

Fig. 60. Front elevation of gas works on a smaller scale, where dry lime is used.

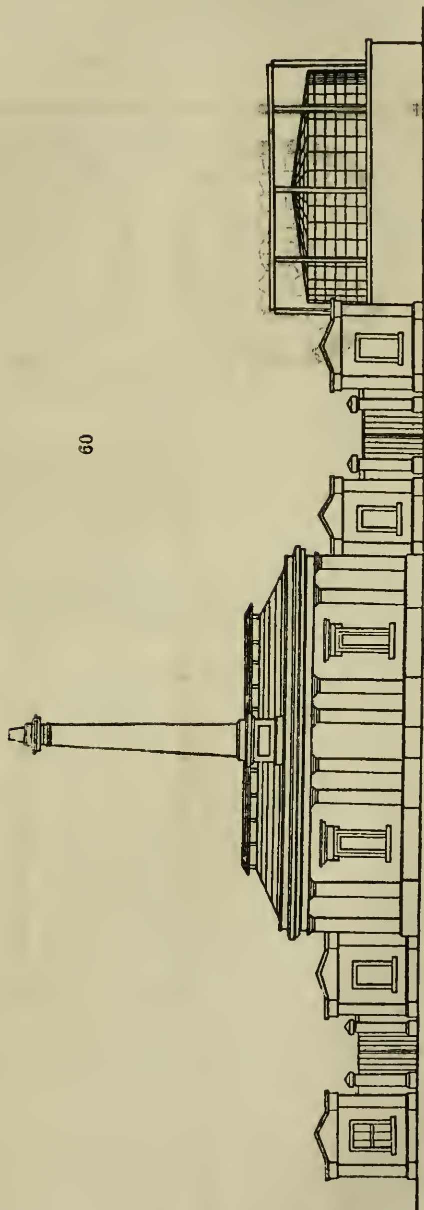

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Fig. 61. Plan of gas works, consisting of, viz.: A, retort house; B, retort beds; C, chimney stack; D, flue; E, hydraulic main; F, coal store: G, lime store; H, washer and purifiers; J, store; K, tar-tank; L, horizontal condenser laid on the ground; M, inlet pipe; N, outlet pipe; O, tanks and gas-holders; P, meter and governor; Q, smith's shop; R, office; S, coke store.

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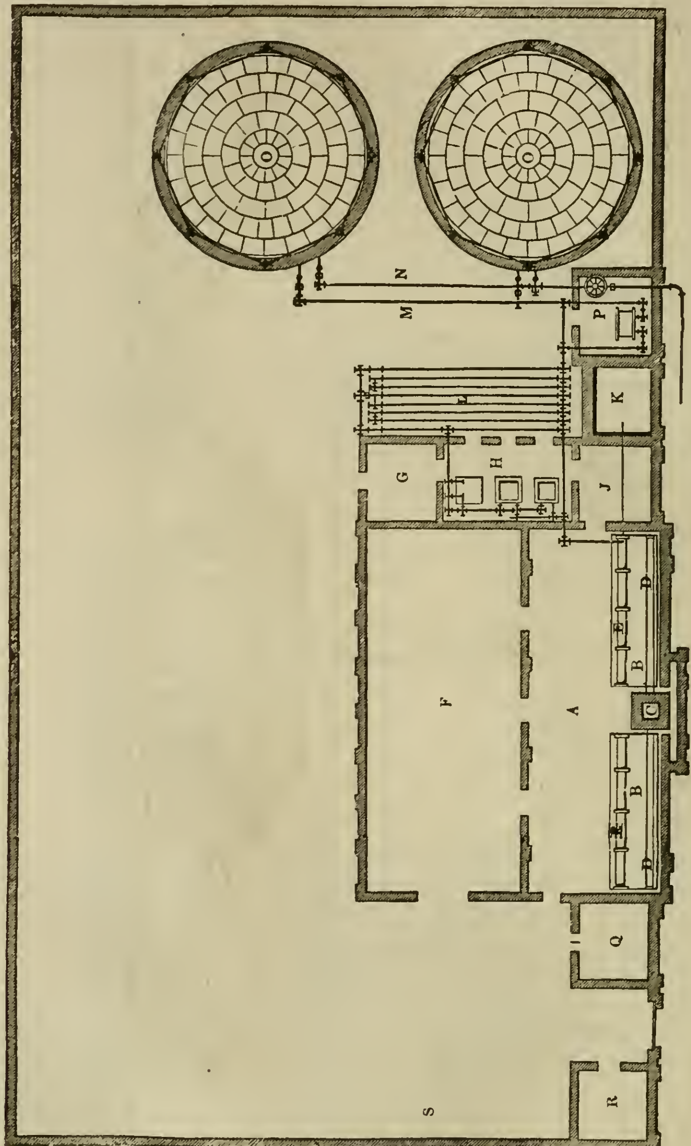
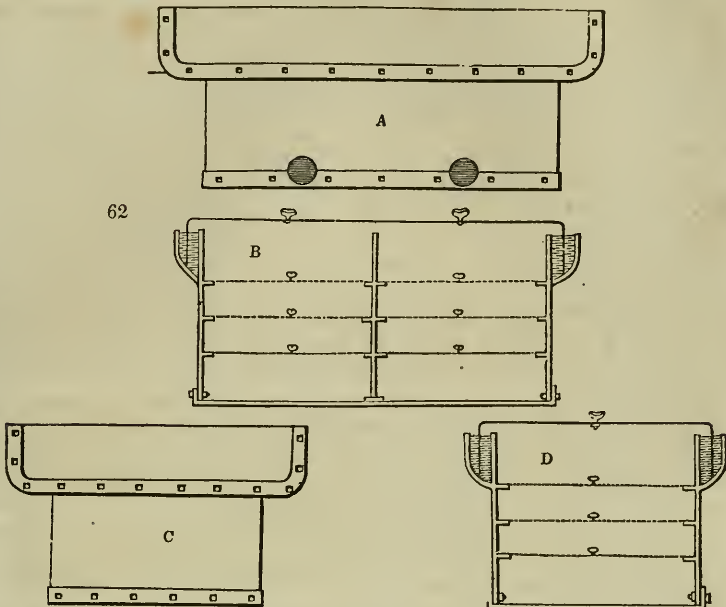


Fig. 62. Elevations and sections of dry-lime purifiers; A, longitudinal elevation; B, ditto section; C, transverse elevation; D, ditto section.



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I am well convinced that a distribution and arrangement of gas-works, combining effectiveness, economy, convenience, and elegance, at all equal to the preceding, have never before met the public eye, in this or any other country.

Trials of, and Experiments on, various Kinds of Coal as regards the Production of Gas from each, and its Quality or Illuminating Power; by Joseph Hedley, Esq., Consulting Gas Engineer, London.

Note.—In all the experiments the gas was passed through a governor, on a pressure of 5 10ths of an inch.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.
Name and Description of Coal.	Through an Aperture or Tube without a Burner, 2 10ths of an Inch, turned full on.—Height of Flame.	Gas Consumed per Hour by ditto.	Single Jet Hole, 28th of an Inch Diameter, turned full on.—Height of Flame.	Gas consumed per Hour by ditto.	Single Jet Flame, restricted to 4 Inches High, consumed per Hour.	Equal in Illuminating Power to	Argand with 20 Holes; outer Diameter 9 10ths of an Inch; inner ditto 6·4 of an Inch; Holes 40th of an Inch Diameter; Distances apart, 1 10th of an Inch; full Illuminating Power equal to 12 Candles; consumed per hour.	Arranged with 30 Holes; outer Diameter 1 1-4 Inch; inner ditto 7-8 of an Inch; Holes 40th of an Inch Diameter; Distances apart, 1-10th of an Inch; full Illuminating Power equal to 25 Candles; Consumption per Hour.	Specific Gravity.	Total Production of Gas from 20 lbs. of Coal, and Duration of Charge.		At End of 1st Half-hour.	2d Half-hour.	3d ditto.	4th ditto.	5th ditto.	6th ditto.
	Inch'a	Cubic Feet.	Inches.	Cubic Feet.	Cubic Feet.	Candles	Cubic Feet.	Cubic Feet.	Parts of 1·000.	Cubic Feet.	Hours.	Cubic Feet.	Cubic Feet.	Cubic Feet.	Cubic Feet.	Cubic. Feet.	Cubic Feet.
Lismahago, or Glasgow Cannel - - - -	21to22	12	7½	12·1	7·2	2·77	2·3	3·9	·737	101	2½	39	27	22	11	2	
Newcastle coal	18	16	6	16·2	11·1	1·75	5·	7·5	.475	104	3	30	20	18	15	15	6
Welsh Cannel	22	11	9	12·1	7·1	3·	2·	3·	·737	102	2	50	30	20	2		
Pelaw, Newcastle Coal -	18	16	5½	16·1	11·1	1·75	5·	7·5	·444	102	3	29	20	17	16	14	6
Pelton, ditto -	18	16	5¾	16·2	11·2	1·73	5·	7.5	.437	102	3	28	20	19	16	14	6
Bickerstaff, Liverpool ditto	19	14	6½	16·2	11·1	2·04	4·6	6·6	.475	102	3	30	24	18	16	10	4
Wigan Cannel	22	12	8½	13·1	7.2	3·	2·	3·	.606	100	2½	38	30	18	10	4	
Blenkinsopp, Carlisle Coal	27	16	6½	16·1	11·1	1·87	4·6	7.	·521	100	3	28	24	18	18	10	2
Neath Coal -	18	16	7	19·1	12·1	1·75	5·22	7·5	·468	100	3	26	21	20	14	12	7

Note.—The candle here used was a composition candle, with plaited wick, requiring no snuffing giving at least one third more light than mould tallow candles.

Attention to the preceding tabular statement of experiments is important, as exhibiting several very important facts, particularly interesting at this moment to the science of gas-lighting, *and now for the first time made public.*

It will not fail to be observed by these experiments that all the coals produced nearly equal *quantities* of gas, notwithstanding the variable characters and qualities of the coal. The greatest quantity produced being at the rate of 11·648 cubic feet per ton of 20 cwt., the smallest 11·200 cubic feet. All these experiments were performed with the greatest care, and under *precisely similar circumstances* as to pressure, manufacture, &c., &c. The *time* in which the *quantity* of gas is produced from the several coals varies considerably, and deserves notice, as it most materially affects the economy of production —*that coal being the most valuable*, all other things being alike, which yields or gives out its gas in the *shortest time;* and particular attention is claimed to this fact. For the more ready reference to the table the columns are numbered. No. 11 exhibits this difference, and it will also be seen by this column that the *time* varies as the *quality* of the coal, the best coal yielding its gas in *two* hours, and the worst in *three* hours.

Another most important, material, and interesting fact is established by these experiments—that the *flow of gas* is *as its density*—demonstrated by the variation in the heights of the flames, as shown in column No. 1, being 18 inches in the inferior gases to 22 inches in the superior; while the quantity of gas required to supply these flames is in the inverse ratio of their heights, the *longer* flame requiring but *twelve* cubic feet to maintain it, when the *shorter* flame, from the inferior gas, required *sixteen* cubic feet. See column No. 2.

Remarkable as this difference in the heights of the flames and the consumption is, it is not so great as the difference caused by the quality or illuminating power of the several gases, shown by columns Nos. 5 and 6; where it will be seen that the consumption of the best gas per hour was only $\frac{7}{10}$ of a cubic foot, and its light was equal to 3 candles, while that of the worst gas was $\frac{12}{10}$ of a cubic foot, and its lights equal only to 1·75 candles, or nearly, the best to the worst, as 1 to 3.

The next column, No. 7, exhibits similar results as to the superior value or illuminating power of one gas over another. In this case an *argand burner* was used. The best gas required only *two* feet to be equal to *twelve* candles, while the inferior required *five* feet to be equal to the same.

And in column No. 8, in which another and superior *argand burner* was used, the best gas required only *three* feet to be equal to *twenty-five* mould candles, while the inferior required *seven and a half* feet: from this it results that the 7½ cubic feet of inferior gas, to be equal to the 3 feet of good gas, should have given light equal to *sixty-two and a half* candles, whereas they only gave light equal to *twenty-five* candles; *so great is the difference in the* QUALITIES *of gas for producing light.*

While on the subject of the illuminating power and the value of one gas over another, it will not fail to be observed, by the table, that another great difference also exists, caused by the use of particular burners; as, for example, the best gas in column No. 5, where the single jet was used, required *seven tenths* of a cubic foot to be equal to *three* candles, while the same gas in column No. 7, where a 20-hole argand burner was used, required only *two* feet to be equal to *twelve* candles; and in column No. 8, where a 30-hole argand burner was used, only *three* feet was required to be equal to *twenty-five* candles; demonstrating the fact that a great and extraordinary improvement in the quantity of illuminating power is effected by the simple increase or enlargement of the burner, affording, where great light in one position is required, a most extraordinary economy in the use of gas, shown in fact practically by the recent introduction of the celebrated "Bude" light, patented by Mr. Goldsworthy Gurney.

TABULAR STATEMENT, deduced from the foregoing experiments, showing the cost of candles to produce as much light as 9,000 cubic feet of gas would afford, being the product of one ton of coal. (The candles are moulds, 6 to the pound, 9 inches long, and each candle is calculated to burn 9½ hours. Cost of candles 7½*d.* per pound, or 7*s.* 6*d.* per dozen pounds.)

Candles would cost, to be equivalent to	Where a single jet burner is used.	Where a 20-hole argand burner is used.	Where a 30-hole argand burner is used.	Where a Bude burner is used according to statement of company.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Common coal gas - -	10 18 6	15 15 8	21 18 0	59 2 7
Good do. - -	25 18 4	39 9 6	54 16 7	148 0 9

TABLE, also deduced from the foregoing, showing the Cost of Gas at the several Prices undermentioned, and equivalent to 100 pounds of Mould Candles, costing 3*l*. 2*s*. 6*d*.

Description of Gas	If burnt in in a single Jet Gas equal to 100 lbs. of Mould Candles.	Gas would cost at per thousand Cubic Feet.			If burnt in a 20 hole Argand Burner, Gas equal to 100 lbs. of Candles.	Gas would cost at per thousand Cubic Feet.			If burnt in a 30 hole Argand Burner. Gas equal to 100 lbs. of Candles.	Gas would cost at per thousand Cubic Feet.		
	Cub. feet	5*s*.	7*s*.	9*s*.	Cub. feet.	5*s*.	7*s*.	9*s*.	Cub. feet.	5*s*.	7*s*.	9*s*.
		s. d.	*s. d.*	*s. d.*		*s. d.*	*s. d.*	*s. d.*		*s. d.*	*s. d.*	*s. d.*
Common	2,687	13 5	18 9	24 2	1,781	8 10	12 5	16 0	1,282	6 5	8 11	11 6
Good -	1,072	5 4	7 5	9 7	712	3 6	4 11	6 4	513	2 7	3 7	4 7

In the brief description of the meter given in the Dictionary, I omitted to state, that this most ingenious scientific contrivance for measuring aeriform or gaseous fluids as they flow through pipes is the invention of Samuel Clegg, Esq., Civil Engineer, of London, Manchester, Liverpool, Birmingham, Chester, Bristol, &c., &c., in all which places he has erected gas-works. To this gentleman's genius and skill the public are mainly indebted for many valuable improvements in the application of gas from coal to purposes of illumination.

Brought up in the great engineering establishment of Messrs. Boulton and Watt, at Soho, near Birmingham, he became connected with Mr. William Murdoch, who most undoubtedly was the author and originator of gas-lighting, as the evidence given before a committee of the house of commons in the year 1809 abundantly verified. He demonstrated that the light produced from gas was superior in economy to all other modes of artificial illumination; and by that evidence, though so long back as 1809, it will be seen that all the information of the present day was even then known to him, clearly pointed out, and illustrated by his experiments, which strangely contrasted with the statements put forward by the parties then attempting to introduce this mode of lighting into the metropolis. All the ephemeral plans of those parties have, however, long since disappeared, or nearly all. One, unfortunately, remains, and that a most unlucky one—the unprofitable manufacture of coke in gas-making—an article worthless in the scale of value, which should never have been sought for. Messrs. Watt and Murdoch predicted that when the parties became incorporated by parliament, they would resort to *their* apparatus, notwithstanding their repudiation of it at the time, alleging their own schemes to be so much superior; and they verified this prediction a very few years afterward by engaging the services of Mr. Clegg, to extricate them from their manifold and egregious errors. He began by introducing the very apparatus of Messrs. Murdoch and Watt, so inconsiderately condemned by them.

Mr. Clegg put up the *first* gas-holder ever erected in London.

To Mr. Clegg is due also the introduction of lime for the purification of the gas, without which gas-lighting would to this day have afforded little comfort and economy. The hydraulic main, for separating the gas *making* from the gas *made*, valves, lutes, and many other admirable contrivances, are peculiarly due to Mr. Clegg. But the crowning performance of all his inventions, was that for measuring out the gas to the several parties requiring it exactly according to their demands. The manufacture of gas having by this time been so far mechanically perfected as to be brought to our doors, it became at once apparent that some contrivance should be found by the use of which every person might consume as much or as little gas as he pleased, paying only for what he really used, thus making science subservient to fair dealing.

Mr. Clegg took out a patent for the gas-meter about the year 1814; but great as its merits were, he soon found that serious difficulties remained to be overcome, in inducing parties to support and encourage its use, even where their interests should have prompted them to adopt it. Mr. Clegg had, however, fortunately associated with him, toward the completion of the apparatus, Mr. Samuel Crosley; and by their joint labors it acquired its present precision.

The value of the meter is *primarily* to the gas companies, *next* to the public. By its use, the gas companies are enabled to supply gas to all places where light is required, at a rate proportioned to its just value. The public thereby see the economy afforded by gas over candles, oil, or other material; but they gain also in another most important way—by the use of the meter, gas companies, being duly paid, are enabled to *reduce* the *price of gas*, and *yet realize equal profits*, thus bringing it within the reach of a much larger class of the community; and it is a well-established fact that in towns where gas is sold by meter, gas companies can and do sell at nearly one half the price they otherwise could do.

Reduction of price increases demand; increased demand increases profits; increased profits again enable prices to be reduced; and again, reduced prices increase the demand, thus benefiting reciprocally companies and consumers.

Notwithstanding, however, all these advantages, there are not wanting persons who have set up an outcry against the use of the meter, by impugning its accuracy, and accusing the gas companies with fraud in charging by it. It would be idle to follow these parties in their baseless allegations. An action for pirating it was brought and tried in the Court of King's Bench, in which not only the novelty of the machine was fully established, but its accuracy and usefulness proved by the ablest mathematicians, mechanicians, and chemists of the day; and a verdict in its favor obtained. Subsequently very large damages have been given for the infringement—in one case as much as 5,000*l*., and in another, in the court of chancery, a decree was made referring it to the master, to take an account of the profits made by the use of the meter; this is not yet finally settled, the master's report finding 6,000*l*. to be due; but this is excepted to by the parties infringing: the chancellor, however, allowed the exceptions to be argued, only on payment by the infringers of 4,000*l*. into court to meet the patentee's law costs. These exceptions have no reference whatever to the question of the accuracy of the meter, but are simply as to whether the advantages of the meter were as great as allowed by the master.

The patent for the meter expired about the year 1828; since that period numerous competitors have commenced making the machine.

Mr. Clegg has recently obtained a patent for a *dry* gas-meter, of which the following are its advantages and construction, as described by the very meritorious inventor:—

1. Working without water.
2. Working without membranes or valves.
3. Working without requiring the least pressure.
4. Working without interference with the perfect steadiness of the lights.
5. Registering more accurately than any other meter.
6. Occupying only one tenth of the space of the common meters.
7. Being subject to little or no wear and tear.
8. And being cheaper.

Prices.—For plain meters—

	£	s.	d.
Three-light meter - - -	1	12	0
Six-light do. - - -	2	4	0
Twelve-light do. - - -	3	3	0

The highest numbers will be still cheaper in proportion.

Ornamental meters, appearing like handsome timepieces, for halls, living-rooms, committee-rooms, offices, counting-houses, &c., are charged extra, at *ten shillings each* and upward, according to pattern.

Description of Clegg's patent dry Gas-meter.

The two *figs.*, 63, 64, are half the full size of the apparatus, and the letters of reference are the same in both.

B, B, *fig.* 63, represents a cylindrical vessel, about three inches and three quarters diameter, and four 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* and *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.

C is a hollow brass box, called the heater, about four inches long, and half an inch broad, projecting out of the meter about one 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 by 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

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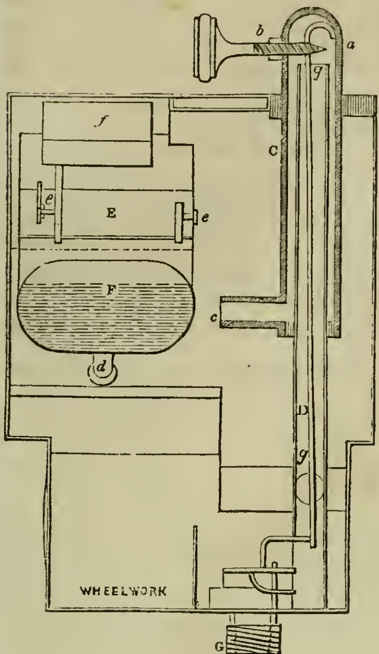

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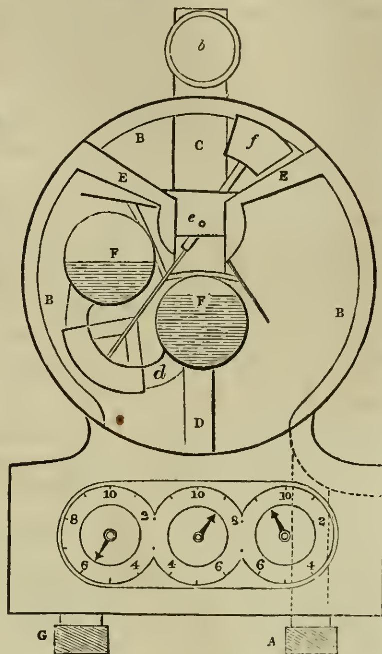


contact with the box, and not at all on the length of the jet. The jet being lighted, and the box C thereby heated, the gas which passes through it is raised to the same temperature, and, flowing out at the tube c, impinges on the glass cylinder which happens for the time to be lowest; the heated gas soon raises a vapor 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 EE, impinges on the upper cylinder, and hastens the condensation of the vapor 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 EE.

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.

Directions for fixing and using Clegg's patent dry Gas-meters.

Choose a situation for fixing the meter, where the small jet of flame will be of the greatest use, such as an office-desk or counter, taking care to screw the same firm and level on its base. When the jet at the top of the meter is required to be kept constantly burning as a useful flame, press in the brass knob at the front of the meter, and before lighting the burners pull it out; when the small flame is not required, let it be lighted about an hour before you want the burners lighted. Adjust the size of the small flame at pleasure by the screw *b*.

On the back of each meter is marked the number of lights it will supply.

The inlet and outlet pipes are marked at the bottom of the meter.

The quantity of gas consumed is recorded by the index in the usual way.

For testing Clegg's patent dry Gas-meters.

Pass the gas through two meters at least, and take the mean. Vary the number of lights at pleasure, not exceeding the number marked on the meter, and when one or two hundred cubic feet of gas have been consumed, compare the indices.

These meters are not for measuring small fractional parts; but taking the average for any periodical consumption, are more accurate than any other meter.

Mr. Thomas Edge, of Great Peter Street, Westminster, has contrived the following meter, of which drawings are annexed.

Fig. 65 is a front view of a three-light meter, the front plate being removed, and some of the parts shown in section 65.

65

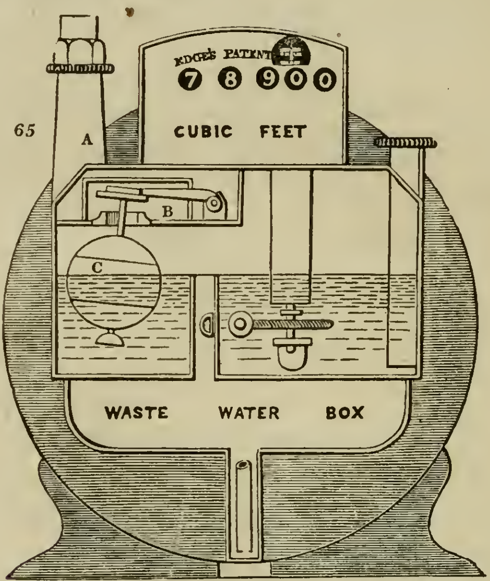
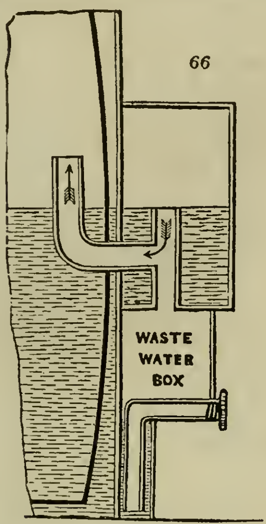


Fig. 66 is a transverse section of the same.

The gas enters at A into the small chamber B, in the bottom of which is a lever valve (part of Mr. Edge's patent improvements), moving upon its axis and attached by the rod to a metal float C, which in the present drawing is buoyant. The object of this arrangement is to intercept the passage of the gas into the meter, unless a sufficient quantity of water is in it, that being necessary to its proper action; the gas then passes through the inverted syphon or tunnel into the convex cover, whence it passes into the chambers of the drum.

Another of Mr. Edge's improvements consists in the cutting down of this syphon pipe or tunnel to the proper water level, and connecting the bottom of it to a waste water-box, into which any surplus water must fall. The importance of this precaution will be seen on investigating the drum, as an excessive height of the water will materially interfere with the measurement, the quantity of gas delivered per revolution being considerably less. This, in connexion with the lever valve and float, confines the variation of the water levels within such narrow limits, that the measurement may be considered perfectly just on all occasions.

66



The last patent by Mr. Edge is for an improved index, which is composed of a series of moving dials, with 10 figures upon each, one figure only appearing of each series at a time.

This contrivance is very ingenious, and will no doubt be applied to other machines, where indexes (*indices*) of quantity are required.

Recurring to Mr. Clegg, he is also the inventor of an instrument of great value—appropriately called a "governor." Its purpose is to render equal the height of flame of the several burners in any house or establishment, and to keep them so, notwithstanding any, and whatever alteration may be made in the pressure at the works or elsewhere. This instrument is perfected, and successfully applied, though it is not so generally in use as it ought to be. By the use of this instrument a light once set at the height desired will maintain that height uniformly, and without the least variation the whole evening; and continue to do so till altered.

Without this instrument, it is necessary to pay attention to the burning of gas-lights, as their heights are frequently affected by the most trifling circumstance, such, for example, as their extinction at the hour of closing the shops, which makes a sensible difference in the neighborhood.

All these works have prodigiously increased in the quantity of gas made and supplied. Since the account in the former edition of this work, large additional manufactories have been erected by new companies, and great additions made by the old ones. There are now in the metropolis alone 15 public gas companies, having among them 23 gas establishments. The quantity of gas manufactured by these 23 gas-works, and supplied to the public was during the past year three thousand one hundred millions of cubic feet of gas; and the coal used to produce this quantity of gas was at the least 400,000 tons!

Baked clay retorts are very generally used in Scotland, and found to be most economical as regards wear and tear; in London, however, they are mostly of cast iron.

The pressure upon the retorts is caused principally by the use of *wet lime*, used in London, because the process is less expensive and less cumbersome than dry lime. Wet lime can not be used with clay retorts, owing to this excess of pressure.

Merit is due, for enlarging the capacities of double gas-holders, to the late Mr. Joshua Horton, of West Bromwich, near Birmingham; and to Mr. Stephen Hutchinson, engineer of the New London Gas-Works, Vauxhall, where they were first successfully introduced, and manufactured by Mr. Horton. They have now come very generally into use throughout the kingdom, and are manufactured by all gas-holder makers.

Separate gas-holders are advisable and advantageous, but they are not generally used, except in Glasgow, Manchester, Birmingham, Sheffield, and a few other places.

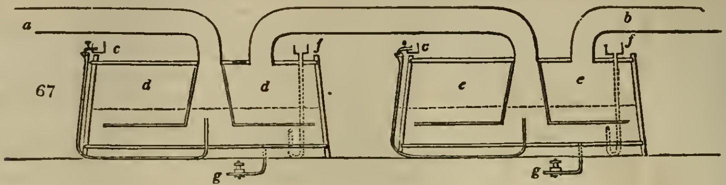
The annexed drawing represents Mr. Croll's vessels for the purification of gas from ammonia, which is effected by means of dilute sulphuric acid applied between the condensers with the ordinary lime purifiers. The vessels are made of either wood or iron, and lined with lead; have a wash-plate similar to the wet lime purifiers. The radiating bottom formed of wooden bars, as shown in the drawing, is for the purpose of supporting the wash-plate and distributing the gas.

Fig. 67: *a*, is the inlet pipe; *b*, the outlet pipe; *c*, *c*, the tube with funnel for introducing the sulphuric acid; *d*, the first purifying vat; *e*, the second ditto, both lined with lead, and which are filled up to the dotted line with the dilute acid; *f*, *f*, the water supply-pipe; *g*, *g*, the discharging cocks.

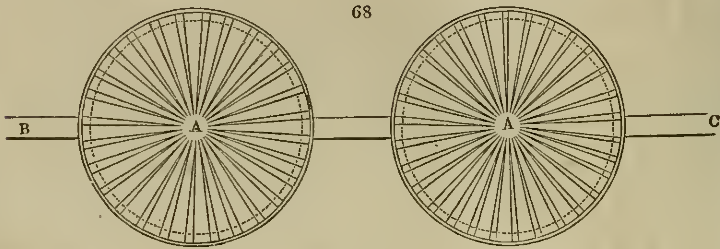
Fig. 68 represents a ground-plan of the vats, each 10 feet in diameter; A, the bottom of the middle; B, the inlet of the gas; C, the outlet of ditto.

In commencing the process, these vessels are charged with water and sulphuric acid, in the proportion of seven pounds, or thereabouts, of the latter, to 100 gallons of the former. As the acid is neutralized by the ammonia contained in the gas passing through the vessels, the above proportion, as near as may be, is kept up by a continuous dropping or running of acid, regulated according to the quantity of ammonia contained in the gas, from a reservoir placed on the top of the saturator. This mode of supplying the acid is continued until the specific gravity of the solution arrives at 1170, or close

67



68



to the point of crystallization, after which the supply of acid is discontinued, and the liquor retained in the vessel until neutral, when it is drawn off and evaporated, and yields a pure sulphate of ammonia.

This process has been introduced at several of the provincial gas-works, the three stations of the Chartered, the Imperial, Phœnix, &c., &c. Mr. Croll is also now in treaty with several other companies for its introduction.

The produce—sulphate of ammonia—from the process, by the gas-companies using it, now amounts to several tons per week—and it may be here mentioned, as one of the advantages of science, that the ammonia so produced before the adoption of this process passed along with the gas to the consumer, destroying rapidly the main pipes, fittings, and metres, through which it was transmitted, as well as deteriorating the illuminating power of the gas, and producing a choky effect when consumed in close apartments. It is now employed as a manure, and found to be superior in its effects as a fertilizer, as well as comparatively cheaper than any of the other artificial manures; so that whether Mr. C.'s invention be looked upon as affecting improvements in the manufacture of gas, hitherto unknown, or as producing a valuable manure, the results are alike of the utmost importance.

(When Mr. Croll's process is employed before the lime purifiers, dry lime can be used without creating the nuisance hitherto complained of, and a much less quantity is required for this purification.)

Mr. Croll has recently patented another invention, connected also with the manufacture of gas, which consists in the combination of clay and iron retorts, so that the heat of the furnace first acts on the clay retorts and then passes to those of iron.

The annexed drawing is a transverse section :—

A is the fireplace.

B B are piers of fire-bricks, placed at intervals to form nostrils or flues, and the fire tile resting upon them in conjunction with the front and back wall, form the bed or support of the clay retort 1, and the clay retort 2 is also supported by the front and back brickwork, and a lump, or fire-brick, E, placed midway on the crown of the retort 1.

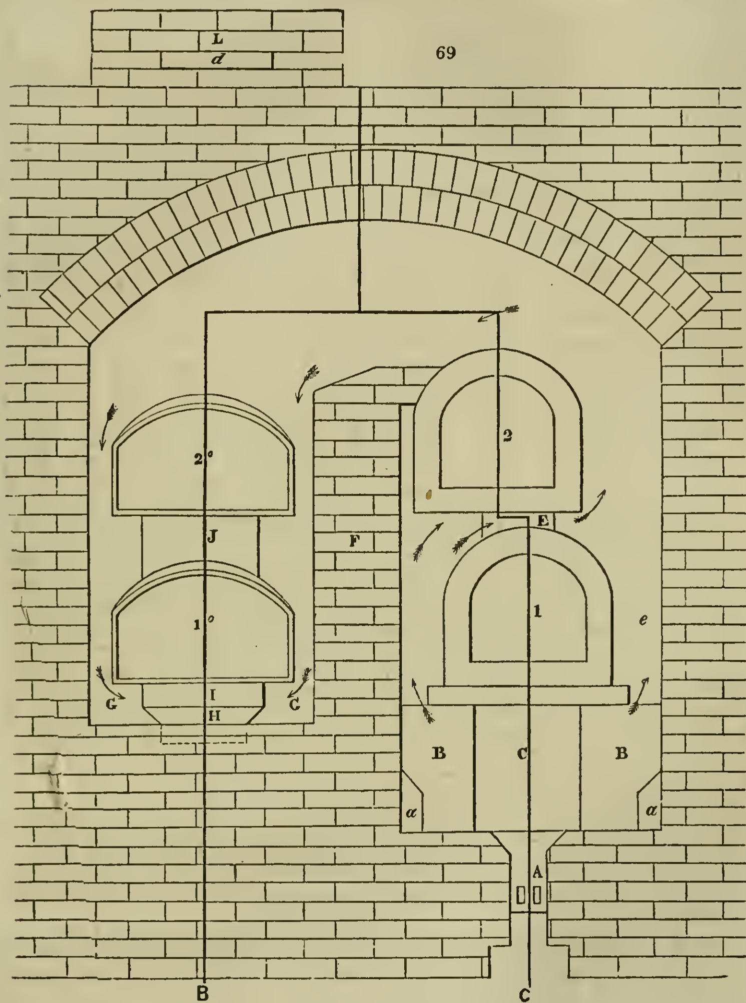
F is a wall which separates the clay retorts 1 and 2, and the iron retorts 1° and 2°; a space being left between the top of the said wall F, and the under surface of the arch, to allow the fire or heated air to pass freely from the clay to the iron retorts.

G G is the bed, and H H is the flue under the iron retort 1°. The retort 2° is supported by the front wall and pieces or lumps.

J, placed at the back and crown of the retort 1°, in connexion with the horizontal flue. H is a vertical flue, forming a passage thence into the shaft or chimney.

The heat passes from the furnace or fireplace A, through the spaces or nostrils formed by the piers B B, and around the clay retorts 1 and 2, over the wall F, descends between and around the iron retorts and along the flue H, and escapes by the vertical flue into the chimney. The advantages of this mode of setting retorts are the small quantity of brickwork necessary for the erections, the increased durability of the retorts, and the economy in fuel. From adopting this mode of setting a brick lump, it has been found that 12 tons of coke will carbonize 100 tons of coal.

69



L is the oimney stalk, and *d* is a damper or register plate for regulating the chimney draught.

Before disnissing Mr. Croll's patent improvements, it is proper to state, that the sulphuric acid ued for condensing the ammonia should be free from iron, otherwise the sulphurettedhydrogen of the coal gas is apt to give rise to sulphuret of that metal which will blacken he sulphate of ammonia and reduce its value in the market. An occurrence of this ind was recently brought professionally before me for investigation. The sulphuric aci had been made from pyrites.

Copy of a paper laid before a committee of the House of Commons, showing, not only the relative values of the gases produced at the under mentioned places, but showing in like manner the relative economy of gas, as produced at the different places, over candles. By Joseph Hedley, Esq.

Names of the Places where Experiments were made.	Illuminating power of a single Jet of Gas-flame four inches high, taken by a comparison of Shadows.	The Jet of Gas burnt, four inches high, consumed per hour and was equal to the Candles in the last column.	Gas required to be equal to 100 lbs. of mould Candles 6 to the lb., 9 inches long each.*	Selling price of Gas per meter per 1000 cubic feet.	Cost of Gas equal in illuminating power to 100 pounds of candles.†	Average discount allowed off the charge for Gas.	Net cost of Gas equal to 100 pounds of Candles.	Specific gravity of the Gas.
	Equal to Candles.	*Cubic Feet.*	*Cubic Feet.*	*s. d.*	*L. s. d.*	*Per Cent.*	*L. s. d.*	
Birmingham; Birmingham and Staffordshire; two Companies	2·572	1·22	2704	10 0	1 7 0	9	1 4 7	.541
Stockport	3·254	·85	1489	10 0	0 14 11	12½	0 13 0	·534
Manchester	3·060	·825	1536	8 0	0 12 3	11¼	0 10 10	
Liverpool Old Company‡	2·369	1·1	2646	10 0	1 6 5	6¼	1 4 9	·4
Liverpool New Gas Company	4·408	·9	1164	10 0	0 11 8	6¼	0 9 10	·580
Bradford	2·190	1·2	3123	9 0	1 8 1	12½	1 4 6	·420
Leeds	2 970	·855	1644	8 0	0 13 2	6¼	0 12 4	·530
Sheffield	4·434	1·04	2440	8 0	0 19 6	6¼	0 18 3	·466
Leicester	2·435	1·1	2575	7 6	0 19 3	15	0 16 5	·528
Nottingham	1.645	1·3	4200	9 0	1 17 9	15	1 11 3	·424
Derby	1·937	1·2	3521	10 0	1 15 4	15	1 10 0	·448
Preston	2·136	1·15	3069	10 0	1 10 8	15	1 6 2	·419
London	2·083	1·13	3092	10 0	1 10 11	none allowed.	1 10 11	·412

* 100 lbs. of candles are estimated to burn 5,700 hours. † The candles cost 3*l*. 2*s*. 6*d*.
‡ The Liverpool Old Company have since resorted to the use of Cannel coal, and consequently very nearly assimilated to the Liverpool New Company in illuminating power.

Memorandum.—It will not fail to be observed that in deducing the comparative value between candles and gas by these experiments, the single jet (and in every instance, of course, it was the same), has been the medium. This, however, though decidedly the most correct way of making the comparative estimate of the illuminating power of the several gases, is highly disadvantageous in the economical comparison, inasmuch as gas burnt in a properly regulated argand burner, with its proper sized glass, air aperture, and sufficient number of holes, gives an advantage in favor of gas consumed in an argand, over a jet burner, of from 30 to 40 per cent. At the same time it must not be overlooked that in many situations where great light is not requied, it will be found far more economical to adopt the use of single jets, which by means of swing brackets and light elegant shades, become splendid substitutes for candles, in banking establishments, offices, libraries, &c., &c.

Note.—In Glasgow, Edinburgh, Dundee, Perth, and the Scotch towns, generally, the Parrot or Scotch Cannel coal is used; in illuminating power and specific gravity the gas produced is equal to that from the best description of Cannel coal in England. The price per 1,000 cubic feet ranges about 9*s*., with from 5 to 30 per cent. off for discounts, leaving the net price about 9*s*., to be equal in the above table to 100 lbs. of candles.

Epitome of Experiments made in Gas produced from different qualities of coal, and consumed in different kinds of Burners, tried at the Sheffield Gas Light Company's Works, and laid before a Committee of the House of Commons. By Joseph Hedley, Esq.

Date 1835.	Description of Burner.	Species of Coal.	Specific Gravity of Gas.	Distance of Candle from Shadow	Gas consumed per hour.	Height of Gas-flame.	Equal to Mould Tallow Candles, 6 to the pound, 9 inches long each.	Gas equal to 100 pounds of Mould Candles.	Cost of Gas at 8 per 1000. cubic feet.	Cost of 100 lbs. of Mould Candles at 7*s*. 6*d*. per dozen lbs.
				Inches	*Cubic Feet.*	*Inches.*	*Candles.*	*Cubic Feet.*	*L. s. d.*	*L. s. d.*
May 8	Single Jet	Deep Pit	·410	75	1·	4	2·36	2415	0 19 3½	
9	Ditto	Mortormley	·450	74	·95	4	2·434	2224	0 17 9½	
9	Ditto	Cannel	·660	61¼	·7	4	3·54	1127	0 [illegible] 0	
8	Argand 14 holes	Deep Pit.	·410	34	3·3	3½	11·53	1631	0 1[illegible] 0½	3 2 6
9	Ditto	Mortormley	·450	33	3·1	3½	12·24	1443	0 1[illegible] 6½	
9	Ditto	Cannel	·660	29	2·6	3½	15·85	935	0 [illegible] 5¾	

Copy of Experiments made at the Alliance Gas Company's Works in Dublin, during the past year 1837. By Joseph Hedley, Esq.

Results of experiments on the qualities of various coals for the production of gas; its value in illuminating power; produce of coke, and quality; and other particulars important in gas-making:—

1st Experiment, Saturday, May 27th, 1837.—Deane coal (Cumberland), 2 cwt. of 112 lbs. each (or 224 lbs.) produced 970 cubic feet of gas; 4 bushels of coke of middling quality; specific gravity of the gas, 475. Consumed in a single-jet burner, flame 4 inches high, $1\frac{4}{10}$ cubic feet per hour; distance from shadow 76 inches or 2·3 mould candles. Average quantity of gas made from the charge (6 hours) 4·33 cubic feet per lb., or 9,700 cubic feet per ton of 20 cwt. Increase of coke over coal in measure, not quite 30 per cent. Loss in weight between coal, coke, and breize, 56 lbs., converted into gas, tar, ammonia, &c.

2d Experiment, May 28th.—Carlisle coal (Blenkinsopp). 224 lbs. produced 1,010 cubic feet of gas, 4 bushels of coke of good quality though small; increase of coke over coal in measure not quite 30 per cent. Loss in weight, same as foregoing experiment. Average quantity of gas made from the charge (6 hours) 4·5 cubic feet per lb. or 10,080 per ton.

Illuminating Power of the Gas.

	Consumed per hour, single jet.	Distance from candle.	Equal to candles.	Specific gravity.
	Feet.	*Inches.*		
At the end of the 1st hour -	$1\frac{1}{10}$	70	2·72	·475
Ditto ditto with 20-hole argand burner - - -	5	25	21·33	·475
When charge nearly off - -	$1\frac{4}{10}$	85	1·84	·442
When charge quite off, with 20-hole argand burner - -	9	100	not 1	·266

3d Experiment, May 29th.—Carlisle coal (Blenkinsopp). 112 lbs. produced 556 cubic feet of gas. Other products, loss of weight, &c., same proportion as foregoing experiment. Average quantity of gas made from the charge (6 hours) 4·96 cubic feet per lb., or 11,120 per ton.

In this experiment the quantity of gas generated every hour was ascertained; the illuminating power, the specific gravity, and the quantity of gas consumed by the single jet with a flame 4 inches high, was tried at the end of each hour, with the respective gases generated at each hour; and the following is a table of results.

RESULTS.

Hour.	Gas produced.	Consumed per hour per single jet, 4 inches high.	Specific gravity.	Distance of candle from shadow.	Illuminating power equal to mould candles.
	Cubic Feet.	*Cubic Feet.*		*Inches.*	
1st.	150	$11\frac{1}{2}$ 10ths. or 1·15	·534	70	2·72
2d.	120	11	·495	75	2·36
3d.	95	12	·344	75	2·36
4th.	95	15	·311	80	2·08
5th.	80	17	·270	85	1·81
6th.	16	29	·200	100	not one.
Total	556				

Average of the above gas, 6-hour charge.

$92\frac{2}{3}$	16 10ths. nearly	·359	81	2·03

Average of the above gas, at 4-hour charge.

115	$12\frac{1}{2}$ 10ths.	·421	75	2·36

Production of gas in 6 hours, 556 feet, or at the rate of 11,120 cubic feet per ton.
Ditto in 4 hours, 460 feet, or at the rate of 9,200 ditto.

The relative value of these productions of gas is as follows, viz :—

11,120 at 16 10ths per hour nearly (or 1.5916 accurately), and equal to 22·03 candles; the 11,120 feet would be equal to and last as long as 1,597 candles, or $266\frac{1}{6}$ lbs. of candles.

9200 at $12\frac{1}{8}$ 10ths per hour (or 1·2375 accurately), and equal to 2·36 candles; the 9,200 feet would be equal to 1,949 candles, or $324\frac{5}{6}$ lbs. candles.

Now $266\frac{1}{6}$ lbs. of mould candles, at 7*s.* 6*d.* per dozen lbs. will cost 8*l.* 6*s.* $4\frac{1}{2}$*d.*; while
$324\frac{5}{8}$ lbs. of do. do. at 7*s.* 6*d.* per do. do. 10*l.* 3*s.*

Showing the value of 4-hour charges over 6-hour charges; and of 9,200 cubic feet over 11,120 cubic feet.

Note.—9500 cubic feet of Wigan cannel coal gas are equal in illuminating power to 859 1-6 lbs. of candles, which at 7*s.* 6*d.* per dozen lbs., will cost 25*l.* 10*s.* $5\frac{1}{2}$*d.* It is also found that any burner with superior gas, will consume only about half the quantity it would do with common gas.

4th Experiment, May 30th.—Cannel and Cardiff coal mixed $\frac{1}{2}$ and $\frac{1}{2}$, together 112 lbs., produced 460 feet of gas, 2 bushels of coke of good quality; increase of coke over coal in measure about 30 per cent.; loss in weight 41 lbs.; coke weighed 71 lbs., no breize. Average quantity of gas made from the charge (4 hours), 4·1 cubic feet per lb., or 9·200, per ton.

Illuminating Power.—At end of first hour,

	Candles.		Cubic feet.
Distance of candle from shadow - -	73 or 2·49	Consumed per hour, single jet, 4 inches high -	12 10ths.
At end of 2d hour, do.	70 or 2·72	Do. do. do.	$11\frac{1}{2}$ 10ths.
At end of 3d hour.	This gas very indifferent.		
Average of the three -	70 or 2·72	Do. do. do.	$11\frac{1}{2}$ 10ths.

Specific gravity 3·44; 5 feet per hour, with a 20-hole argand burner, equal to 14·66 candles.

5th Experiment, May 31st.—Carlisle coal, 112 lbs. produced 410 feet of gas; other products, same as in former experiments with this coal, but heat very low.

Illuminating Power and Produce of Gas.

410 feet	1st hour	120 cubic feet.	Average of this gas: specific gravity, 540; distance of candle from shadow, 55 inches, or 4·4 candles consumed per single jet, 9 10ths of a cubic foot per hour 20-hole argand burner, 4 feet per hour, equal to 21·33 candles.
	2d	100	
	3d	90	
	4th	100	

It is possible, from the superior quality of this gas, that a little of the cannel gas made for a particular purpose may have got intermixed with it in the experimental gas-holder and apparatus.

Various other experiments were tried on different qualities of coal, and mixtures of ditto, too tedious to insert here, though extremely valuable, and all tending to show the superior value of gas produced at short over long charges; and also showing the importance and value of coal producing gas of the highest illuminating power; among which the cannel coal produced in Lancashire, Yorkshire, and some other counties of England and Wales, and the Parrot or splent coal of Scotland, stand pre-eminent.

Note.—In all the foregoing experiments the same single-jet burner was used; its flame in all instances exactly 4 inches high.

The coal when drawn from the retort was slaked with water, and after allowing some short time for drying, was weighed.

A Table of the Number of Hours Gas is burnt in each Month, Quarter, and Year.

Time of Burning.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apl.	May.	June	Mid. quar.	Mic. quar.	Xms. quar.	Lady day quar.	Totl. of Year	
o'clock.																		
From Dusk to 6	—	—	2	31	62	80	65	33	4	—	—	—	—	2	173	102	277	For Sundays off deduct one seventh.
7	—	14	22	62	92	111	96	61	31	4	—	—	4	36	265	188	493	
8	—	40	52	93	122	142	127	89	62	28	4	—	31	92	357	278	759	
9	13	71	82	124	152	173	158	117	93	58	29	8	95	166	449	368	1078	
10	44	102	112	155	182	204	189	145	124	88	60	38	186	258	541	458	1443	
11	75	133	142	186	212	235	220	173	155	118	91	68	277	350	633	548	1808	
12	106	164	172	217	242	266	251	201	186	148	122	98	368	442	725	638	2173	
All night -	217	307	345	421	473	527	512	411	382	295	242	195	732	869	1421	1305	4327	
Morning from 4	—	16	48	80	110	137	137	98	71	28	2	—	30	64	327	306	727	
5	—	—	18	49	80	106	106	70	40	3	—	—	3	18	235	216	472	
6	—	—	—	18	50	75	75	42	9	—	—	—	—	—	143	126	269	
7	—	—	—	—	20	44	44	14	—	—	—	—	—	—	64	58	122	

A **Table** showing the Rate per Thousand Cubic Feet received for any Burner consuming from $\frac{1}{2}$ a Cubic Foot to 10 Cubic Feet per Hour, at any given Price per Annum, and to the Times below stated. By Joseph Hedley, Esq.

Time of Burning per Annum.	No. of hours.*	Single Jets.			Two Jets.			Three Jets.			Small Argand.			Large Argand.			Fancy and extravagant Burners.		
		Cub. ft. $\frac{1}{2}$	Cub. ft. $\frac{3}{4}$	Cub. ft. 1	Cub. ft. $1\frac{1}{4}$	Cub. ft. $1\frac{1}{2}$	Cub. ft. $1\frac{3}{4}$	Cub. ft. 2	Cub. ft. $2\frac{1}{2}$	Cub. ft. 3	Cub. ft. $3\frac{1}{2}$	Cub. ft. 4	Cub. ft. $4\frac{1}{2}$	Cub. ft. 5	Cub. ft. 6	Cub. ft. 7	Cub. ft. 8	Cub. ft. 9	Cub. ft. 10
From dusk to 8 o'clock - - - - - -	781	2·56	1·706	1·28	1·026	·853	·731	·64	·5132	·4268	·3658	·3201	·2846	·2561	·2134	·1829	·16	·1423	·128
ditto and Sundays - - -	902	2·216	1·478	1·108	·887	·739	·633	·554	·4434	·3695	·3168	·2771	·2464	·2217	·1848	·1584	·1383	1232	·1108
ditto and from 6 o'clock mornings	1050	1·904	1·27	·952	·762	·635	·544	·476	·381	·3174	·272	·2381	·2116	·1905	·1587	·136	·119	·1058	·0952
ditto and Sundays and from ditto	1172	1·706	1·138	·853	·682	·569	·487	·426	·3412	·2844	·2438	·2133	·1896	·1706	·1422	·1219	·1067	·0948	0853
9 o'clock - - - - - - -	1054	1·896	1·264	·948	·759	·632	·542	·474	·3794	·3162	·271	·2371	·2108	·1897	·1581	·1355	·1185	·1054	·0948
ditto and Sundays - - -	1221	1·638	1·092	·819	·675	·546	·463	·409	·3376	·273	·234	·2047	·182	·1638	·1365	·117	·1024	·091	0819
ditto and from 6 o'clock mornings	1323	1·510	1·006	·755	·604	·503	·431	·378	·3022	·2519	·2158	·1889	·1678	·1511	·1259	·1079	·0945	·0839	·0755
ditto and Sundays and from ditto	1490	1·342	·894	·671	·536	·447	·383	·335	·2684	·2236	·1918	·1675	·1492	·1312	·1118	·0959	·0839	·0746	·0671
10 o'clock - - - - - - -	1367	1·462	·974	·731	·585	·487	·418	·366	·2926	·2438	·209	·1829	·1626	·1463	·1219	·1045	·0914	·0813	·0731
ditto and Sundays - - -	1586	1·26	·84	·63	·504	·42	·36	·315	·2522	·2101	·1802	·1576	·14	·1261	·1051	·0901	·0789	·07	·0630
ditto and from 6 o'clock mornings	1636	1·222	·814	·611	·489	·407	·349	·305	·2444	·2037	·1746	·1528	·1358	·1222	·1019	·0873	·0764	·0679	·0611
ditto and Sundays and from ditto	1855	1·078	·718	·539	·431	·359	·308	·269	·2156	·1796	·154	·1347	·1198	·1078	·0898	·077	·0674	·0599	·0539
11 o'clock - - - - - - -	1680	1·19	·794	·595	·476	·397	·34	·297	·238	·1984	·17	·1488	·133	·119	·0992	·085	·0744	·0665	·0595
ditto and Sundays - - -	1951	1·024	·682	·512	409	·341	·293	·256	·2048	·1707	·1466	·1281	·1138	·1024	·0854	·0733	·064	·0569	·0512
ditto and from 6 o'clock mornings	1949	1·026	·684	·513	·41	·342	·294	·256	·2052	·171	·1466	·1282	·114	·1020	·0855	·0733	·0641	·057	·0513
ditto and Sundays and from ditto	2220	·9	·6	·45	·36	·3	·257	·225	·1802	·1501	·1286	·1126	·1	·0981	·0751	·0643	·0563	·05	·045
12 o'clock - - - - - - -	1993	1·	·668	·502	·4	·334	·287	·251	·2006	·1672	·1434	·1254	·1114	·1003	·0836	·0717	·0627	·0557	·0502
ditto and Sundays - - -	2316	·862	·574	·432	·345	·287	·247	·215	·1726	·1439	·1236	·1079	·0958	·0863	·0719	·0618	·0539	·0479	·0432
ditto and from 6 o'clock mornings	2262	·884	·59	·442	·353	·295	·255	·221	·1768	·1476	·1274	·1105	·0982	·0884	·0737	·0637	·0552	·0491	·0442
ditto and Sundays and from ditto	2585	·772	·514	·387	·309	·257	·221	·193	·1546	·1289	·1104	·0967	·0858	·0773	·0645	·0552	·0483	·0429	·0387
1 o'clock - - - - - - -	2306	·866	·578	·434	·347	·289	·247	·217	·1734	·1445	·1238	·1080	·0962	·0867	·0723	·0619	·0542	·0481	·0434
ditto and Sundays - - -	2681	·746	·498	·373	·298	·249	·213	·186	·1492	·1243	·1066	·0932	·0828	·0746	·0621	·0533	·0466	·0414	·0373
ditto and from 6 o'clock mornings	2575	·776	·518	·388	·31	·259	·222	·194	·1552	·1294	·111	·0971	·0862	·0776	·0647	·0555	·0485	·0431	·0388
ditto and Sundays and from ditto	2950	·678	·452	·339	·271	·226	·193	·169	·1356	·113	·0968	·0847	·0754	·0678	·0565	·0484	·0424	·0377	·0339
All night - - - - - -	4327	·462	·308	·231	·185	·154	·132	·115	·6924	·077	·066	·0578	·0515	·0462	·0385	·033	·0289	·0257	·0231

To use the Table.—Select the hour to which it is agreed the gas is to burn—9, 10, 11 o'clock, Sundays, &c., as the case may be, and the description of the burner.—Multiply the decimal number opposite to it by the amount in shillings agreed to be paid per annum, and the product will be the sum received per M. cubic feet for the gas.

Example.—Suppose a small argand which should burn $3\frac{1}{2}$ feet per hour, is agreed for till 9 o'clock at 2*l.* per annum. Look along the line at 9 o'clock till you arrive at the column of $3\frac{1}{2}$ feet per hour, and you find the number, 271. Multiply this number by 40*s.*, and the result gives 10*s.* 10*d.* per M. cubic feet. But suppose instead of keeping to 9 o'clock the party burns till 1 o'clock, Sundays and mornings, and by enlarging the holes or height of flame consumes 8 cubic feet of gas per hour; then you have the number, ·0424 which multiplied by 40*s.*, still the price paid, gives 1*s.* 8*d.* per M. cubic feet only, and so on for any greater or lesser variation of the agreement.

* The "number of hours" includes $\frac{1}{4}$ of an hour allowed for shutting shops, and 1 hour's extra burning on Saturday nights.

Copy of a Paper submitted to a Committee of the House of Commons in the Session of 1837, of England; and procured by actual Survey and

Name of the Place where Gas Works are situated.	Price of Gas per Meter, and Discounts allowed.	Price of Coal, and Description; delivered per Ton.	Average Quantity of Gas made per Ton of Coals.	Coke made from a Ton of Coal.	Selling Price of Coke.	Material usual to heat Retorts.	Quantity used per Ton of Coal.	No. of Public or Street Lamps supplied.	Description. — Size or Sort.	Price paid per Annum for Ditto.	Who lights, cleans, puts out, and repairs.
			Cu. ft.							*L. s. d.*	
Birmingham Gas Company	10*s.* per 1000 cub. feet. Discounts. 10*l.* to 30*l.* 2½ 30*l.* to 50*l.* 5 50*l.* to 75*l.* 7½ 75*l.* to 100*l.* 10 (per an. per cent.) 100*l.* & upward 15	Lump coal from West Bromwich pits risen much of late. 1837, 11*s.* 10*d.*	6,500	32 bushels.	2*s.* 1*d.* per quarter delivered or about 3*d.* per bushel.	Slack.	About 5 cwt. of slack, at 6*s.* per ton, 25 per cent.	490	Batswings 460 30	1 10 8 2 0 0	Company, and provides posts, services, &c.
Birmingham and Staffordshire.	10*s* per 1000 cub. feet. Discounts as above.	From West Bromwich pits, 1837, 9*s.* 3*d.*	6,600	24 bush. but larger measure than Birmingham	2*s.* 10*d.* per sack of 8 bushels	Slack and Tar.	5 cwt. of slack, at 4*s.* 25 per cent.	1,500	Batswings	average 1 18 0	Ditto.
Macclesfield	10*s.* per 1000 cub. feet. Discounts. Above 50*l.* and not exceeding 75*l.* 5 75*l.* — 100*l.* 7½ 100*l.* — 125*l.* 10 125*l.* — 150*l.* 12½ 150*l.* — 175*l.* 15 175*l.* — 200*l.* 17½ per cent. 200*l.* & upward 20	Common, 8*s.* average 1834.	6,720	12 cwt.	10*s.* per ton	Coke	No account kept.	220	Ditto.	2 10 0	Company.
Stockport	10*s.* per 1000 cub. feet. Discounts same as Macclesfield. Macclesfield discounts taken from Stockport card.	Coal 10*s.* 6*d.* cannel 19*s.* 5*d.* about half and half used. Average 15*s.* 1834.	7,800	7 cwt.	6*s.* 8*d.* per ton.	Coal, coke, and tar.	Ditto.	230	Ditto.	2 10 0 1834. 2 0 0 1837.	Comrs. provide lamps & posts. Company's service light, repair, clean, and extinguish.
Manchester	10*s.* per m. cub. ft. 1834. 9*s.* and 8*s.* — 1837. Discounts. 50*l.* and under 100*l.* 2½ 100*l.* — 150*l.* 5 150*l.* — 200*l.* 7½ 200*l.* — 225*l.* 10 225*l.* — 250*l.* 12½ 250*l* — 300*l.* 15 300*l.* — 400*l.* 17½ per cent. 400*l.* & upward 20	15*s.* 2*d.* average. Oldham, Watergate, Wigan, } cannel. Mixed, 1834.	9,500	14 cwt.	Ditto.	Coke.	4, 2 3ds cwt.	2,375	Single jets and flat flames. about half and half.	1 2 0 2 0 0	Commissioners of police.
Liverpool Old Company, 1834.	10*s.* per 1000 cub. feet. Discounts. 10*l.* & under 30*l.* 2½ 30*l.* to 100*l.* 5 100*l.* to 200*l.* 7½ 300*l.* & upward 10 per cent.	7*s.* 3*d.* per ton of 112lbs. per cwt. Ormskirk or Wigan slack.	8,200	11¾ cwt.	8*s.* 4*d.* per ton of 112 lb per cwt.	Slack. 7*s.* 3*d.* per ton.	6½ cwt.	1,700 30	Batswings 1 jet, 2 — 3 — 4 —	4 10 0 2 5 0 2 13 0 3 2 9 3 13 11	Company light, clean, put out, and repair.
Ditto ditto	In 1835 this Company resorted to the use of cannel coal similar to the Liverpool New Gas and Coke Company, producing nearly										
Liverpool New Gas and Coke, 1835.	10*s.* per 1000 cub. feet. Discounts same as Liverpool Old Company.	18*s.* all cannel Wigan.	9,500	13 cwt.	7*s.* 6*d.* per ton.	Coke and slack.	5½ cwt.	Only a few	Argands.	4 0 0	Commissioners.
Bradford, 1834.	9*s.* per 1000 cub. feet to large consumers. Discounts. 20*l* to 30*l.* 5 30*l.* to 40*l.* 7½ 40*l.* to 60*l.* 10 60*l.* to 80*l.* 12½ 80*l.* to 100*l.* 15 per cent. 100*l.* & upward 20 Small consumers. 10*s.* per 1000 cub. feet, and 5 per cent. off from 10*l.* to 20*l.*	8*s.* 6*d.* per ton. 3 sorts used average. Slack 5*s.* 6*d.* Low Moor 8*s.* 10*d.* Catherine slack 8*s.*	8,000	13 cwt.	12*s.* per ton	Coke.	8½ cwt.	220	Batswings	2 12 6	Company light, repair, &c.
Leeds, 1834	8*s.* per 1000 cubic feet. Discounts. 2½, 5, 7½, 10 } per cent. on half-yearly payments { 15*l.*, 30*l.*, 50*l.*, 100*l.*	8*s.* per ton average. 2 3d common 7*s.* 1 3d cannel, 10*s.*	6,500	12 cwt.	7*s.* 6*d.* per ton	Ditto.	5¼ cwt	617	Ditto.	2 12 6	Commis'ers, except extinguishing, for which Comp pay 3*s.* 10*d.* per lamp.
Sheffield, 1835.	8*s.* per 1000 cubic feet. Discounts same as Leeds.	7*s.* 9. per ton average. 3 sorts used, 1, 2 10th cannel, at 16*s.* 8, 2 10 deep pit 7*s.* 1 10th silk stone, 10*s.*	8,000	10 cwt. of salable coke.	10*s.* per ton.	Ditto.	3½ cwt.	600	Ditto.	2 10 0	Company provide lamps, clean, repair, put out, &c.
Leicester, 1837.	7*s.* 6*d.* per 1000 cubic feet. Discounts on half-yearly rental not exceeding 10*l.*, 5 per cent. Above 10*l.* and not exceeding 20*l.* 7½ 20*l.* — 30*l.* 10 30*l.* — 40*l.* 12½ 40*l.* — 50*l.* 15 50*l.* — 60*l.* 20 per cent. 60*l.* & upward 25	13*s* 6*d.* average. Derbyshire soft coal.	7,500	4 quarters	10*s.* 8*d.* or 2*s.* 8*d.* per qr.	Coke, tar, &c.	About 1 3d of coke.	414	Ditto.	2 18 6	Company light, put out, and clean.
Derby, 1834.	10*s* per 1000 cub. feet. Discounts. 6 to 35 per cent.	Same coal used as at Leicester.	7,000	Ditto.	Ditto.	Coke.	Ditto.	219	Ditto.	2 2 0 2 7 0	Commis'ers light, put out, &c.
Nottingham, 1834.	9*s.* per 1000 cubic feet. Discounts as above.	Ditto.	7,000	Ditto.	Ditto.	Ditto.	Ditto.	300	Ditto.	3 3 0	Commis'ers light, clean, repair, &c.
London, 1834.	10*s.* per 1000 cub. feet. No discounts.	17*s.* average. Newcastle.	8,500	36 bush.	12*s.* per chaldron.	Ditto.	13 bush.	26,280	Ditto.	4 0 0	Company light, clean, put out, but not repair.
Ditto, 1837	Ditto.	Ditto.	8,600	Ditto.	Ditto.	Ditto.	Ditto.	30,400	Ditto.	4 0 0	Ditto.

being a Synopsis of the Proceedings of the under-mentioned principal Gas Light Establishments Experiments between the years 1834 and 1837. By Joseph Hedley, Esq.

No. of Hours, or Time burnt in the Year.	Gas consumed in each Lamp per Hour.	Rate per 1000 Cubic Feet received for Ditto.	Deducted for cleaning, lighting, extinguish'g, providingLampposts,&c	Per Centage of Loss of Gas made.	Greatest Quantity of Gas delivered in one Night.	Duration of Charges.	Method of Purification.	Number of Gas Holders.	Specific Gravity of the Gas.	Distance of Candle from Shadow.	Gas equal to Candles, burnt in a singleJet 4 in. high.	Gas consumed per Hour with a 4 Inch Flame.	Gas Flame reduced to Candle burnt per Hour.	Height of Gas Flame equal to Light from Candle
		s. d.	*s. d.*		*Cubic feet.*					*In'h*	*Cand.*	*Cu. ft.*	*Cu. ft.*	*Inch.*
226 nights, or 2938 hours, 9 months, omitting 5 nights for moons.	5 feet per hour.	30 10 40 18	18 0	Receives net about 6*s.* 8*d.* per 1000 cubic feet.	48 millions in the year.	6 hours.	Drylime	4, and 2 in the towo, and large new gas station.	·453	72	1,929	1·22	·8	2½
234 nights, or 3042 hours.	Ditto.	1 3½	18 0	Receives net about 5*s.* 6*d.* per 1000 cubic feet.	85 millions in the year.	Ditto.	Ditto.	6, and 6 in the town 7 miles off.	·455	72	1 929	1·22	·8	2½
8 months, omitting 5 nights for moons.	4 feet per hour.	3 0	12 0	Could not say.	80,000 Total for year about 15 millions.	8 hours.	Ditto.	3 gas holders.	Not taken	70	204	Not taken	·8	2¾
8 months. 4 nights omitted for moons. 237 nights, 2800 hours.	Ditto.	2 6	12 6	Ditto.	65,000. Total for year about 12 millions.	Ditto.	Ditto.	4 gas holders.	·539	64	2,441	·85	·55	2⅝
3390 hours.	1 foot 2 feet, per hour.	6 6 5 6	nothing	About 15 to 17½ per cent. receive about 7*s.* 4*d.* per 1000 cubic feet, public and private. Nearly all by meter.	500,000. Total for year 100 millions.	6 hours.	wet lime	10 gas holders, and 2 in the town.	·534	66	2,295	·825	·475	2¼
3600 hours.	5 feet per hour.	4 4	12 0	Could not learn in the absence of the manager.	360,000. Total for year 72 millions.	8 hours, large retorts, holding 6 cwt. each.	Wet and dry lime, principally dry.	8 gas holders in all, 4 in the town, 1000 yards off the works.	·462	75	1,777	1·1	·75	2⅝
similar results, which see.														
3000 hours.	3½ ft. per hour.	6 6	nothing	Nearly all by meter.	Not sufficiently long at work.	4 hours.	wet lime	2 large gas holders.	·580	55	3,306	·9	·45	2
8 months, omitting 7 nights. 2600 hours to 4 o'clock in the morning.	5 feet per hour.	3 1	12 6	Receive 8*s.* per 1000 cubic feet. less 5½ per cent.	42,500. Total for year 8,519,000.	8 hours.	dry lime.	4 gas holders.	·420	78	1,643	·12	·9	3
2330 hours.	4 feet per hour.	6 2	3 10	Receive for public and private 6*s.* 8*d.* per 1000 cubic feet. Public 5*s.*, private 7*s.*; meters used 6 to 1 for private rental.	176,000. Total for year 31 millions.	6 hours.	Ditto.	5 gas holders.	·530	67	2,228	·85	.51	2¼
2200 hours.	Ditto.	3 2½	18 0	Receive for public and private lights 5*s.* per 1000 cubic feet. Public 3*s.* 2½*d.*, private 6*s.* 9½*d.* Few meters used.	220,000. Total for year 40 millions.	Ditto.	Ditto.	4 gas holders, and 2 more erecting.	·466	74	1,826	1.04	·735	2
From August 14th to September. 1st, omitting 3 nights for moons, 3000 hours	5 feet per hour.	3 4¾	7 0	Not sufficiently long, at 7*s.* 6*d.*	Total for year 18 millions.	Ditto.	Ditto.	3 gas holders, and 1 erecting.	·528	74	1,826		·75	2¾
2173 hours, from August to May.	Ditto.	4 0 nearly	—	Lose about 17½ per cent.	Ditto.	Ditto	wet lime	4 gas holders.	·448	83	1,453	1·2	·925	3
All the year, 4327 hours.	Ditto.	3 0 nearly	—	Could not learn.	Ditto.	Ditto.	Ditto.	—	·424	90	1,234	1·3	1 175	3
4327 hours, all the year.	4 feet per hour.	4 0	12 0	Receive for public and private lights 7*s.* public, 4*s.* private, 8*s.*; few meters used.	Do. for year 1000 millions longest night 4,910,000	Ditto.	Ditto.	130 gas holders.	·412	80	1,562	1·13	·84	2¾
Ditto.	Ditto.	4 0	12 0	Ditto.	Do. for year 1460 millions longest night 7,120,000.	Ditto.	Ditto.	176 gas holders.	·412	80	1,562	1·13	·84	2¾

Bude-light.—This brilliant mode of illumination has been so called from the name of the residence in Cornwall of Mr. Goldsworthy Gurney, who obtained a patent for it in the year 1838. In its first form it consisted of a common argand oil flame or lamp of rather narrow circular bore, into the centre of whose wick a jet of oxygen gas was admitted through a tube inserted in the middle of the burner. This contrivance was not, however, new in this country, for a similar lamp, similarly supplied with oxygen gas, was employed by the celebrated Dr. Thomas Young in his lectures at the Royal Institution of Great Britain for the purpose of illuminating a solar microscope, or gas microscope, about 40 years ago, and I had done the same thing in Glasgow in the year 1806 or 1807. When used as a light for lighthouses or for other continuous illumination, it has been found to be too expensive and difficult to manage. It was tried upon a good scale a few years ago both by the Trinity House in Tower Hill, and in one of their lighthouses on the coast, as well as by the House of Commons. The Masters of Trinity did not find it to be essentially superior for the use of their lighthouses to their old and ordinary plan of illumination with a number of argand lamps placed in the focus, or near the focus, of reflecting mirrors. It was, after several expensive trials by them and in the House of Commons, abandoned by both.

In the course of numerous experiments in the Trinity House, Tower Hill, Mr. Gurney had occasion to examine the structure and see the performance of Mr. Fresnel's compound argand lamps which are used in the French lighthouses, furnished with refracting lenses of peculiar forms which surround these lamps, and transmit their concentrated light in any desired horizontal direction along the surface of the sea. Two of Mr. Fresnel's lamps are placed in the lamp apartment of the Trinity House. Each consists of a series of 4, 5, or 6 concentric wicks in the same plane, supplied with oil from the fountain below by means of a pumping mechanism, as in the well-known Parisian lamps of Carcel and Gagneau. The effect of 4, 5, or 6 concentric flames thus placed in close proximity to each other, with suitable supply of air through the interior of the innermost tube and the interstices between the exterior ones, is, to increase the heat in a very remarkable degree, and by this augmentation of the heat to increase proportionably the light. For it has been long known that a piece of even incombustible matter, such as a lump of brick, intensely heated, sends forth a most brilliant irradiation of light. This fact was applied first to the purpose of illuminating objects by Professor Hare of Philadelphia, fully 40 years ago. By directing the very feebly luminous flame of the compound jet of hydrogen and oxygen upon a bit of clay, such as one of Wedgwood's pyrometer pieces, a most vivid illumination was sent forth from it as soon as it became intensely heated. More lately, a piece of lime has been used instead of a bit of clay, as it is not so apt to change by the ignition, and affords, therefore, a more durable effect. It is used in our modern gas microscopes. Mr. Gurney suggested the use of lime for the above purpose in a work on chemistry which he published more than twenty years ago. It was afterward adopted by Mr. Drummond, in order to make signal lights in the trigonometrical survey of the Board of Ordnance, and was therefrom called the Drummond light, though he had no share whatever in the merit of the invention.

The structure of the Fresnel lamp would naturally suggest to Mr. Gurney the idea of trying the effect of a similar construction of an argand gas-lamp. But prior to the execution of this scheme, he obtained a second patent in the year 1839, for increasing the illuminating power of coal-gas by feeding its flame in a common argand burner with a stream of oxygen. But here a serious difficulty occurred. The stream of oxygen when admitted into the centre of such a flame, instead of augmenting its quantity of light, destroys it almost entirely. This result might have been predicted by a person well versant in the principles of gas illumination, as long ago expounded in Sir Humphrey Davy's admirable Researches on Flame. This philosopher demonstrated that the white light of gas-lamps, as also of oil-lamps, was due to the vivid ignition of solid particles of carbon evolved by the igneous decomposition of the hydro-carburet, either in the state of gas or vapor; and that if, by any means, these particles were not deposited, but burned more or less completely in the moment or act of their evolution from the hydro-carburet, then the illumination would be more or less impaired. Mr. Gurney, on observing this result, sought to obviate the evil, by charging the coal-gas with the vapor of naphtha. Thus a larger supply of hydro-carburet, and of carbon of course, being obtained, the flame of the naphthalized gas, admitted with advantage the application of oxygen gas, for the increase of its light; on the principle of greater intensity of ignition, and consequently of light being produced by the burning of carbon in oxygen than in common air, as had been long known to the chemical world. But an obstruction to the permanent employment of naphthalized gas was experienced by Mr. Gurney, by the deposition of liquid naphtha in the pipes of distribution. He was therefore induced to renounce this project. He then resorted to the use of coal-gas, purified in a peculiar way, and burned in compound Argand lamps, consisting of two or more concentric metallic rings, perforated with rows of holes in their upper surfaces, having intervals between the rings for the admission of a proper quantity of air, the burner being enclosed in a glass chimney at the level of the flame, surmounted by a tall iron chimney. Between these two chimneys, a certain space is left for the admission of air, and to favor draught and ventilation. The intensity and whiteness of the cylinder of light produced by the combustion of coal gas in this lamp are truly admirable, and form such an improvement in illumination for streets, churches, public rooms, and private houses, as to merit the protection of a patent, and the encouragement of the public at large.

General Estimate of Sizes, Number of Concentrics, Consumption of Gas, and Comparative Light.

Size.	Number of Concentrics.	Bude Consumption per hour.		Height of Flame.	Comparative Light.	Argand Consumption Per Hour.
Inches.		Feet.	Inches.	Inches.	15-hole argands.	Cubic feet.
2½	2	10	6	3	5	30
3	2	16	4	3	8	48
3½	2	21	6	3	10	60
4	2	26	4	3	12	72
4½	2	33	7	3	15	90
5	3	40	0	3¼	18	108
5⅓	3	43	5	3½	20	120
6	3	56	4	4	24	144

GELATINE. The substance produced by boiling the skin of animals in water, which in its crude but solid state is called *glue*, and when a tremulous semi-liquid, *size*. The latter preparation is greatly used by the paper-makers, and was much improved by the following process, for which Mr. William Rattray obtained a patent in May, 1838. The parings and scrows of skins are steeped in water till they begin to putrefy; they are then washed repeatedly in fresh water with the aid of stampers, afterward subjected, in wooden or leaden vessels, to the action of water strongly impregnated with sulphurous acid for from 12 to 24 hours; they are now drained, washed with stampers in cold water, and next washed with water of the temperature of 120° F., which is poured upon them and run off very soon to complete their purification. The scrows are finally converted into size, by digestion in water of 120° for 24 hours; and the solution is made perfectly fine by being strained through several thicknesses of woollen cloth. They must be exhausted of their gelatinous substance, by repeated digestions in the warm water. The claim is for the sulphurous acid, which, while it cleanses, acts as an antiseptic.—*Newton's Journal*, xiv. 173.

A fine gelatine for culinary uses, as a substitute for isinglass, is prepared by Mr. Nelson's patent, dated March, 1839. After washing the parings, &c., of skin, he scores their surfaces, and then digests them in a dilute caustic soda ley during ten days. They are next placed in an air-tight vat, lined with cement, kept at a temperature of 70° F.; then washed in a revolving cylinder apparatus with plenty of cold water, and afterward exposed to the fumes of burning sulphur (sulphurous acid) in a wooden chamber. They are now squeezed to expel the moisture, and finally converted into soluble gelatine by water in earthen vessels, enclosed in steam cases. The fluid gelatine is purified by straining it at a temperature of 100° or 120° F. I have examined this patent gelatine, and found it to be remarkably good, and capable of forming a fine calf's foot jelly.

Very recently a very beautiful sparkling gelatine has been prepared under a patent granted to Messrs. J. & G. Cox, of Edinburgh. By their process the substance is rendered perfectly pure, while it possesses a gelatinizing force superior even to isinglass. It makes a splendid calves' feet jelly and a milk-white blanc-mange. The patentees also prepare a semi-solid gelatine, resembling jujubes, which readily dissolves in warm water, as also in the mouth, and may be employed to make an extemporaneous jelly.

The gelatine of bones may be extracted best by the combined action of steam and a current of water trickling over their crushed fragments in a properly constructed apparatus. When the gelatine is to be used as an alimentary article, the bones ought to be quite fresh, well preserved in brine, or to be dried strongly by a stove. Bones are best crushed by passing them between grooved iron rolls. The cast-iron cylinders in which they are to be steamed, should be three times greater in length than in diameter. To obtain 1,000 rations of gelatinous soup daily, a charge of four cylinders is required; each being 3½ feet long, by 14 inches wide, capable of holding 70 lbs. of bones. These will yield each hour about 20 gallons of a strong jelly, and will require nearly one gallon of water in the form of steam, and 5 gallons of water to be passed through them in the liquid state. The 5 quarts of jelly produced hourly by each cylinder, proceeds from the 1 quart of steam-water and 4 quarts of percolating water.

The boiler should furnish steam of about 223° Fahr., at a pressure of about 4 lbs. on the square inch.

In *fig*. 70, A, B, C, D, represents a vertical section of the cylinder; G, H, I, K, a

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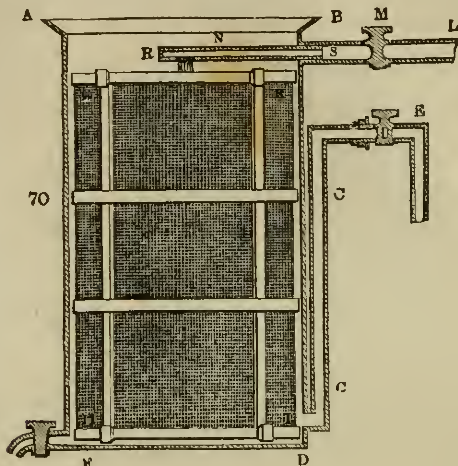

section of the basket or cage, as filled with the bruised bones, enclosed in the cylinder; E, C, C, the pipe which conducts the steam down to the bottom of the cylinder; L, S, a pipe for introducing water into the interior; M, a stopcock for regulating the quantity of water (according to the force of the steam pressure within the apparatus), which should be 3½ quarts per hour; N is a tube of tin plate fitting tightly into the part S, of the pipe L; it is shut at R, and perforated below with a hole; it is inserted in its place, after the cage full of bones has been introduced. *Fig*. 71 is an

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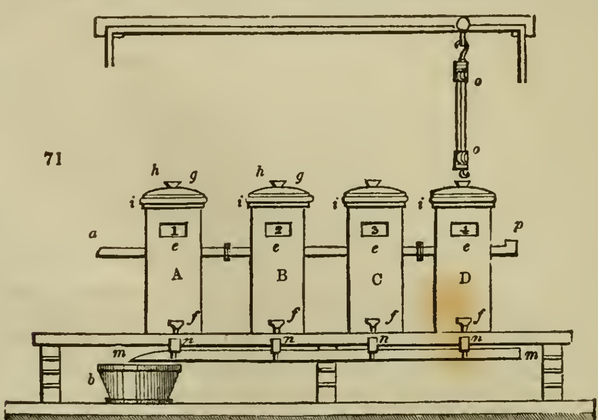

elevation of the apparatus. A, B, C, D, represent the four cylinders raised about 20 inches above the floor, and fixed in their seats by screws; *h*, *h*, are the lids; g, g, tubulures or valves in the lids; *i*, ring junction of the lid; *p*, a thermometer; *f*, *f*, stop-cocks for drawing off the jelly; *n*, *n*, small gutters of tin-plate; *m*, the general gutter of discharges into the cistern *b*; o, a block and tackle for hoisting the cageful of bones in and out. *Fig.* 72 is an end view of the apparatus; *a*, the main steam-pipe; *a*, *b*, *c*, *c*, branches that conduct the steam to the bottom of the cylinder; *o*, the tackle for raising the cage; *s*, stopcock; *n*, small gutter; *m*, main conduit; *b*, cistern of reception.

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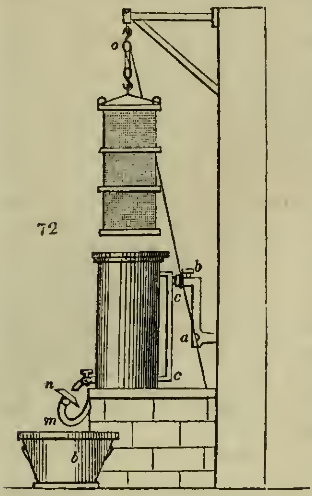

When a strong and pure jelly is wished for, the cylinder charged with the bones is to be wrapped in blanket stuff; and whenever the grease ceases to drop, the stopcock which admits the cold water is to be shut, as also that at the bottom of the cylinder, which is to be opened only at the end of every hour, and so little as to let the gelatinous solution run out, without allowing any of the steam to escape with it.

Butcher's meat contains on an average in 100 pounds, 24 of dry flesh, 56 of water, and 20 of bones. These 20 pounds can furnish 6 pounds of alimentary substance in a dry state; whence it appears that, by the above means, one fourth more nutritious matter can be obtained than is usually got. I am aware that a keen dispute has been carried on for some time in Paris, between the partisans and adversaries of gelatine as an article of food. It is probable that both parties have pushed their arguments too far. Calf's-foot jelly is still deemed a nutritious article by the medical men of this country, at least, though it is not to be trusted to alone, but should have a due admixture or interchange of fibrine, albumine, caseum, &c.

GILDING. See Electro-Metallurgy.

GLASS. Duty collected on it in the United kingdom: In 1831, 732,455*l.*; 1832, 751,448*l.*; 1833, 828,558*l.*; 1834, 916,822*l.*; 1835, 966,121*l.*; 1836, 933,281*l.*; 1837, 903,846*l.*; 1838, 879,859*l.*; 1839, 868,193*l.*; 1840, 965,967*l.*

Crystal glass is rapidly corroded by the sulphate of ammonia, at a heat of 600° F.

GLOVE. See Leather.

GLUCOSE, the name given to grape and starch sugar by M. Dumas.

GROWAN. The name given by the Cornish miners to *granite*, and to rocks of like structure.

GUANO. This extraordinary excrementitious deposite of certain sea-fowls, which occurs in immense quantities upon some parts of the coasts of Peru, Bolivia, and Africa, has lately become an object of great commercial enterprise, and of intense interest to our agricultural world. Four or five years ago it was exhibited and talked of merely as a natural curiosity. No one could then have imagined that in a short period it would be imported from the coasts of the Pacific in such abundance, and at such a moderate price, as to cheer by its fertilizing powers the languid and depressed spirits of the farmers throughout the United Kingdom. Such, however, is now the result, as attested by the concurring reports of almost all the agricultural societies of Great Britain and Ireland. No less than 28,500 tons of guano have been already imported from Peru and Bolivia, 1,500 from Chili, and 8,000 from Africa, altogether 38,000 tons, while more is on the way. The store of it, laid up from time immemorial in the above localities, seems to be quite inexhaustible; especially since it is receiving constant accessions from myriads of cormorants, cranes, &c.

Having been much occupied with the chemical analyses of guano during the last two years for Messrs. Gibbs, of London, and Messrs. Myers, of Liverpool, who are the co-agents of the Peruvian and Bolivian governments, I have enjoyed favorable opportunities of examining samples of every description, and hope to show that many of the analyses of guano hitherto published have been made upon specimens not in their normal or sound state, like the best imported by the above houses from Chincha and Bolivia, but in a certain state of *eremacausis* and decay.

Huano, in the language of Peru, signifies dung; a word spelt by the Spaniards guano. The natives have employed it as a manure from the remotest ages, and have by its means given fertility to the otherwise unproductive sandy soils along their coasts. While Peru was governed by its native incas, the birds were protected from violence by severe laws. The punishment of death was decreed to persons who dared to land on the guaniferous islands during the breeding period of the birds, and to all persons who destroyed them at any time. Overseers were appointed by the government to take care of the guano districts, and to assign to each claimant his due share of the precious dung. The celebrated Baron Von Humboldt first brought specimens to Europe in 1804, which he sent for examination to Fourcroy, Vauquelin, and Klaproth, the best analytical chemists of the day; and he spoke of it in the following terms: "The guano is deposited in layers of 50 or 60 feet thick upon the granite of many of the South sea islands off the coast of Peru. During 300 years the coast birds have deposited guano only a few lines in thickness. This shows how great must have been the number of birds, and how many centuries must have passed over in order to form the present guano-beds." The strata have undergone many changes, according to the length of time they have been deposited. Here and there they are covered with silicious sand, and have thus been protected from the influence of the weather; but in other places, they have lain open to the action of light, air, and water, which have produced important changes upon them. Fresh guano is of a whitish or very pale drab color, but it becomes progressively browner and browner by the joint influence of the above three atmospherical agents. Only one guano examined by Fourcroy and Vauquelin was found to contain a fourth of its weight of uric acid combined with ammonia, whence that appears to have been well selected by Baron Von Humboldt. They also found phosphates of ammonia, of lime, with urate and oxalate of ammonia, and some other constituents of little value in agriculture. Klaproth's analysis reported 16 per cent. of urate of ammonia, no less than 12·75 of oxalate of lime, 10 of phosphate of lime, 32 of clay and sand, with 28·75 of water and indeterminate organic matter. From the great proportion of clay and sand, Klaproth's sample of guano was obviously not genuine. I have met with no specimen of Peruvian guano that contained any appreciable quantity of clay, and none that contained above 4 or 5 per cent. of silicious sand.

To Mr. Bland, of the firm of Messrs. Myers and Co., I am indebted for the following valuable information:—

The Chincha islands, which afford the best Peruvian guano, are three in number, and lie in one line from north to south, about half a mile apart. Each island is from five to six miles in circumference, and consists of granite covered with guano in some places to a height of 200 feet, in successive horizontal strata, each stratum being from 3 to 10 inches thick, and varying in color from light to dark brown. No earthy matter whatever is mixed with this vast mass of excrement. At Mr. Bland's visit to these islands in 1842, he observed a perpendicular surface of upward of 100 feet of perfectly uniform aspect from top to bottom. In some parts of these islands, however, the deposite does not exceed 3 or 4 feet in thickness. In several places, where the surface of the guano is 100 feet or more above the level of the sea, it is strewed here and there with masses of granite, like those from the Alpine mountains, which are met with on the slopes of the Jura chain. These seem to indicate an ancient formation for the guano, and terraqueous convulsions since that period. No such granite masses are found imbedded within the guano, but only skeletons of birds.

The good preservation of the Chincha guano is to be ascribed to the absence of rain; which rarely, if ever, falls between the latitude of 14° south, where these islands lie, about 10 miles from the main land, and the latitude of Paquica, on the island of Bolivia, in 21° S. L. By far the soundest cargoes of guano which I have analysed have come from Chincha and Bolivia. Beyond these limits of latitude where rain falls in greater or less abundance, the guano is of less value—and what has been imported from Chili has been found by me far advanced in decay—most of the ammonia and azotised animal substances having been decomposed by moisture, and dissipated in the air (by the *eremacausis* of Liebig), leaving phosphate of lime largely to predominate along with effete organic matter. The range of the American coast from which the guano is taken must therefore be well considered; and should not extend much beyond the Chincha islands as the northern limit, and Paquica, in Bolivia, as the southern.

The relative estimation of guano and nitrate of soda among the Peruvians is well shown by the following fact communicated to me by Mr. Bland: "Near the coast of Peru, about 45 miles from Iquique (the shipping port of guano) there is the chief deposite of nitrate of soda. The farmers, who collect and purify this natural product, carry it to the place of shipment, and always require to be paid in return with an equivalent quantity of guano, with which they manure their land, to the exclusion of the far cheaper nitrate of soda. We can not be surprised at this preference, when we learn that in the valley of Chancay, about 40 miles distant from Lima, the soil produces, when farmed with irrigation in the natural way, a return upon maize of only 15 for 1; whereas, with the aid of guano, it produces 500 for 1! Hence the Peruvian proverb: Huano, though no saint, works many miracles.

In the pamphlet recently published by Messrs. Gibbs and Myers, entitled "Peruvian and Bolivian Guano, its nature, properties, and results," we have a very interesting view of the best established facts with regard to its operation and effects upon every variety of soil, and in every variety of circumstance, as ascertained by the most intelligent agriculturists of the United Kingdom. The general conclusion that may be fairly deduced from the whole evidence is, that good guano will, under judicious application, increase the crops of grain, turnips, potatoes, and grass, by about 33 per cent.; and with its present price of 10*l.* per ton, at a cost considerably under the average cost of all other manures, whether farm-yard dung and composts, or artificial compounds. Guano is, moreover, peculiarly adapted to horticultural and floricultural improvement, by its relative cleanliness and facility of application.

The following observations upon guano, by Dr. Von Martius, of Munich, addressed to the agricultural society of Bavaria, deserve attention. Among animal manures, says he, it clearly claims the first place. It is uncommonly rich in ammoniacal salts, which act very favorable on vegetation. The ease with which these salts are decomposed, and exhale their ammonia into the air, is by him assigned as the reason why plants manured with guano generally present early in the morning accumulations of dew on the points of their leaves. The guano absorbs the atmospheric vapor, as well as carbonic acid; whereby it becomes so valuable a manure in dry barren regions. If we compare guano with other excrementitious manures, we shall find it far preferable to those afforded by man or other mammalia, which do not generally contain more than 20 per cent. of food that can be appropriated by plants. It is therefore five times better than night-soil, and also very superior to the French *poudrette*, which, being dried night-soil, loses, through putrefaction and evaporation, the greater proportion of its ammoniacal elements. In birds, the excretions both of the kidneys and intestines are contained in the cloaca; whereby the volatile elements of the former get combined with the more fixed components of the latter. The guano is also a richer manure, on account of its being produced by sea-fowl, which live entirely on fish, without admixture of vegetable matter. The exposure also of the guano as soon as deposited to the heat of a tropical sun, in a rainless climate, prevents the components from fermenting, and *mummifies* them, so to speak, immediately into a concrete substance not susceptible of decomposition till it gets moisture; whereas the dung of our dove-cotes suffers a considerable loss by exposure to our humid atmosphere. But in their action on vegetation, and in their chemical composition, these two bird excrements are analogous. Davy found in fresh dove-cote manure 23 parts in 100 soluble in water, which yielded abundance of carbonate of ammonia by distillation, and left carbonaceous matter, saline matter, principally common salt, and carbonate of lime as a residuum. Pigeons' dung readily ferments, but after fermentation afforded only 8 per cent. of soluble matter, which gave proportionably less carbonate of ammonia in distillation than the dung recently voided. Dr. Von Martius proceeds to compare the proportion of soluble salts in guano and pigeons' dung, and thinks that by that comparison alone he can establish the superiority of the former; but he should have considered that the insoluble urate of ammonia, which is so powerful and copious a constituent of good guano, and is present in much smaller proportion in pigeons' dung, is sufficient of itself to turn the balance greatly in favor of the Peruvian manure. His general estimate, however, that the manuring power of genuine guano is four times greater than that of pigeons' dung, is probably not wide of the truth. Besides the above-mentioned constituents, guano derives no small portion of its fertilizing virtue from the great store of phosphoric acid which it contains, in various states of saline combination, with lime, magnesia, and ammonia. Of all the principles furnished to plants by the soil, the phosphates are, according to Liebig, the most important. They afford, so to speak, the bones and sinews of vegetable bodies, while ammonia supplies them with their indispensable element, azote. Their carbon, hydrogen, and oxygen, are derived from the air and water. Those products of vegetation which are most nutritious to man and herbiverous animals, such as bread-corn, beans, peas, and lentils, contain the largest proportion of phosphates. The ashes of these vegetable substances afford no alkaline carbonates. A soil in which phosphates are not present, is totally incapable of producing the above cereals. Agreeably to these views, Liebig believes that the importation of 1 cwt. of guano is equivalent to the importation of 8 cwts. of wheat; so that 1 cwt. of that manure assumes, with due culture, the form of 8 cwts. of substantial food for man.

Since all these testimonies concur to place this remarkable excrementitious product in such high estimation, it becomes a paramount duty of the chemist to investigate its composition, and to discover certain means of distinguishing what may be termed the sound or normal state of guano, from the decomposed, decayed, and effete condition. The analysis by Fourcroy and Vauquelin of a sample of guano presented to them by Baron Von Humboldt, gave the following composition in 100 parts:—

Urate of ammonia	9·0
Oxalate of ammonia	10·6
Oxalate of lime	7·0
Phosphate of ammonia	6·0

Phosphate of ammonia and magnesia	2·6
Sulphate of potash	5·5
——— soda	3·3
Sal ammoniac	4·2
Phosphate of lime	14·3
Clay and sand	4·7
Water and organic matters	32·3

How different are these constituents from those assigned by Klaproth—a no less skilful analyst than the French chemists! and how much this difference shows not only the complexity of the substance, but its very variable nature!

The general results of an analysis by Professor Johnston, published in his paper on guano, in the 3d part of the 2d vol. of the Journal of the Royal Agricultural Society of England, are as follows:—

Ammonia	7·0
Uric acid	0·8
Water and carbonic and oxalic acids, &c., expelled by a red heat	51·5
Common salt, with a little sulphate and phosphate of soda	11·4
Phosphate of lime, &c.	29·3
	100·0

The specimen of guano represented by this analysis must have been far advanced in decomposition, as shown by the very scanty portion of uric acid; and must have been originally impure (*spurious?*) from the large proportion of common salt, of which I have not found above 4 or 5 per cent. in any of the genuine guanos which I have had occasion to analyze. In another sample, Professor Johnston found 44·4 of phosphate of lime, with a little phosphate of magnesia, and carbonate of lime. These results resemble, to a certain degree, those which I have obtained in analyzing several samples of Chilian and African guanos, especially in the predominance of the earthy phosphates. The proportion of ammonia which can be extracted by the action of hydrate of soda and quicklime, at an elevated temperature, is the surest criterion of the soundness of the guano; for by this process we obtain not only the *ready-formed* ammonia, from its several saline compounds, but also the ammonia producible from its uric acid, and undefined animal matter. These two latter quantities have been hitherto too little regarded by most analysts, though they constitute the most durable fund of azote for the nutrition of plants. Uric acid, and urate of ammonia, which contains 10 11ths of uric acid, being both nearly insoluble in water, and fixed at ordinary temperatures, continue to give out progessively to plants in the soil, the azote, of which they contain fully one third of their weight. Under the influence of oxygen and a certain temperature, uric acid passes through a very remarkable series of transformations; producing allantoin, urea, and oxalic acid, which eventually becomes carbonic acid. These changes are producible immediately by the action of boiling water and peroxide of lead. From these metamorphoses, we can readily understand how so much oxalate of ammonia and of lime is reported in many analyses of guano, though none, I believe, is to be found in the normal state, as it is occasionally imported from the Chincha islands and Bolivia; nor were any oxalates found in the dung of the gannet, as analyzed by Dr. Wollaston, or of the sea-eagle, according to the following analysis of Coindet: ammonia, 9·21 per cent.; uric acid, 84·65; phosphate of lime, 6·13 = 100. The Peruvian sea-fowl, by feeding exclusively on fish, would seem to swallow a large proportion of earthy phosphates; since, in the purest guano that has come in my way, I have found these salts to amount to from 10 to 15 per cent.

Dr. Von Martius proposes to use the degree of solubility of the guano in water as a good criterion of its quality; but this is a most fallacious test. Sound guano contains from 15 to 25 per cent. of insoluble urate of ammonia; nearly as much undefined animal matter, along with from 15 to 20 of earthy phosphates, leaving no more than 50 or 55 per cent. of soluble matter, exclusive of moisture; whereas decayed guano yields often 60 or 70 per cent. of its weight to water, in consequence of the uric acid and animal matter being wasted away, and the large portion of moisture in it, the latter amounting very often to from 25 to 35 per cent. The good Peruvian guano does not lose more than from 7 to 9 per cent. by drying, even at a heat of 212° F.; and this loss necessarily includes a little ammonia. Each analysis of guano executed for the information of the farmer should exhibit definitely and accurately to at least 1 per cent.:—

1. The proportion of *actual* ammonia.

2. The proportion of ammonia producible also from the uric acid and azotized animal matter present; and which may be called the *potential* ammonia. This is a

most valuable product, which is, however, to be obtained only from well-preserved dry guano.

3. The proportion of uric acid, to which, if 1 10th of the weight be added, the quantity of urate of ammonia is given.

4. The proportion of the phosphates of lime and magnesia.

5. The proportion of fixed alkaline salts, distinguishing the potash from the soda salts; the former being more valuable, and less readily obtainable, than the latter can be by the use of common salt. Wheat, peas, rye, and potatoes, require for their successful cultivation, a soil containing alkaline salts, especially those of potash.

6. The proportion of sandy or other earthy matter, which, in genuine guano, carefully collected, never exceeds 2 per cent. and that is silica.

7. The proportion of water, separable by the heat of 212° F.

The farmer should never purchase guano except its composition in the preceding particulars be warranted by the analysis of a competent chemist. He should cork up in a bottle a half-pound sample of each kind of guano that he buys; and if his crop shall disappoint reasonable expectation, he should cause the samples to be analyzed; and should the result not correspond to the analysis exhibited at the sale, he is fairly entitled to damages for the loss of his labor, rent, crop, &c. The necessity of following this advice will appear on considering the delusive if not utterly false analyses, under which cargoes of guano have been too often sold. In a recent case which came under my cognizance, in consequence of having been employed professionally to analyze the identical cargo, I found the guano to be nearly rotten and effete; containing altogether only 2½ per cent. of ammonia, ½ per cent. of urate of ammonia, nearly 9 of sea salt, 24 of water, and 45½ of earthy phosphates. Now, this large cargo, of many hundred tons, fetched a high price at a public sale, under the exhibition of the following analysis by a chemist of some note:—

Urate of ammonia, ammoniacal salts, and decayed animal matter	17·4
Phosphate of lime, phosphate of magnesia, and oxalate of lime -	48·1
Fixed alkaline salts - - - - - - - - - - -	10·8
Earthy and stony matter - - - - - - - - - -	1·4
Moisture - - - - - - - - - - - -	22·3
	100·0

The purchasers, I was told by the broker, bought it readily under a conviction that the guano contained 17·4 of ammonia, though the proportion of ammonia is not stated, but merely mystified, and adroitly confounded with the decayed animal matter.

By the following hypothetical analysis, much guano has been well sold:—

"Bone earth, 35; lithic acid, &c., 15; carbonate of ammonia, 14; organic matter, 36 =100." I am quite certain that no sample of guano can contain 14 per cent. of carbonate of ammonia—a very volatile salt. We shall see presently the state of combination in which the ammonia exists. It may contain at the utmost 4 or 5 per cent. of the carbonate; but such guano must have been acted upon powerfully by humidity, and will therefore contain little or no uric acid.

In the very elaborate examination of guano by T. Oellacher, apothecary at Innsbruck, published in a recent number of Buchner's *Repertorium of Pharmacy*, it is said, that if a glass rod dipped into muriatic acid be held over guano, strong fumes are developed; and the solution of guano has an alkaline reaction with litmus-paper. These phenomena evidently indicate the presence of carbonate of ammonia, and of course a partially decomposed guano; for sound Chincha and Bolivian guanos have an *acid* reaction, proceeding from the predominance of phosphoric acid. Farmers frequently judge of the goodness of guano by the strength of the ammoniacal odor; but in this judgment they may egregiously err, for the soundest guano has no smell of ammonia whatever; and it begins to give out that smell only when it is more or less decomposed and wasted.

Oellacher could find no evidence of urea in his guano; I have obtained fully 5 per cent. of this substance from good Peruvian guano.

I shall now describe my own system of analysis:—

1. In every case I determine, first of all, the specific gravity of the guano; which I take by means of spirits of turpentine, with a peculiar instrument contrived to render the process easy and precise. If it exceeds 1·75 in density, water being 1·0, it must contain sandy impurities, or has an excess of earthy phosphates, and a defect of azotized animal matter.

2. I triturate and digest 200 grains of it with distilled water, filter, dry the insoluble matter, and weigh it.

3. The above solution, diffused in 2,000 gr. measures, is examined as to its specific gravity, and then with test paper, to see whether it be acid or alkaline.

4. One half of this solution is distilled along with slaked lime in a matrass connected with a small quintuple globe condenser, containing distilled water, and immersed in a basin of the same. As the condensing apparatus terminates in a water-trap, no part of the ammonia can be lost; and it is all afterward estimated by a peculiar meter, whose indications make manifest one hundredth part of a grain.

5. The other half of the solution is mixed with some nitric acid, and divided into 3 equal portions.

a, the first portion, is treated with nitrate of barytes, and the resulting sulphate of barytes is collected, ignited, and weighed.

b, the second portion, is treated with nitrate of silver, and the resulting chloride of silver ignited and weighed.

c, the third portion, has a certain measure of a definite solution of ferric nitrate mixed with it, and then ammonia in excess. From the weight of the precipitated subphosphate of iron after ignition, the known amount of oxide used being deducted, the quantity of phosphoric acid in the soluble portion of the guano becomes known.

d, the three above portions are now mixed, freed by a few drops of dilute sulphuric and hydrochloric acids from any barytes and silver left in them, and then tested by nitrate of lime for oxalate of ammonia. The quantity of oxalate of lime obtained, determines that point.

6. The last liquor filtered, being freed from any residuary particles of lime by oxalate of ammonia, is evaporated to dryness and ignited, to obtain the fixed alkaline matter. This being weighed, is then dissolved in a little water, neutralized with acid, and treated with soda-chloride of platinum. From the quantity of potash-chloride of platinum, which precipitates, after being filtered, dried, and weighed, the amount of potash present is deducted—the rest is soda. These bases may be assigned to the sulphuric, hydro-chloric, and phosphoric acids, in proportions corresponding to their respective affinities.

7. The proportion of organic matter in the above *solution* of guano, is determined directly by evaporating a certain portion of it to dryness, and igniting. The loss of weight, minus the ammonia and oxalic acid, represents the amount of organic matter.

8. A second portion of a solution of the guano is evaporated to dryness by a gentle steam heat, weighed, enclosed in a stout well-closed phial along with alcohol of 0·825, and heated to 212°. After cooling, the alcoholic solution is decanted or filtered clear, evaporated to dryness by a gentle heat, and weighed. This is urea, which may be tested by its conversion into carbonate of ammonia, when heated in a test tube or small retort. In this way, I have obtained from Bolivian guano, 5 per cent. of urea; a certain proof of its entire soundness.

9. *Analysis of the insoluble matter.* One third of it is digested with heat in abundance of Borax-water, containing $\frac{1}{100}$ of the salt, filtered, and the filter dried by a steam heat. The loss of weight indicates the amount of uric acid, which is verified by supersaturating the filtrate with acetic or hydrochloric acid, thus precipitating the uric acid, throwing it upon a filter, drying, and weighing it. This weight should nearly agree with the above loss of weight, the small difference being due to soluble organic matter, sometimes called geine and ulmic acid. The uric acid is evidenced, 1, by its specific gravity, which I find to be only 1·25, as also that of the urate of ammonia; 2, by its affording fine purple *murexide* when heated in a capsule along with nitric acid, and then exposed to the vapor of ammonia from a feather held over it; 3, by its dissipation when heated, without emitting an empyreumatic odor.

10. Another third of the solid matter is distilled along with half its weight of slaked lime, and 10 times its weight of water, in the apparatus already described, and the ammonia obtained from it estimated.

11. The remaining third having been ignited, is digested with a gentle heat in weak hydrochloric acid, and the undissolved silica and alumina washed on a filter, dried, and weighed. To the hydrochloric solution, dilute sulphuric acid is added, and the mixture is heated till all the hydrochloric acid be expelled, with the greater part of the water. Alcohol of 0·850 is now poured upon the pasty residuum, and the whole, after being well stirred, is thrown upon a filter. The phosphoric acid passes through, as also the magnesia in union with sulphuric acid. The sulphate of lime, which is quite insoluble in spirits of wine, being washed with them, is dried, ignited, and weighed. From the weight of sulphate of lime, the quantity of phosphate of that earth, that was present, becomes known.

12. Ammonia in excess is now added to the filtrate, which throws down the granular phosphate of ammonia and magnesia. After washing and drying this powder at a heat of 150°, its weight denotes the quantity of that compound in the guano.

13. To the filtered liquor (of 12), if a little ammonia be added, and then muriate of magnesia be slowly dropped in, phosphate of ammonia and magnesia will precipitate, from the amount of which the quantity of phosphoric acid may be estimated.

14. The proportion of oxalate of lime is determined by igniting the washed residuum

(of 9) and placing it in an apparatus for estimating the quantity of carbonic acid given off in dissolving carbonate of lime. The apparatus, either *fig.* 1 or 2, described in my little Treatise on Alkalimetry, will serve that purpose well. I have rarely obtained more than ½ gr. of carbonic acid from the insoluble residuum of 100 gr. of good guano, and that corresponds to less than 1½ per cent. of oxalate of lime in the guano. Sometimes no effervescence at all is to be perceived in treating the washed residuum with acid after ignition.

15. The carbonate of ammonia in guano is readily determined by filtering the solution of it in cold water, and neutralizing the ammonia with a test or alkalimetrical acid. (See the Treatise on Alkalimetry, above referred to.)

16. Besides the above series of operations, the following researches must be made to complete our knowledge of guano. The insoluble residuum (of 10) which has been deprived by two successive operations of its uric acid and ammonia, may contain azotized organic matter. It is to be therefore well dried, mixed with 5 times its weight of the usual mixture of hydrate of soda and quicklime, and subjected to gentle ignition in a glass or iron tube closed at one end, and connected at the other with an ammonia condensing apparatus. The amount of ammonia being estimated by a proper ammonia meter, represents the quantity of azote, allowing 14 of this element for 17 of ammonia, being the potential ammonia corresponding to the undefined animal matter. In a sample of Peruvian guano I obtained 5 per cent. of ammonia from this source.

17. The whole quantity of ammonia producible from guano is to be determined by gently igniting 25 gr. of it well dried, and mixed with ten times its weight of the mixture of hydrate of soda and quicklime (2 parts of the latter to 1 of the former). The ammonia disengaged is condensed and measured, as described above.

18. The ready-formed ammonia is in all cases determined by distilling a mixture of 100 gr. of it with 50 gr. of slaked lime, condensing the disengaged ammonia, and estimating it exactly by the meter.

19. The relation of the combustible and volatile to the incombustible and fixed constituents of guano, is determined by igniting 100 gr. of it in a poised platinum capsule. The loss of weight denotes the amount of combustible and volatile matter, including the moisture, which is known from a previous experiment.

20. The insoluble matter is digested in hot water, thrown upon a filter, dried, and weighed. The loss of weight is due to the fixed alkaline salts, which, after concentrating their solutions, are investigated by appropriate tests: 1, nitrate of barytes for the sulphates; 2, nitrate of silver for the chlorides and sulphates; and 3, soda-chloride of platinum, for distinguishing the potash from the soda salts.

21. The insoluble matter (of 20) is digested with heat in dilute nitric or hydrochloric acid, and the whole thrown upon a filter. The silica which remains on the filter is washed, ignited, and weighed. The lime, magnesia, and phosphoric acid, may be determined as already pointed out.

22. I have endeavored to ascertain if muriate of ammonia be present in guano, by evaporating its watery solution to dryness, and subliming the residuum, but I have never obtained a satisfactory portion of sal ammoniac; and therefore I am inclined to think there is little of it. The quantity of chlorine to be obtained from guano is too inconsiderable to lead to a suspicion of its presence, except in combination with sodium and potassium. Phosphate of soda is also a doubtful product—but if present, it may be obtained from the saline matter (of 20), by acidulating it with nitric acid; precipitating first with nitrate of barytes, next with nitrate of silver, taking care to use no excess of these two re-agents, then supersaturating the residuum with ammonia, and adding acetate of magnesia, when the characteristic double phosphate of this earth should fall, in case phosphate of soda be present.

By the preceding train of researches, all the constituents of this complex product may be exactly disentangled and estimated; but they manifestly require much care, patience, time, and dexterity, and also a delicate balance, particularly in using the appropriate apparatus for generating the potential ammonia, and for measuring the whole of this volatile substance separated in the several steps of the process. It may be easily imagined how little confidence can be reposed in many of the analyses of guano, framed, I fear, too often with the view of promoting the sale of an indifferent or even spurious article of commerce.

A. I shall now give in detail my analytical results upon three different samples of a good South American guano; and next the general results upon three samples of African and Chilian guanos:—

I. Guano from Bolivia, imported by the Mary and Anne. This sample was taken by myself, as an average out of several bags in the lighter, before the cargo was landed. Pale yellow brown color, dry, partly pulverulent, partly concreted, in small lumps, with a few small fragments of granite interspersed, and which, being obvious, were separated prior to the analysis. Specific gravity of the pulverulent portion without the granite, 1.60; of the concretions, 1·66; mean 1·63. Water digested on the former portion is neutral to litmus, that on the latter is faintly acid.

2. 100 parts lose 6·5 by the heat of boiling water, and exhale no ammonia. When digested and triturated with cold water, 30·5 parts dissolve, and 69·5 are obtained after drying, at 212° F. Of those 30·5 parts, 6·5 are therefore water, easily separable, and 24·5 parts are solid matter.

3. 100 parts, mixed with 9 times their weight of water, and 50 of lime, being distilled in an alembic connected with the five-globe condenser, &c., afforded exactly 4·2 of ammonia. 20 grains in fine powder, along with 200 of a mixture, consisting of 2 parts of dry lime and 1 of hydrate of soda, were gently ignited in a combustion-tube connected with the ammonia-condensing apparatus, and they produced 4·25 grains of ammonia—equivalent to 21·25 from 100 grains of the guano. Thus only 4·2 per cent. of ammonia were ready formed; while 17·05 lurked, so to speak, in their azotized elements.

From its aspect, and its want of ammoniacal odor, this guano, the first cargo received from Bolivia, was imagined by the importers to be of bad quality; and, accordingly, my very favorable report of its analysis surprised them not a little, and rather unsettled the little faith they at that time (January, 1843) had in chemistry. But about a fortnight after the date of my report they received a letter from Peru, apprizing them of the excellence of that cargo of Bolivian guano, and of its being prized by the Americans, as possessing fertilizing powers in a pre-eminent degree. I consider this guano, therefore, as a type of the substance in its best state.

II. The *soluble* matter was analyzed, in the manner already detailed, and was found to consist of—

1.	Urea	5·00
2.	Sulphate of potash	7·90
3.	Chloride of sodium	5·00
4.	Biphosphate of ammonia	5·50
5.	Oxalate of ammonia	0·60
		24·0

In these ammoniacal salts there are only 1·65 parts of ammonia; but I obtained 2·55 grains in distilling the soluble matter of 100 grains of the guano. The remaining 0·9 parts, therefore, must have proceeded from the partial decomposition of the urea during the long ebullition necessary to extract every particle of ammonia, in distilling the guano along with lime.

III. The *insoluble* matter =69·5 parts, was found to consist of—

1.	Silica	2·25
2.	Subphosphate of lime	9·00
3.	Phosphate of magnesia and ammonia	1·25
4.	Urate of ammonia	15·27
5.	Undefined azotized organic matter, affording, with the 14 parts of uric acid, by ignition with hydrate of soda, 17·05 parts of ammonia	41·73
		69·50

This result as to the large proportion of organic matter in the dried insoluble residuum was verified by igniting a given quantity of it, when it was found to lose, out of 69·5 parts, 57; corresponding to the 15·27 urate of ammonia, 41·73 of undefined organic matter, and 0·08 of ammonia, in the double magnesian phosphate. In the urate and double phosphate are 1·35 of ammonia, which, with the 2·55, make 3·9 parts; the other 0·3 parts may be traced to the urea.

As these results differ very considerably in many respects from those of the analyses made by respectable German chemists, I was careful to verify them by manifold variations of the process, as follows:—

1. The soluble matter, with *acid* reaction, of 100 parts of the *lumps* of the Bolivian guano, was examined by per-acetate of iron and ammonia, for phosphoric acid, and afforded 4 parts of it, which is more than had been found in the *neutral* pulverulent guano. After the phosphoric acid was separated by that method, chloride of calcium gave no cloud with the filtered liquor, proving that no oxalic acid was present in these nodules. The washed insoluble matter, when gently ignited, and treated with dilute nitric acid, afforded no effervescence whatever, and therefore showed that no oxalate of lime had been present, for it would have become a carbonate.

It is necessary to determine from time to time the quantity of ferric oxide in the acetate or nitrate, as it is liable to be deposited from the solution when this is kept for some time. If this point be not attended to, serious errors would be committed in the estimation of the phosphoric acid.

2. The quantity of uric acid was verified by several repetitions, and found to be 14 per cent.

3. The undefined organic matter, when deprived of the uric acid by prolonged digestion with weak borax, being subjected to ignition along with hydrate of soda, yielded the quantity of ammonia requisite to constitute the whole sum, that producible from the uric acid also being taken into account.

4. The little lumps of the guano afforded, by distillation along with quicklime, 5·27 per cent. of ready-formed ammonia, probably from the uric acid having been partially decomposed by the moisture which had caused them to concrete. It is a curious fact, that the solution of borax, from being of an alkaline, becomes of an acid reaction, after digestion with the Bolivian guano.

5. For distinguishing and separating the soda salts from those of potash, I tried the antimoniate of potash, according to Wackenroder's prescription, but I found reason to prefer very much the crystallized soda-chloride of platinum, for that purpose.

From another specimen of the Bolivian guano, I extracted 3·5 per ct. of the ammonia-phosphate of magnesia.

B. A sample of guano from the Chincha islands, of nearly the same light color as the preceding, and the same dryness, being an early importation of 250 tons in the present year, was subjected by me to a careful analysis.

1. The solution in water of this guano had an alkaline reaction from carbonate of ammonia, which, being neutralized by test acid, indicated 0·34 per cent. of ammonia, equivalent to about 1 of the smelling sesqui-carbonate.

2. Of this guano, 47 per cent. were soluble in water, and 53 per cent. remained, after drying at a heat of 212° F. Of the above 47 parts, 8·5 were moisture in the guano.

3. The solution being acidulated with nitric acid, was treated with acetate of barytes, in a quantity equivalent to the sulphuric acid present, and it afforded 12 parts of sulphate of barytes. With the filtered liquor, 700 water grain measures of ferric acetate were mixed, and then ammonia in excess; 18·5 parts of washed and ignited sub-phosphate of iron were obtained, from which deducting 8·8 parts present in the acetate, 9·7 remain as the quantity of phosphoric acid; but 9·7 of acid produce 13·25 of bi-phosphate of ammonia, which contain only 2·3 of ammonia, combined with 0·95 of water, or its elements. From the alkaline excess in the guano, there can be no doubt, however, that it contained the sub-phosphate (*found in the urine of Carnivora*), and not the bi-phosphate of that base. In this case, 9·7 of acid produce 14·32 of dry saline compound, containing 4·62 of ammonia, which, with the 0·34 of ammonia in the carbonate, constitute a sum of 4·96. To the liquor freed from the phosphate of iron, and acidulated with nitric acid, acetate of lime being added, 3·33 parts of oxalate of this base were obtained, which are equivalent to 3·23 oxalate ammonia, containing 0·89 of ammonia.

4. Nitrate of silver now produced from the filtered residual solution 8 parts of chloride, corresponding to nearly 3 of sal ammoniac, which contain nearly 0·95 of ammonia.

5. The 53 parts insoluble in water were digested with weak solution of borax at a boiling heat, thrown on a filter, and the uric acid being precipitated from the filtrate by means of a little hydrochloric acid, washed and dried, was found to weigh 13·5 parts. There were left on the filter 36·5 parts, dried at 212° F., so that 3 parts of soluble organic matter had passed through the filter. These 36·5 parts lost by ignition only 9·7 parts in organic matter, became white, and afforded a very faint effervescence with hydro-chloric acid, showing that a very little oxalate of lime had been present. 1·25 parts of silica were left after the action of the acid. To the solution of the 26·55 parts, sulphuric acid was added, and the mixture being heated to expel the hydro-chloric acid and the excess of the sulphuric, the residuary matter was digested and washed with dilute alcohol, and thrown on a filter; the solution of magnesia passed through, while the sulphate of lime remained. After ignition, this weighed 27·5 parts, equivalent to 22 of sub-phosphate of lime. On supersaturating the filtrate with ammonia, 4·5 parts of the magnesian ammonia phosphate were precipitated, containing 0.32 of ammonia. With the 13·5 parts of uric acid, 1·23 of ammonia had been originally combined, forming 14·73 of urate.

6. 25 grains of the dry guano afforded, by ignition in the combustion-tube along with 200 grains of the mixed lime and hydrate of soda, 4·165 of ammonia, which correspond to 16·66 in 100 parts of the dry, or to 15·244 in the natural state; leaving therefore 5 parts for the quantity of potential ammonia, or of ammonia producible from the decomposition of its azotized organic matter. This guano is, therefore, well adapted to promote permanently the fertility of a soil. It yields besides to alcohol a notable quantity of urea, which I did not think it worth while to determine quantitively, and

from which undoubtedly a portion of the ammonia proceeded, in the distillation with milk of lime.

7. 100 parts afforded by distillation with milk of lime, 10·2 of ammonia.

8. The total constituents of that guano, being tabulated, are—

I.	Matter soluble in water	47·00	
consisting of—			Ammonia.
1.	Sulphate of potash, with a little sulphate of soda	6·00	
2.	Muriate of ammonia	3·00	0.95
3.	Phosphate of ammonia	14·32	4·62
4.	Sesqui-carbonate of ammonia	1·00	0·34
5.	Sulphate of ammonia	2·00	0·50
6.	Oxalate of ammonia	3·23	0·89
7.	Water	8·50	
8.	Soluble organic matter and urea	8·95	
		47·00	
II.	Matter insoluble in water	53·00	
consisting of—			
1.	Silica	1·25	
2.	Undefined organic matter	9·52	
3.	Urate of ammonia	14·73	1·23
4.	Oxalate of lime	1·00 ?	
5.	Sub-phosphate of lime	22·00	
6.	Phosphate of magnesia and ammonia	4·50	0·32
		53·00	9·80

The remaining 1.25 of *actual* ammonia may be fairly traced to the partial decomposition of the urea during the distillation with lime; whereas the 5 per cent. of potential ammonia proceeded from the transforming decomposition of the uric acid.

C. *Foliated guano*, from Peru, in caked pieces, the layers very thin, parallel, and interspersed with white streaks. This guano was somewhat dense for a pure specimen, having a specific gravity of 1·7. The insoluble matter afforded by digestion with borax water, no less than 25·2 per ct. of pale yellow uric acid; 9 of other combustible organic matter, and 15 of earthy matter; consisting of silica, 3·5; phosphate of magnesia and ammonia, 6·5; and only 5 of sub-phosphate of lime or bone earth. It lost 10 per cent. when dried in a heat of 212° F. The remaining 30·8 parts soluble in water, had a strong acid reaction, and afforded, by ferric acetate and ammonia, 6 of phosphoric acid, equivalent to 9·7 of crystallized bi-phosphate of ammonia, after acetate of barytes had separated the sulphuric acid. No less than 17 parts of chloride of silver were obtained, by precipitating with nitrate of silver the liquor filtered from the phosphate of iron, and acidulated with nitric acid. As the present is an accidental sample, and not an average of any importation, I did not prosecute the research further.

D. *Chincha guano*, of a somewhat darker color than the preceding, and alkaline reaction; specific gravity, 1·62. Digested with water and strained, 56·75 parts remained after drying it at 212° F. The solution, evaporated and dried also at 212°, afforded 31·25 of saline matter. This saline mass being mixed with four fifths of its weight of slaked lime, nine times its weight of water, and distilled, afforded of ammonia 14·28 per cent. Some chemists have prescribed potash instead of lime, for separating the ammonia in distillation; but no person of intelligence who has made the experiment once will choose to repeat it, because the potash forms with the organic matter of the guano a viscid compound, that froths up like a mass of soap-bubbles, and coming over with the vapors, obstructs and vitiates the result.

2. When dried altogether by a steam heat, 100 parts lost 12 in moisture; whereas by evaporating and drying the soluble matter by itself, the loss amounted to 16·3, no doubt by the dissipation of some of the ammoniacal salts; for 100 parts of the entire guano afford, by distillation with quicklime, 9 parts of ammonia, and by the transforming decomposition with hydrate of soda and lime, 16·25, indicating 7·25 of *potential* ammonia, in addition to the 9 of ready formed. The insoluble matter of 100 parts afforded to borax-water a solution containing 16·5 of uric acid, corresponding to 18 of urate of ammonia. There remained on the filter, after drying it at 212° F., only 33·8 parts; so that about 5 parts of soluble organic matter had passed through the filter in

the borax water. These 33·8 consisted of subphosphate of lime 17, magnesian phosphate of ammonia 5·5, silica 0·7, and combustible organic matter 10·6.

The ammonia in the soluble portion was in the state chiefly of phosphate; there was merely a faint trace of oxalate of ammonia.

E. *African Guano.*—Among the many samples of African guano which I have had occasion to analyze for the importers, none has contained any appreciable quantity of uric acid, or by consequence of potential ammonia. The best afforded me 10 per cent. of ready-formed ammonia, existing chiefly in the state of a phosphate, though they all contain carbonate of ammonia, and have of consequence an alkaline reaction. The said sample contained 21·5 of moisture, separable by a heat of 212° F. Its specific gravity was so low as 1·57, in consequence of the large proportion of moisture in it. It contained 23 per cent. of subphosphate of lime, 3 of magnesian phosphate of ammonia, 1 of silica, and 1·5 of alkaline sulphate and muriate. The remaining 50 parts consisted of decayed organic matter, with phosphate of ammonia, and a little carbonate, equivalent to half a grain of ammonia, which is the largest quantity in such guanos. Other African guanos have afforded from 24 to 36 of moisture, no uric acid; no potential ammonia; but decayed organic matter; from 5 to 7 of ready-formed ammonia in the state of phosphate, with a little carbonate; from 25 to 35 per cent. of subphosphate of lime; 5 or 6 of the magnesian phosphate of ammonia; more or less oxalates from the decomposition of the uric acid, and 3 to 5 per cent. of fixed alkaline salts.

F. The *Chilian Guano* gathered on the coast, already adverted to, contained a remarkable proportion of common salt, derived probably from the sea spray.

The following is the general report of the chemical examination of several samples of guano, which I made for Messrs. Gibbs of London, and Messrs. Myers of Liverpool:—

"In these various analyses, performed with the greatest care, and with the aid of the most complete apparatus for both inorganic and organic analysis, my attention has been directed, not only to the constituents of the guano which act as an immediate manure, but to those which are admitted by practical farmers to impart durable fertility to the grounds. The admirable researches of Professor Liebig have demonstrated that AZOTE, the indispensable element of the nourishment of plants, and especially of wheat and others abounding in gluten (an azotized product), must be presented to them in the state of *ammonia*, yet not altogether ammonia in the pure or saline form, for, as such, it is too readily evaporated or washed away; but in the dormant, or as one may say, in the *potential* condition in contradistinction from the *actual*. Genuine Peruvian and Bolivian guanos, like those which I have minutely analyzed, surpass very far all other species of manure, whether natural or artificial, in the quantity of *potential* ammonia, and, therefore, in the permanency of their action upon the roots of plants, while, in consequence of the ample store of *actual* ammonia which they contain ready formed, they are qualified to give immediate vigor to vegetation. Urate of ammonia constitutes a considerable portion of the azotized organic matter in well-preserved guano; it is nearly insoluble in water, not at all volatile, and is capable of yielding to the soil, by its slow decomposition, nearly one third of its weight of ammonia. No other manure can rival this animal saline compound. One of the said samples of guano afforded me no less than 17 per cent. of potential ammonia, besides 4½ per cent. of the actual or ready formed; others from 7 to 8 per cent. of ammonia in each of these states respectively. These guanos which I have examined are the mere excrement of birds, and are quite free from the sand, earth, clay, and common salt, reported in the analyses of some guanos, and one of which (sand) to the amount of 30 per cent. I found myself in a sample of guano from Chile.

"The Peruvian guano, moreover, contains from 10 to 25 per cent. of phosphate of lime, the same substance as bone-earth, but elaborated by the birds into a pulpy consistence, which, while it continues insoluble in water, has been thereby rendered more readily absorbable and digestible (so to speak) by the roots of plants. I have therefore no doubt, that by the judicious application of these genuine guanos, mixed with twice or thrice their weight of a marly or calcareous soil, to convert their phosphate of ammonia into phosphate of lime and carbonate of ammonia, as also to dilute all their ammoniacal compounds—such crops will be produced, even on sterile lands, as the farmer has never raised upon the most improved soil by the best ordinary manure. To the West India planter, guano will prove the greatest boon, since it condenses in a portable and inoffensive shape the means of restoring fertility to his exhausted cane-fields, a benefit it has long conferred on the poorest districts of Peru.

"I respectfully observe, that no analysis of guano hitherto made public at all exhibits the value of the cargoes referred to above, while none gives the quantity of ammonia dormant in the azotized animal matter of the birds' dung, which, called into activity with the seeds in the soil, becomes the most valuable of its constituents, as a source of perennial fertility. In the detailed account of my analyses of this complex excretion (now preparing for publication), all the above statements will be brought within the scope of general comprehension. I shall also describe my 'ammonia generator,' based on the process invented in the laboratory of Professor Liebig, and also my 'ammonia meter,' which, together, can detect and measure one hundredth part of a grain weight of absolute ammonia, whether potential or actual, in any sample of guano.

"Meanwhile the following may be offered as the average result of my analyses of genuine guano in reference to its agricultural value :—

"1.	Azotized animal matter, including urate of ammonia, together capable of affording from 8 to 16 per cent. of ammonia by slow decomposition in the soil	50
2.	Water	8 to 11
3.	Phosphate of lime	12 to 25
4.	Phosphate of ammonia, sulphate of ammonia, ammonia-phosphate of magnesia, together containing from 5 to 9 parts of ammonia	13
5.	Siliceous sand	1
		100

"Very moist guano has in general more actual and less potential ammonia than the dry guano.

"Andrew Ure.

"*London*, 13 *Charlotte street, Bedford square,*
"*February* 14, 1843."

Oellacher's analysis of a brownish yellow guano is as follows :—

			Ammonia.
1.	Urate of ammonia	12·20	1·06
2.	Oxalate of ammonia	17·73	6·50
3.	Oxalate of lime	1·30	
4.	Phosphate of ammonia	6·90	1·79
5.	Phosphate of ammonia and magnesia	11·63	1·68
6.	Phosphate of lime	20·16	
7.	Muriate of ammonia	2·25	0·72
8.	Chloride of sodium (common salt)	0·40	
9.	Carbonate of ammonia	0·80	0·23
10.	Carbonate of lime	1·65	
11.	Sulphate of potash	4·00	
12.	Sulphate of soda	4·92	
13.	Humate of ammonia	1·06	0·09
14.	Substance resembling wax	0·75	
15.	Sand	1·68	
16.	Water (hygroscopic)	4·31	
17.	Undefined organic matter	8·26	
		100·00	12·07

I am satisfied from its large proportion of oxalate of ammonia, that the sample thus analyzed was by no means a fair or normal specimen of guano; and it is in fact widely different from all the fresh samples which have passed through my hands. It is described as "knobby, being mixed with light laminated crystalline portions, in white grains, from the size of a pea to that of a pigeon's egg." Having some lumpy concre tions of a similar aspect in my possession, I submitted them to chemical examination.

G. 1,000 grains being digested in boiling water and strained, afforded a nearly colorless solution. This was concentrated till crystals of oxalate of ammonia appeared. It was then acidulated with hydrochloric acid, to protect the phosphoric acid from precipitation, and next treated carefully with a solution of nitrate of lime equivalent to the oxalic acid present. The oxalate of lime thus obtained being converted into carbonate weighed 80·5 grains, corresponding to 100 of oxalate of ammonia, being 10 per cent. of the weight of the guano.

The liquor filtered from the oxalate was precipitated by nitrate of barytes, and afforded 112 grains of sulphate of barytes=38 sulphuric acid; and the last filtrate being mixed with a given measure of ferric acetate, and the mixture supersaturated with ammonia, yielded subphosphate of iron, equivalent to 5 per cent of phosphoric acid. I digested with heat other 500 grains of the same guano in a weak solution of borax, filtered, acidulated the liquid, but obtained merely a trace of uric acid. It is clear therefore that the oxalate of ammonia had been formed in this guano at the expense of the uric acid, and that its concreted state, and the crystalline nodules disseminated through it, were the result of transformation by moisture in a hot climate, which had agglomerated it to a density of 1·75; whereas clean fresh guano, friable and dry like the above, is seldom denser than 1·65. The guano contained only 3·23 of ammonia; 65 of insoluble matter, 53 of earthy phosphates, 5 silica, 3 alkaline salts (fixed), and 7 organic matter.

Oxalate of ammonia, being readily washed away, it is a bad substitute for the urate of ammonia, urea, and azotized animal matter, which it has replaced. Oellacher could find no urea in the guano which he analyzed; another proof of its disintegration.

Bartel's analysis of a brown-red guano is as follows:—

1. Muriate of ammonia	6·500
2. Oxalate of ammonia	13·351
3. Urate of ammonia	3·244
4. Phosphate of ammonia	6·450
5. Substances resembling wax and resin	0·600
6. Sulphate of potash	4·277
7. Sulphate of soda	1·119
8. Phosphate of soda	5·291
9. Phosphate of lime	9·940
10. Phosphate of ammonia and magnesia	4·196
11. Common salt	0·100
12. Oxalate of lime	16·360
13. Alumina	0·104
14. Sand insoluble in nitric acid, and iron	5·800
15. Loss (water and volatile ammonia and undefined organic matter)	22·718
	100·000

Voelckel, in his analysis of guano, states 7 per cent. of oxalate of lime—a result quite at variance with all my experience—for I have never found so much as 2 per cent. of carbonate of lime in the washed and gently ignited insoluble matter; whereas, according to Bartels and Voelckel, from 10 to 5 per cent. of carbonate should be obtained, as the equivalents of the proportions of the oxalate assigned by them.

All these analyses are defective moreover in not showing the total quantity of ammonia which the guano is capable of giving out in the soil; and since it appears that the freshest guano abounds most in what I have called *potential* ammonia, it must possess, of consequence, the greatest fertilizing virtue.

A sample of *decayed dark-brown* moist guano from Chile, being examined as above described, for oxalate of ammonia, was found to contain none whatever; and it contained less than 1 per cent. of uric acid.

H. An article offered to the public, by advertisement, as Peruvian guano, was lately sent to me for analysis. I found it to be a spurious composition; it consisted of—

1. Common salts	32·0
2. Common siliceous sand	28·0
3. Sulphate of iron or copperas	5·2
4. Phosphate of lime	4·0, with
5. Organic matter from bad guano, &c. (to give it smell)	23·3
6. Moisture	7·5
	100·0

Genuine guano, when burned upon a red hot shovel, leaves a white ash of phosphate of lime and magnesia; whereas this factitious substance left a black fused mass of sea salt, copperas, and sand. The specific gravity of good fresh guano is seldom more than 1·66, water being 100; whereas that of the said substance was so high as 2·17; produced by the salt, sand, and copperas.

GUMS. Under the generic name Gum several substances have been classed, which differ essentially, though they possess the following properties in common: viz., forming a thick mucilaginous liquid with water, and being precipitable from that solution by alcohol. Properly speaking, we should style gums only such substances as are transformed into mucic acid by nitric acid; of which bodies there are three: 1. *Arabine*, which constitutes almost the whole of gum arabic; 2. *Bassorine*, which forms the chief part of gum tragacanth; and 3. *Ceracine*, which occurs in cherry-tree gum, and is convertible into gum arabic by hot water.

1. Gum arabic, in its ordinary state, contains 17 per cent. of water, separable from it by a heat of 212° F.

2. Cherry-tree gum consists of 52 per cent. of arabine, and 35 of a peculiar gum, which has been called *Cerasine*. This latter substance is convertible into grape sugar by boiling it with very dilute sulphuric acid.

GUNPOWDER, ANALYSIS OF. M. Bolley dissolves out the sulphur from charcoal in gunpowder (previously freed from its nitre by water), by digesting it, at a boiling heat for 2 hours, with the solution of 20 times its weight of sulphite of soda, which is thereby converted into hyposulphite. To the mixture water must be added, as it is wasted by the boiling. If the residuum be heated on platinum foil, it will exhale sulphur, if this had not been all removed by the sulphurous salt.

H.

HAIR CLOTH. See Weaving.

HATS. The body of a beaver hat is made of fine wool and coarse fur mixed and felted together, then stiffened and shaped; the covering consists of a coat of beaver fur felted upon the body. Cheap hats have their bodies made of coarse wool, and their coverings of coarse fur or fine wool. The body or foundation of a good beaver hat, is at present made of 8 parts of rabbit's fur, 3 parts of Saxony wool, and 1 part of lama, vicunia, or red wool. About two ounces and a half of the above mixture are sufficient for one hat, and these are placed in the hands of the *bower;* his tool is a bow or bent ashen staff, from 5 to 7 feet long, having a strong catgut string stretched over a bridge at each end, and suspended at its middle by a cord to the ceiling, so as to hang nearly level with the work-bench, and a small space above it. The wool and coarser fur are laid in their somewhat matted state upon this bench, when the bower, grasping the bent rod with his left hand, and *by means of a small wooden catch plucking the string with his right,* makes it vibrate smartly against the fibrous substances, so as to disentangle them, toss them up in the air, and curiously arrange themselves in a pretty uniform layer or fleece. A skilful bower is a valuable workman. The bowed materials of one hat are spread out and divided into two portions, each of which is compressed, first with a light wicker frame, and next under a piece of oil cloth or leather, called a hardening skin, till by pressing the hands backward and forward all over the skin, the filaments are linked together by their serrations into a somewhat coherent fleece of a triangular shape. The two halves or " bats" are then formed into a cap; one of them is covered in its middle with a 3-cornered piece of paper, smaller than itself, so that its edges may be folded over the paper, and by overlapping each other a little, form a complete envelope to the paper; the junctions are then partially felted together by rubbing them hard, care being taken to keep the base of the triangle open by means of the paper; the second bat being made to enclose the first by a similar process of folding and friction. This double cap, with its enclosed sheet of paper, is next rolled up in a damp cloth and kneaded with the hands in every direction, during which it is unfolded and creased up again in different forms, whereby the two layers get thoroughly incorporated into one body; thus, on withdrawing the paper, a hollow cone is obtained. The above operations have been partially described in the body of the Dictionary, and the remaining steps in making a hat are there sufficiently detailed.

In a great hat factory women are employed, at respectable wages, in plucking the beaver skins, cropping off the fur, sorting various qualities of wool, plucking and cutting rabbit's fur, shearing the nap of the blocked hat, picking out unseemly filaments of fur, and in trimming the hats; that is, lining and binding them.

The annual value of the hats manufactured at present in the United Kingdom is estimated at 3,000,000*l.* sterling. The quantity exported in 1840, was 22,522 dozens, valued at 81,583*l.*

With regard to the *stiffening* of hats, I have been furnished by a skilful operator with the following valuable information: "All the solutions of gums which I have hitherto seen prepared by hatters, have not been perfect, but, in a certain degree, a mixture, more or less, of the gums, which are merely suspended, owing to the consistency of the composition. When this is thinned by the addition of spirit, and allowed to stand, it lets fall a curdy looking sediment, and to this circumstance may be ascribed the frequent breaking of hats. My method of proceeding is, first to dissolve the gums by agitation in twice the due quantity of spirits, whether of wood or wine, and then, after complete solution, draw off one half the spirits in a still, so as to bring the stiffening to a proper consistency. No sediment subsequently appears on diluting this solution, however much it may be done.

"Both the spirit and alkali stiffenings for hats made by the following two recipes, have been tried by some of the first houses in the trade, and have been much approved of:—

Spirit Stiffening.

7 pounds of fine orange shellac.
2 pounds of gum sandarac.
4 ounces of gum mastic.
Half a pound of amber rosin.
1 pint of solution of copal.
1 gallon of spirit of wine or wood naphtha.

"The shellac, sandarac, mastic, and rosin, are dissolved in the spirit, and the solution of copal is added last.

Alkali Stiffening.

7 pounds of common block shellac.
1 pound of amber rosin.
4 ounces of gum thus.
4 ounces of gum mastic.
6 ounces of borax.
Half a pint of solution of copal.

"The borax is first dissolved in a little warm water (say 1 gallon); this alkaline liquor is now put into a copper pan (heated by steam), together with the shellac, rosin, thus, and mastic, and allowed to boil for some time, more warm water being added occasionally until it is of a proper consistence; this may be known by pouring a little on a cold slab somewhat inclined, and if the liquor runs off at the lower end, it is sufficiently fluid; if, on the contrary, it sets before it reaches the bottom, it requires more water. When the whole of the gums seem dissolved, half a pint of wood naphtha must be introduced, and the solution of copal; then the liquor must be passed through a fine sieve, and it will be perfectly clear and ready for use. This stiffening is used hot. The hat bodies, before they are stiffened, should be stiffened in a weak solution of soda in water, to destroy any acid that may have been left in them (as sulphuric acid is used in the making of the bodies). If this is not attended to, should the hat body contain any acid when it is dipped into the stiffening, the alkali is neutralized, and the gums consequently precipitated. After the body is steeped in the alkaline solution, it must be perfectly dried in the stove before the stiffening is applied; when stiffened and stoved it must be steeped all night in water, to which a small quantity of sulphuric acid has been added; this *sets* the stiffening in the hat body, and finishes the process. A good workman will stiffen 15 or 16 dozen hats a day. If the proof is required cheaper, more shellac and rosin must be introduced."

HIDES, untanned; buffalo, bull, cow, ox, or horse. Imported in 1840, 352,867; retained for consumption, 302,789. Rates of duty: from west coast of Africa, not exceeding 14 pounds, 2*s*. 4*d*.; from British possessions, dry, 2*s*., wet, 1*s*. 2*d*.; from other places, dry, 4*s*. 8*d*., wet, 2*s*. 4*d*. Net revenue, 40,139*l*. in 1840, and 45,328*l*. in 1839. In 1839, 16,557 pounds of tanned hides were imported for home consumption, and in 1840 only 5,822: at the rate from foreign parts of 6*d*. per pound, but if cut and trimmed, 9*d*.; from British possessions 3*d*., if cut and trimmed 4½*d*. per pound.

HOPS.

Annual amount of hop duty.

Yrs	Amount.	Yrs.	Amount.	Yrs.	Amount.	Yrs.	Amount	Yrs.	Amount.	Yrs.	Amount.
1711	£43,437	1733	£70,215	1755	£82,157	1777	£43,581	1799	£73,279	1821	£154,609
1712	30,278	1734	37,716	1756	48,106	1778	159,891	1800	72,928	1822	203,724
1713	23,018	1735	42,745	1757	69,713	1779	55,800	1801	241,227	1823	26,058
1714	14,457	1736	46.482	1758	72,896	1780	122,724	1802	15,463	1824	148,832
1715	44,975	1737	56,492	1759	42,115	1781	120,218	1803	199,305	1825	24,317
1716	20,354	1738	86,575	1760	117,992	1782	14,895	1804	177,617	1826	269,331
1717	54,669	1739	70,742	1761	79,776	1783	75,716	1805	32,904	1827	140.848
1718	15,005	1740	37,875	1762	79,295	1784	94,359	1806	153,102	1828	172,027
1719	90,317	1741	65,222	1763	88,315	1785	112,684	1807	100,071	1829	38,398
1720	38,169	1742	45,550	1764	17.178	1786	95,973	1808	251,089	1830	88,047
1721	61,362	1743	61,072	1765	73,778	1787	42,227	1809	63,452	1831	174,864
1722	49,443	1744	46,708	1766	116,445	1788	143,168	1810	73,514	1832	139,018
1723	30.279	1745	34,635	1767	25,997	1789	104,063	1811	157,025	1833	156,905
1724	61,271	1746	91,879	1768	114,002	1790	106,841	1812	30,633	1834	189.713
1725	6,526	1747	62,993	1769	16,201	1791	90,059	1813	131,482	1835	235,207
1726	80,031	1748	87,155	1770	101,131	1792	162,112	1814	140,202	1836	200,332
1727	69,409	1749	36,805	1771	33,143	1793	22,619	1815	123,878	1837	178,578
1728	41,494	1750	72,138	1772	102,650	1794	203,063	1816	46,302	1838	171,556
1729	48,441	1751	73,954	1773	45,847	1795	82,342	1817	66,522	1839	205,537
1730	44,419	1752	82,163	1774	138,887	1796	75,223	1818	199,465	1840	34,091
1731	22,600	1753	91,214	1775	41,597	1797	157,458	1819	242,476	1841	146,159
1732	35,135	1754	102,012	1776	125,691	1798	56,032	1820	138,330	1842	169,776

Number of acres under the cultivation of hops in England.

1807	38,218	1813	39,521	1819	51,014	1825	46,718	1831	47,129	1837	56,323
1808	38,436	1814	40,571	1820	50,148	1826	50,471	1832	47,101	1838	55,045
1809	38,357	1815	42,150	1821	45,662	1827	49,485	1833	49,187	1839	52,305
1810	38,265	1816	44,219	1822	43,766	1828	48,365	1834	51,273	1840	44,805
1811	38,401	1817	46,493	1823	41,458	1829	46,135	1835	53,816	1841	45,769
1812	38,700	1818	48,593	1824	43,449	1830	46,726	1836	55,422	1842	

Hop duties of particular districts.

	1839.	1840.	1841.	1842.
Rochester - - -	£60,802 16 6	£23,256 19 8	£51,490 3 8	£58,812 4 7
Canterbury - - -	50,649 3 0	5,757 0 4	33,960 14 10	31,019 13 5
Kent - - - -	111,451 19 6	29,014 0 0	85,450 18 6	90,731 18 0
Sussex - - - -	65,026 19 7	3,080 12 9	38,086 13 10	43,561 10 0
Worcester - - -	16,639 16 4	239 19 0	12,076 19 8	19,815 2 11
Farnham - - -	7,730 7 2	1,643 18 7	7,702 10 2	11,678 18 4
North Clays - - -	2,005 13 10	57 4 1	1,159 7 10	1,724 2 7
Essex - - - -	1,624 5 9	35 17 1	977 3 0	2,050 19 11
Sundries - - -	1,058 11 5	20 4 8	705 8 7	203 14 3
	205,538 12 7	34,091 17 2	146,159 1 7	169,776 6 0

HORN. Mr. J. James has contrived a method of opening up the horns of cattle, by which he avoids the risk of scorching or frizzling, which is apt to happen in heating them over an open fire. He takes a solid block of iron pierced with a conical hole, which is fitted with a conical iron plug, heats them in a stove to the temperature of melting lead, and having previously cut up the horn lengthwise on one side with a saw, he inserts its narrow end into the hole, and drives the plug into it with a mallet. By the heat of the irons, the horn gets so softened in the course of about a minute, as to bear flatting out in the usual way.

HYPOSULPHITE OF SODA. This salt, so extensively used in the practice of *Daguerrotyping*, may be easily prepared in quantities by the following process:—Mix one pound of finely pulverized ignited carbonate of soda with ten ounces of flowers of sulphur, and heat the mixture slowly in a porcelain dish till the sulphur melts. Stir the fused mass, so as to expose all its parts freely to the atmosphere, whereby it passes from the state of a sulphuret, by the absorption of atmospherical oxygen, into that of a sulphite, with the phenomenon of very slight incandescence. Dissolve in water, filter the solution, and boil it immediately along with flowers of sulphur. The filtered concentrated saline liquid will afford, on cooling, a large quantity of pure and beautiful crystals of hyposulphite of soda.

I.

ILLUMINATION, COST OF. The production, diffusion, and economy of light, are subjects of the highest interest both to men of science and men of the world; leading the former to contemplate many of the most beautiful phenomena of physics and chemistry, while they provide the latter with the artificial illumination so indispensable to the business and pleasures of modern society. The great cost of light from wax, spermaceti, and even stearic candles, as also the nuisance of the light from tallow ones, have led to the invention of an endless variety of lamps, of which the best hitherto known is undoubtedly the mechanical or Carcel lamp, so generally used by the opulent families in Paris. In this lamp the oil is raised through tubes by clock-work, so as continually to overflow at the bottom of the burning wick; thus keeping it thoroughly soaked, while the excess of the oil drops back into the cistern below. I have possessed for several years an excellent lamp of this description, which performs most satisfactorily; but it can hardly be trusted in the hands of a servant; and when it gets at all deranged, it must be sent to its constructor in Paris to be repaired. The light of this lamp, when furnished with an appropriate tall glass chimney, is very brilliant, though not perfectly uniform; since it fluctuates a little, but always perceptibly to a nice observer, with the alternating action of the pump-work; becoming dimmer after every successive jet of oil, and brighter just before its return. The flame, moreover, always flickers more or less, owing to the powerful draught, and rectangular reverbatory shoulder of the chimney. The mechenical lamp is, however, remarkable for continuing to burn, not only with unabated but with increasing splendor for seven or eight hours; the vivacity of the combustion increasing evidently with the increased temperature and fluency of the oil, which, by its ceaseless circulation through the ignited wick, gets eventually pretty warm.. In the comparative experiments made upon different lights by the Parisian philosophers, the mechanical lamp is commonly taken as the standard. I do not think it entitled to this pre-eminence: for it may be made to emit very different quantities of light, according to differences in the nature and supply of the oil, as well as variations in the form and position of the chimney. Besides, such lamps are too rare in this country to be selected as standards of illumination.

After comparing lights of many kinds, I find every reason to conclude that a large wax candle of three to the pound, either long or short, that is, either 12 or 15 inches in length, as manufactured by one of the great wax-chandlers of London, and furnished with a wick containing 27 or 28 threads of the best Turkey cotton, is capable of furnishing a most uniform, or nearly invariable standard of illumination. Its affords one tenth of the light emitted by one of the Argand lamps of the Trinity house, and one eleventh of the light of my mechanical lamp, when each lamp is made to burn with its maximum flame, short of smoking.

The great obstacle to the combustion of lamps, lies in the viscidity, and consequent sluggish supply of oil, to the wicks; an obstacle nearly insuperable with lamps of the common construction during the winter months. The relative viscidity, or relative fluency of different liquids at the same temperature, and of the same liquid at different temperatures, has not, I believe, been hitherto made the subject of accurate researches. I was, therefore, induced to make the following experiments with this view.

Into a hemispherical cup of platinum, resting on the ring of a chemical stand, I introduced 2,000 water-grain measures of the liquid whose viscidity was to be measured, and ran it off through a glass syphon, $\frac{1}{8}$ of an inch in the bore, having the outer leg $3\frac{1}{4}$ inches, and the inner leg 3 inches long. The time of efflux became the measure of the viscidity; and of two liquids, if the specific gravity, and consequent pressure upon the syphon, were the same, that time would indicate exactly the relative viscidity of the two liquids. Thus, oil of turpentine and sperm oil have each very nearly the same density; the former being, as sold in the shops, =0·876, and the latter from 0·876 to 0·880, when pure and genuine. Now I found that 2,000 grain-measures of oil of turpentine ran off through the small syphon in 95 seconds, while that quantity of sperm oil took 2,700 seconds, being in the ratio of 1 to $28\frac{1}{2}$; so that the fluency of oil of turpentine is $28\frac{1}{2}$ times greater than that of sperm oil. Pyroxilic spirit, commonly called naphtha, and alcohol, each of specific gravity 0·825, were found to run off respectively in 80 and 120 seconds; showing that the former was 50 per cent. more fluent than the latter. Sperm oil, when heated to 265 Fahr., runs off in 300 seconds, or one ninth of the time it took when at the temperature of 64°. Southern whale oil, having a greater density than the sperm oil, would flow off faster were it not more viscid.

2,000 grain-measures of water at 60° run off through the said syphon in 75 seconds, but when heated to 180°, they run off in 61.

Concentrated sulphuric acid, though possessing the great density of 1·840, yet flows off very slowly at 64°, on account of its viscidity; whence its name of oil of vitriol. 2,000 grain-measures of it took 660 seconds to discharge.

Mr. Samuel Parker, long advantageously known to the public for his sinumbral and pneumatic fountain lamps, as well as other inventions subservient to domestic comfort, having obtained a patent for a new lamp, in which the oil is heated by a very simple contrivance, in the cistern, to any desired degree, before arriving at the wick, I instituted an extensive series of experiments to determine its value in the production of light, and consumption of oil, compared to the value of other lamps, as well as candles, in these respects.

In *fig.* 73. A, A, B, B, is a section of the cylinder which constitutes the cistern; the oil being contained between the inner and outer cylinders, and receiving heat from the flame of the lamp which passes up through the inner cylinder, and is reverberated more or less against its sides by the top of the metal chimney, being notched and bent back. D is a slide-valve which is opened to allow the oil to descend to the wick, and is shut when the cistern is to be separated from the pipe of supply, at E, for the purpose of recharging it with oil. The flame is modified, not by raising or lowering the wick, as in common lamps, but by raising or lowering the bell-mouthed glass chimney which rests at its bottom on three points, and is moved by means of the rack-work mechanism F. The concentric cylindric space A, A, and B, B, contains a pint imperial, and should be made entirely full before lighting the lamp; so as to leave no air in the cistern, which, by its expansion with the heat, would inevitably cause an overflow of the oil.

The following arrangement was adopted in these experiments for determining the relative illumination of the different lights. Having trimmed, with every precaution, my French mechanical lamp, and charged it with pure sperm oil, I placed it upon an oblong table, at a distance of 10 feet from a wall, on which a white sheet of paper was stuck. One of Mr. Parker's hot-oil lamps, charged with a quantity of the same oil, was placed upon the same table; and each being made to burn with its maximum

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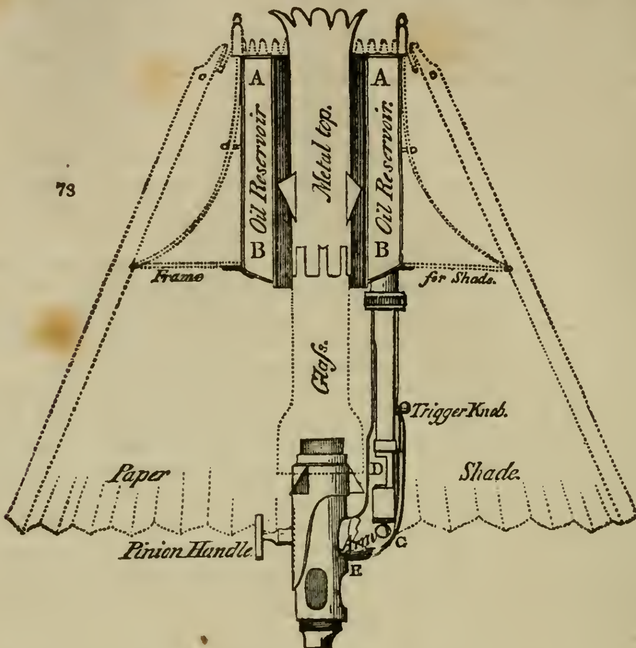


brilliancy, short of smoking, the relative illumination of the two lamps was determined by the well-known method of the comparison of shadows; a wire a few inches long, and of the thickness of a crow-quill, being found suitable for enabling the eye to estimate very nicely the shade of the intercepted light. It was observed in numerous trials, both by my own eyes and those of others, that when one of the lamps was shifted half an inch nearer to or further from the paper screen, it caused a perceptible difference in the tint of the shadow. Professor Wheatstone kindly enabled me to verify the precision of the above method of shadows, by employing, in some of the experiments, a photometer of his own invention, in which the relative brightness of the two lights was determined by the relative brightness of the opposite sides of a revolving silvered ball, illuminated by them.

1. The mechanical lamp was furnished with a glass chimney 1·5 inches in diameter at the base, and 1·2 at top; the wide bottom part was 1·8 inches long, and the narrow upper part 8 inches. When placed at a distance of 10 feet from the wall its light there may be estimated as the square of this number, or 100. In the first series of experiments, when burning with its maximum flame, with occasioned flickerings of smoke, it emitted a light equal to that of 11 wax candles, and consumed 912 grains of oil per hour. The sperm oil was quite pure, having a specific gravity of 0·874 compared to water at 1,000. In a subsequent series of experiments, when its light was less flickering, and equal only to that of 10 wax candles, it consumed only 815 grains, or 0·1164 of a lb. per hour. If we multiply this number into the price of the oil (8*s.* per gallon) per lb. 11*d.*, the product 1·2804*d.* will represent the relative cost of this illumination, estimated at 100.

2. The hot-oil lamp burns with a much steadier flame than the mechanical, which must be ascribed in no small degree to the rounded slope of the bell-mouthed glass chimney, whereby the air is brought progressively closer and closer into contact with the outer surface of the flame, without being furiously dashed against it, as it is by the rectangular shoulder of the common contracted chimney. When charged with sperm oil, and made to burn with its maximum flame, this lamp required to be placed one foot further from the screen than the mechanical lamp, in order that its shadow should have the same depth of tint. Hence, its relative illumination was, in that case, as the square of 11 to the square of 10; or as 121 to 100. Yet its consumption of oil was

only 696 grains, or somewhat less than 0·1 of a pound per hour. Had its light been reduced to 100, it would have consumed only 576 grains per hour, or 0·82 of a pound. If we multiply this number by 11*d*., the product 0·902*d*. will represent the relative cost of 100 of this illumination.

3. The hot-oil lamp being charged with the southern whale oil, of specific gravity 0·926, at 2*s*. 6*d*. per gallon, or 3¾*d*. per lb., when burning with its maximum flame, required to be placed 9 feet and 1 inch from the screen to drop the same tint of shadow upon it as the flames of the other two lamps did at 10 and 11 feet with the sperm oil. The square of 9 feet and 1 inch = 82 is the relative illumination of the hot-oil lamp with the southern whale oil. It consumed 780 grains, or 0·111 of a pound per hour; but had it given 100 of light it would have consumed 911 grains, or 0·130 of a pound, which number being multiplied by its price 3¾*d*., the product 0·4875*d*. will represent the relative cost of 100 of this light.

4. A hot-oil lamp charged with olive oil of specific gravity 0·914, at 5*s*. 6*d*. per gallon, or 7½*d*. per lb. when burning with its maximum flame, required to be placed at 9 feet 6 inches, to obtain the standard tint of shadow upon the screen. It consumed 760 grains per hour. The square of 9½ feet is 90¼, which is the relative intensity of the light of this lamp. Had it emitted a light = 100, it would have consumed 840 grains, or 0·12 of a pound per hour—which number multiplied by the price per pound, gives the product 0·9*d*. as the relative cost of 100 of this light.

5. A hot-oil lamp charged with Price and Co.'s cocoa-nut oil (oleine), of specific gravity 0·925, at 4*s*. 6*d*. per gallon, or 5¾*d*. per lb., had to be placed 9 feet from the screen, and consumed 1,035 grains per hour. Had its light been 100 instead of 81 (9^2), the consumption would have been 1,277 grains, or 0·182 of a pound per hour! which number multiplied by its price per pound, the product 1·031*d*. will represent the cost of 100 of this illumination.

6. In comparing the common French annular lamp in general use with the mechanical lamp, it was found to give about one half the light, and to consume two thirds of the oil of the mechanical lamp.

7. Wax candles from some of the most eminent wax-chandlers of the metropolis were next subjected to experiment; and it is very remarkable that, whether they were threes, fours, or sixes in the pound, each afforded very nearly the same quantity of light, for each required to be placed at a distance of three feet from the screen to afford a shadow of the same tint as that dropped from the mechanical lamp, estimated at 100. The consumption of a genuine wax candle, in still air, is upon an average of many experiments, 125 grains per hour, but as it affords only 1 11th of the light of the mechanical lamp, 11 times 125 = 1,375 grains, or 0·1064 of a pound is the quantity that would need to be consumed to produce a light equal to that of the said lamp. If we multiply that number by the price of the candles per lb. = 30*d*. the product = 5·892*d*. is the cost of 100 of illumination by wax. A wax candle, three in the pound (short), is one inch in diameter, 12 inches in length, and contains 27 or 28 threads, each about 1 10th of an inch in diameter. But the quality of the wick depends upon the capillarity of the cotton fibrils, which is said to be greatest in the Turkey cotton, and hence the wicks for the best wax candles are always made with cotton yarn imported from the Levant. A wax candle, three in the pound (long), is ⅞ of an inch in diameter, 15 inches long, and has 26 threads in its wick. A wax candle, six to the pound, is 9 inches long, 4 5ths of an inch in diameter, and has 22 threads in its wick. The light of this candle may be reckoned to be, at most, about 1 11th less than that of the threes in the pound. A well-made short three burns with surprising regularity in still air, being at the rate of an inch in an hour and a half, so that the whole candle will last 18 hours. A long three will last as long, and a six about 9½ hours. Specific gravity of wax = 0·960.

8. A spermaceti candle, three in the pound, is 9 10ths of an inch in diameter, 15 inches long, and has a plaited wick, instead of the parallel threads of a wax candle. The same candles four in the pound, are 8 10ths of an inch in diameter, and 13½ inches long. Each gives very nearly the same quantity of light as the corresponding wax candles: viz., 1 11th of the light of the above mechanical lamp, and consumes 142 grains per hour. Multiplying the last number by 11, the product, 1,562 grains = 0·223 of a pound, would be the consumption of spermaceti requisite to give 100 of illumination. Multiplying the last number by 24*d*., the price of the candles per pound, the product 5·352*d*. is the relative cost of 100 of this illumination.

9. *Stearic acid* candles, commonly called German wax, consume 168·5 grains, or 0·024 of a pound per hour, when emitting the same light as the standard wax candle. Multiplying the latter number by 11, and by 16*d*. (the price of the candles per pound), the product 4·224*d*. will represent the relative cost of 100 of this illumination.

10. Tallow candles: moulds, short threes, 1 inch in diameter, and 12½ in length; do. long threes, 9 10ths of an inch in diameter, and 15 in length; do., long fours, 8 10ths of

an inch in diameter, and 13¾ in length. Each of these candles burns with a most uncertain light, which varies from 1 12th to 1 16th of the light of the mechanical lamp—the average may be taken at 1 14th. The threes consume each 144 grains, or 0·2 of a pound, per hour; which number, multiplied by 14, and by 9*d.* (the price per pound), gives the product 2·52*d.* for the relative cost of 100 of this illumination.

11. Palmer's spreading wick candles. Distance from the screen 3 feet 4 inches, with a shadow equal to the standard. Consumption of tallow per hour 232·5 grains, or 0·0332 of a pound. The square of 3 feet 4 inches = 11·9 is the relative illumination of this candle = 11·9 : : 0·3332 : : 100 : 0·28 ⁄ 10*d.* = 11·9 is the relative cost of this illumination.

12. Cocoa-nut stearine candles consumed each 168 grains per hour, and emitted a light equal to 1 16th of the standard flame. Multiplying 168 by 16, the product 30·88 grains, or 0·441 of a pound, is the quantity which would be consumed per hour to afford a light equal to 100. And 0·441 multiplied by 10*d.*, the price per pound, gives the product 4·441*d.* as the cost of 100 of this illumination per hour.

A gas argand London lamp, of 12 holes in a circle of ¾ of an inch in diameter, with a flame 3 inches long, afforded a light = 78½ compared to the mechanical lamp: and estimating the light of the said mechanical lamp as before, at 100, that of the hot-oil lamp is 121, and that of the above gas flame of 78·57, or in round numbers 80, *and the common French lamp in general use* 50.

Collecting the preceding results, we shall have the following tabular view of the cost per hour of an illumination equal to that of the mechanical lamp, reckoned 100, or that of eleven wax candles, three to the pound.

TABLE of COST per HOUR of ONE HUNDRED of ILLUMINATION.

	Pence.	Pence.
1. Parker's hot-oil lamp, with southern whale oil	0·4875	or about ½*d.*
2. Mechanical or Carcel lamp, with sperm oil	1·2804	1¼
3. Parker's hot-oil lamp, with sperm oil	0·902	1
4. Ditto ditto common olive oil	0·900	1
5. Ditto ditto cocoa-nut oleine or oil	1·031	1
6. French lamp in general use, with sperm oil	1·7072	1¾
7. Wax candles	5·892	6
8. Spermaceti candles	5·352	5¼
9. German wax (Stearic acid) ditto	4·224	4¼
10. Palmer's spreading wick candles	2·800	2¾
11. Tallow (mould) candles	2·520	2½
12. Cocoa-nut stearine of Price and Co.	4·41	4½

Since the hot-oil lamp affords sufficient light for reading, writing, sewing, &c., with one fifth of its maximum flame, it will burn at that rate for 10 hours at the cost of about ONE PENNY, and it is hence well entitled to the inventor's designation, "The Economic."

Sir D. Brewster, in his examination lately before the committee of the house of commons on lighting the house, stated, that the French light-house lamp of Fresnel emitted a light equal to that of forty argand flames; whereas, according to other accounts, it gave much less light. With the view of settling this point, before being examined by the said committee, I repaired to the Trinity house, and tried one of the two original Fresnel lamps, which had been deposited there by that eminent French engineer himself. This lamp consists of four concentric circular wicks, placed in one horizontal plane; the innermost wick being ⅞ of an inch in diameter, and the outermost 3½ inches. Being carefully trimmed, supplied with the best sperm oil, surmounted with its great glass chimney, burning with its maximum flame, and placed at a distance of 13 feet 3 inches from the screen, it let fall a shadow of the same tint as that let fall by the flame of my mechanical lamp, placed at a distance of 4 feet 6 inches from the screen. The squares of these two numbers are very nearly as 8¾ to 1 (175·5625 to 20·25); showing that the Fresnel lamp gives less than 9 times the light of my mechanical lamp, and about 9·6 times the light of one of the Trinity house argand lamps. The Fresnel lamp is exceedingly troublesome to manage, from the great intensity of its heat, and the frequent fractures of its chimneys—two having been broken in the course of my experiments at the Trinity house.

Mr. Goldsworthy Gurney, the ingenious inventor of the new light-house lamp, in which a stream of oxygen gas is sent up through a small tube within the burning circular wick of a small argand lamp, having politely sent two of his lamps to my house, along with a bag of oxygen gas, I made the following experiments, to ascertain their illuminating powers compared to those of the mechanical lamp and wax candles.

His larger lamp has a wick ⅝ of an inch in diameter, but emits an oxygen flame of only ⅝ of an inch. The flame is so much whiter than that of the best lamp or candle, that it becomes difficult to determine, with ultimate precision, the comparative depths of the shadows let fall by them. The mean of several trials showed that the above *Bude*-light (as Mr. Gurney calls it, from the name of his residence in Cornwall), has an illuminating power of from 28 to 30 wax candles. His smaller lamp has a flame ¾ of an inch in diameter, and a wick ½ of an inch. Its light is equal to that of from 18 to 20 wax candles.

The committee of the house of commons on lighting it, having asked me what was the relative vitiation of air by the breathing of men and the burning of candles, I gave the following answer:—

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 1,632 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 vapor, 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.

The following table contains, according to Péclet, the illuminating powers of different candles, and their consumption of material in an hour; the light emitted by a *Carcel* argand lamp, consuming 42 grammes (= 42 × 15½ grains) in an hour, being called 100:—

	Intensity of Light.	Consumption per Hour.
Tallow Candles 6 in lb. - -	10·66	8·51
Stearine, or Pressed Tallow, 8 in lb. -	8·74	7·51
——————— 5 in lb. -	7.50	7·42
Wax Candles, 5 in lb. - - -	13·61	8·71
Spermaceti ditto, 5 in lb. - -	14·40	8·92
Stearic Acid, commonly called Stearine, 5 in lb. - - - -	14·40	9·33

The subjoined table shows the economical ratios of the candles, where the second column gives the quantity of material in grammes which is requisite to produce as much light as the Carcel lamp:—

	Quantity of Material.	Price per Kilogramme.	Cost of Light per Hour.
Tallow Candle 6 per lb. -	70·35	1 f. 40 c.	9·8 c.
——————— 8 per lb. -	85·92	1 f. 40 c.	12·0 c.
Pressed Tallow, 5 per lb. -	98·93	2 f. 40 c.	23·7 c.
Wax Candle, 5 per lb. - -	64·04	7 f. 60 c.	48·6 c.
Spermaceti ditto, 5 per lb. -	61·94	7 f. 60 c.	47·8 c.
Stearine ditto, 5 per lb. -	65·24	6 f.	37·1 c.

These results may be compared with mine given above. A kilogramme, or 1,000 grammes = 15,440 grains = 2¼ lbs., avoirdupois.

INDIGO. Imported for home consumption, in 1839, 2,704,396 pounds; in 1840, 2,996,215; duty 3*d*. on West Indian, 4*d*. on East Indian.

INK. Mr. Stephen's patent blue ink is made by dissolving Prussian blue in a solution of oxalic acid.

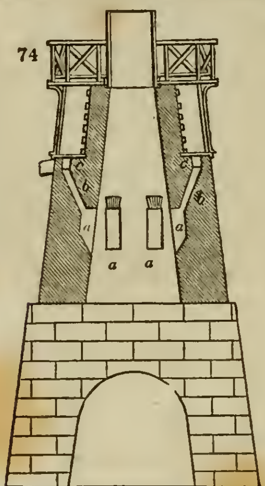
IRON. For certain new processes for making malleable iron, Mr. W. N. Clay has obtained two successive patents. Under the first, of December, 1837, he mixed bruised hematite, with one fifth of its weight of clean carbonaceous matter in coarse powder, and subjected the mixture in a ⌓ shaped retort to a bright red heat for twelve or more hours, till the ore be reduced to the metallic state, as is easily ascertained by applying a file to one of the fragments. When discharged, the metal is to be transferred into a balling or puddling furnace, along with about five per cent. of ground coke or anthracite, and worked therein in the usual way. He also proposes to use a conical kiln, like that for burning lime, instead of the retorts.

In his second patent, dated March, 1840, Mr. Clay prescribes above 28 per cent. (from 30 to 40) of carbonaceous matter to be mixed with the ground-iron ore, containing at least 45 per cent. of metal, which mixture is to be directly treated in a puddling furnace. He also proposes to use a mixture of pig or scrap iron and ore, in equal quantities.

The application of the waste gases (carbonic oxide chiefly) of the blast furnace to the purpose of heating the puddling or balling furnace, was made the subject of a patent in June, 1841, by a foreigner not named. The process had been previously practised in Germany, and is fully described in the *Annales des Mines*, about two years ago.

In *fig*. 74 the manner of conveying the waste carbonic oxide from a blast furnace is shown: *a*, *a*, *a*, are openings leading into the vertical channels or passages, *b*, and thence into the chamber *c*. There is a top to this chamber, with openings corresponding to the passages *b*. These openings are closed with cast-iron plates that can be taken off for the purpose of clearing out the passages *b*, and the chamber *c*. From the chamber *c*, the gas may be conducted in any direction, and to a distance of several hundred feet.

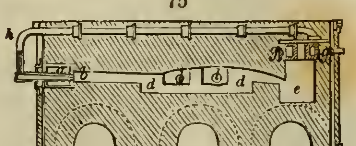
74



In some localities, and in cases where it is required to take the gas from a blast furnace in operation, a metal cylinder, of a smaller diameter than the top of the furnace, and of a depth equal to its diameter, is suspended vertically within the top of the blast furnace the whole of its length. The space between the cylinder and the furnace at the top or mouth is to be hermetically sealed, and the furnace is to be charged through the cylinder, which must be kept full of minerals and combustibles. Thus the space between the cylinder and the interior of the furnace remains vacant, but the gas may be conducted out of that part laterally, if required. The gases led off from the blast furnace may, if need be, pass through heated pipes, as for the hot blast.

Figs. 75 and 76 represent a refining furnace for iron, with the necessary apparatus for working it with the gases, without the use of other fuel; *fig*. 75 being a vertical section, and *fig*. 76 a sectional plan view.

75



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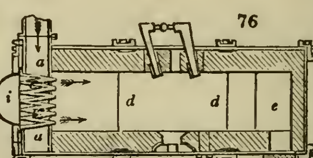


The gas from the blast furnace is brought into the chamber *a a*, and passing through an opening *b b*, it enters the furnace; *c c* are a series of blow pipes, through which the heated air is forced into the furnace. In the space between the part marked *b* and the tubes *c*, the gas becomes mixed with the heated atmospherical air.

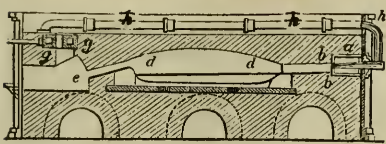
This combustible gas from the blast furnace, mixed with the heated air, produces an intense heat in the furnace, adequate to the refining of iron. The warm air for burning the gas is usually obtained from the blowing machine and hot blast pipes.

For giving a still greater heat, the air may be carried through the tube *f*, into the iron chambers g g, or a system of pipes, whence it is led through the tube *h*, into the semi-circular chamber *i*, and then through the small pipes *c*, *c*, *c*, into the furnace.

The metal to be refined is placed in the space *d d*, in a liquid state, if the arrangement of the furnaces will admit of its being so taken from the blast furnace; if not, it may be nearly melted by the waste heat in the chamber *e e*. In order to decarbonize the metal, a quantity of warm air, from the pipe *h*, is conducted through the pipe *k*, which is divided into two nozzles or *tuyères l l*, and blown upon the fluid metal in the space *d d*. After having been thus exposed for an hour or two, it is run off through the opening *m*, and will be found in a refined state.

Figs. 77, 78, show the application to a puddling furnace. The openings *n n* admit a stream of cold water to flow through the cast-iron piece *o o*, to preserve it from injury by the fire.

77



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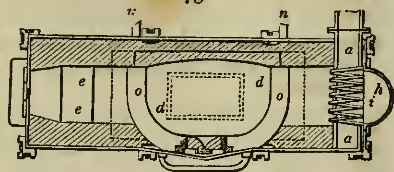

Fig. 79 is a welding furnace; the interior dimensions and the casing of the hearth being different, as well as the fire bridge, from those of the puddling furnace. The pipes for conducting the gases are made of cast-iron, and must have at least a sectional area of one foot for every furnace that is to be heated.

Figs. 80, 81, 82, 83, 84, show the application of this invention to the generation of steam. A chimney is here employed only at the commencement of the operation. The

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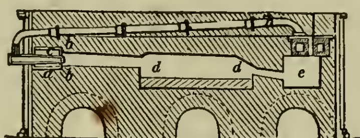

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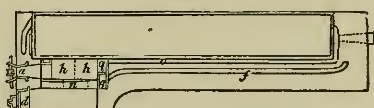

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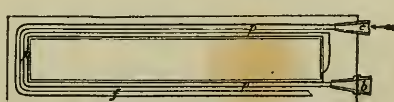

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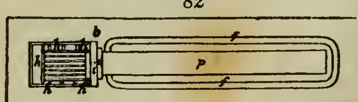


air is forced into the furnace by any sort of blowing machine, or in any other convenient way. The fuel is introduced into the fireplace, upon the grate *n n*, through the door *a*, which can be closed. The fireplace must contain as much fuel as will last for several hours. When the fire is first lighted, the combustion takes place in the ordinary way, on opening the door *d*, and the slide-valve *b*, and carrying through them a current of air by the chimney draught. This is continued till the steam-engine furnace, or any working (power) engine is in operation, after which a blowing apparatus is employed to force the air through the tube *c*, as shown in *fig.* 81. The openings *d* and *b* are then closed; the air forced in now passes through the flues *f*, *f*, *f*, placed round and beneath the boiler. The air, on arriving at the point *g*, is divided, one portion passes through the opening *h*, regulated by a valve, into the open space beneath the grate *n n*, to assist in the slow combustion of the fuel. The other part of the air passes through *g*, into *h h*, round the fireplace, in order to heat the air to an intense degree. After the second portion of the air has passed into the chamber *h h*, it enters another *i i*, thence through a series of blowpipes, or through *o*, into *p p*, beneath the boiler. The burnt air goes off through *p p* into a small chimney, through the opening *b b*, which is regulated by a valve.

IRON, Cast, Strength of.

In the following Table, each bar is reduced to exactly one inch square; and the transverse strength, which may be taken as a criterion of the value of each iron, is obtained from a mean between the experiments upon it, given in the Memoirs;—first on bars 4 ft. 6 in. between the supports, and next on those of half the length, or 2 ft. 3 in. between the supports. All the other results are deduced from the 4 ft. 6 in. bars. In all cases the weights were laid on the middle of the bar.

Table of Results obtained from Experiments on the Strength and other Properties of Cast Iron, from the principal Iron Works in the United Kingdom. By Mr. Wm. Fairbairn.

Number of Iron in the scale of strength.	Names of Irons.	Number of Experiments on each.	Specific gravity.	Modulus of elasticity in lbs. per square inch, or stiffness.†	Breaking weight in lbs. of bars 4 ft. 6 in. between supports.	Breaking weight in lbs. of bars 2 ft. 3 in. reduced to 4 ft. 6 in. between supports.	Mean breaking weight in lbs. (S.)	Ultimate deflection of 4 ft. 6 in. bars, in parts of an inch.	Power of the 4 ft. 6 in. bars to resist impact.	Color.	Quality.
1	Ponkey, No. 3. Cold Blast - - -	4	7·122	17211000	567	595	581	1·747	992	Whitish gray	Hard.
2	Devon, No. 3. Hot Blast* - -	2	7·251	22473650	537	—	537	1·09	589	White - -	Hard.
3	Oldberry, No. 3. Hot Blast -	5	7·300	22733400	543	517	530	1·005	649	White - -	Hard.
4	Carron, No. 3. Hot Blast* - - -	2	7·056	17873100	520	534	527	1·365	710	Whitish gray	Hard.
5	Beaufort, No. 3. Hot Blast - - -	5	7·069	16802000	505	529	517	1·599	807	Dullish gray	Hard.
6	Butterley - - - - - - - - - -	4	7·038	15379500	489	515	502	1·815	889	Dark gray -	Soft.
7	Bute, No. 1. Cold Blast - - -	4	7·066	15163000	495	487	491	1·764	872	Bluish gray	Soft.
8	Wind Mill End, No. 2. Cold Blast	4	7·071	16490000	483	495	489	1·581	765	Dark gray -	Hard.
9	Old Park, No. 2. Cold Blast - -	5	7·049	14607000	441	529	485	1·621	718	Gray - - -	Soft.
10	Beaufort, No. 2. Hot Blast - -	4	7·108	16301000	478	470	474	1·512	729	Dull gray -	Hard.
11	Low Moor, No. 2. Cold Blast - -	4	7·055	14509500	462	483	472	1·852	855	Dark gray -	Soft.
12	Buffery, No. 1. Cold Blast* - -	5	7·079	15381200	463	—	463	1·55	721	Gray - - -	Rather hard.
13	Brimbo, No. 2. Cold Blast - - -	5	7·017	14911666	466	453	459	1·748	815	Light gray -	Rather hard.
14	Apedale, No. 2. Hot Blast - -	3	7·017	14852000	457	455	456	1·730	791	Light gray -	Stiff.
15	Oldberry, No. 2. Cold Blast - -	4	7·059	14307500	453	457	455	1·811	822	Dark gray -	Rather soft.
16	Pentwyn, No. 2. - - - - - - -	4	7·038	15193000	438	473	455	1·484	650	Bluish gray	Hard.
17	Maesteg, No. 2. - - - - - -	5	7·038	13959500	453	455	454	1·957	886	Dark gray -	Rather soft.
18	Muirkirk, No. 1. Cold Blast* - -	4	7·113	14003550	443	464	453	1·734	770	Bright gray	Fluid.
19	Adelphi, No. 2. Cold Blast - -	5	7·080	13815500	441	457	449	1·759	777	Light gray -	Soft.
20	Blania, No. 3. Cold Blast -	5	7·159	14281466	433	464	448	1·726	747	Bright gray	Hard.
21	Devon, No. 3. Cold Blast* - - -	4	7·285	22907700	448	—	448	·790	753	Light gray -	Hard.
22	Gartsherrie, No. 3. Hot Blast - -	5	7·017	13894000	427	467	447	1·557	998	Light gray -	Soft.
23	Frood, No. 2. Cold Blast - - -	5	7·031	13112666	460	434	447	1·825	841	Light gray -	Open.
24	Lane End, No. 2. - - - - - - -	3	7·028	15787666	444	—	444	1·414	629	Dark gray -	Soft.
25	Carron, No. 3. Cold Blast* - - -	5	7·094	16246966	444	443	443	1·336	593	Gray - - -	Soft.
26	Dundivan, No. 3. Cold Blast - -	4	7·087	16534000	456	430	443	1·469	674	Dull gray -	Rather soft.
27	Maesteg (Marked Red) - - - -	5	7·038	13971500	440	444	442	1·887	830	Bluish gray	Fluid.
28	Corbyns Hall, No. 2. - - - -	5	7·007	13845866	430	454	442	1·687	727	Gray - - -	Soft.
29	Pontypool, No. 2. - - - - - - -	5	7·080	13136500	439	441	440	1·857	816	Dull blue -	Rather soft.
30	Wallbrook, No. 3. - - - - - -	5	6·979	15394766	432	449	440	1·443	625	Light gray -	Rather hard.
31	Milton, No. 3. Hot Blast - - -	4	7·051	15852500	427	449	438	1·368	586	Gray - -	Rather hard.
32	Buffery, No. 1. Hot Blast* - -	3	6·998	13730500	436	—	436	1·64	721	Dull gray -	Soft.
33	Level, No. 1. Hot Blast - - - -	5	7·080	15452500	461	403	432	1·516	699	Light gray -	Soft.
34	Pant, No. 2. - - - - - - - -	5	6·975	15280900	408	455	431	1·251	511	Light gray -	Rather hard.
35	Level, No. 2. Hot Blast - - - -	6	7·031	15241000	419	439	429	1·358	570	Dull gray -	Soft.
36	W. S. S., No. 2. - - - - - - -	5	7·041	14953333	413	446	429	1·339	554	Light gray -	Soft.
37	Eagle Foundry, No. 2. Hot Blast	4	7·038	14211000	408	446	427	1·512	618	Bluish gray	Soft.
38	Elsicar, No. 2. Cold Blast - - -	4	6·928	12586500	446	408	427	2·224	992	Gray - --	Soft.
39	Varteg, No. 2. Hot Blast - - -	4	7·007	15012000	422	430	426	1·450	621	Gray - - -	Hard.
40	Coltham, No. 1. Hot Blast - -	5	7·128	15510066	464	385	424	1·532	716	Whitish gray	Rather soft.
41	Carroll, No. 2 Cold Blast - - -	4	7·069	17036000	430	408	419	1·231	530	Gray - - -	Hard.
42	Muirkirk, No. 1. Hot Blast* - -	4	6·953	13294400	417	419	418	1·570	656	Bluish gray	Soft.
43	Bierley, No. 2. - - - - - - -	5	7·185	16156133	404	432	418	1·222	494	Dark gray -	Soft.
44	Coed-Talon, No. 2. Hot Blast* -	4	6·969	14322500	409	424	416	1·882	771	Bright gray	Soft.
45	Coed-Talon, No. 2. Cold Blast*	5	6·955	14304000	408	418	413	1·470	600	Gray - - -	Rather soft.
46	Monkland, No. 2. Hot Blast - -	3	6·916	12259500	402	404	403	1·762	709	Bluish gray	Soft.
47	Ley's Works, No. 1. Hot Blast -	3	6·957	11539333	392	—	392	1·890	742	Bluish gray	Soft.
48	Milton, No. 1. Hot Blast - - -	4	6·976	11974500	353	386	369	1·525	538	Gray - - -	Soft and fluid.
49	Plaskynaston, No. 2. Hot Blast -	5	6·916	13341633	378	337	357	1·366	517	Light gray	Rather soft.

Rule.—To find from the above table the breaking weight in rectangular bars, generally, calling b and d the breadth and depth in inches, and l the distance between the supports in feet, and putting 4·5 for 4 ft. 6 in., we have $\frac{4{\cdot}5 \times bd^2S}{l}$ = breaking weight in lbs., the value of S being taken from the table above.

For example:—What weight would be necessary to break a bar of Low Moor iron, 2 inches broad, 3 inches deep, and 6 feet between the supports? According to the rule given above, we have $b=2$ inches, $d=3$ inches, $l=6$ feet, $S=472$ from the table. Then $\frac{4{\cdot}5 \times bd^2S}{l} = \frac{4{\cdot}5 \times 2 \times 3^2 \times 472}{6} = 6372$ lbs., the breaking weight.

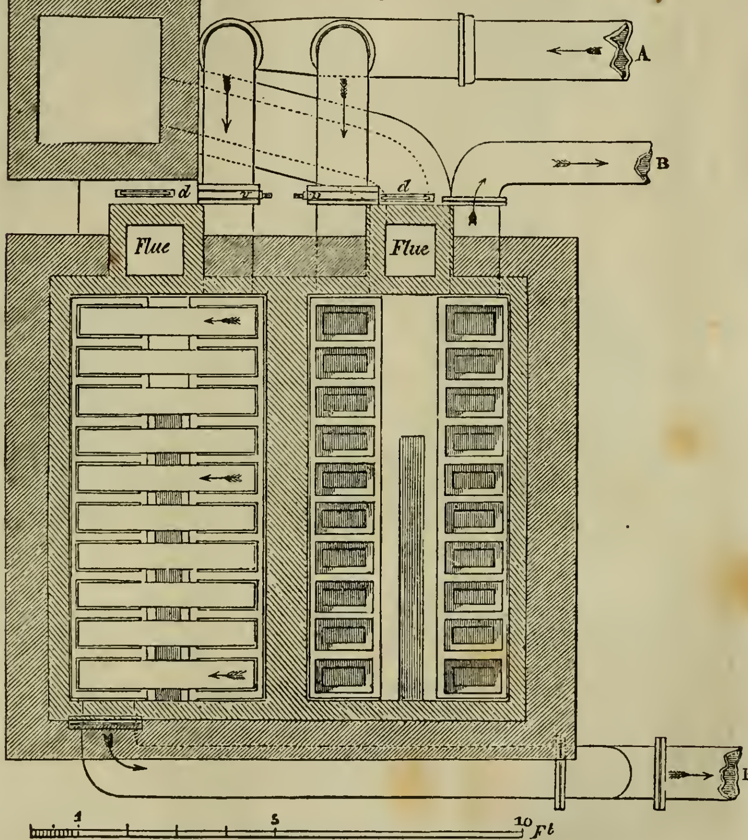
* The irons with asterisks are taken from the experiments on hot and cold blast iron, made by Mr. Hodgkinson and myself for the British Association for the Advancement of Science.—See Seventh Report, vol. vi.

† The modulus of elasticity was usually taken from the deflection caused by 112 lbs. on the 4 ft. 6 in. bars.

IRON. *Hot Blast.* To the account of this interesting innovation in the smelting of iron ores, given in the dictionary, I have now the pleasure of representing in accurate plans, the complete system mounted at the Codner Park Works belonging to William Jessop, Esq. For the drawings, from which the woodcuts are faithfully copied, I am indebted to Mr. Joseph Glynn, F.R.S., the distinguished engineer of the Butterly Iron Works.

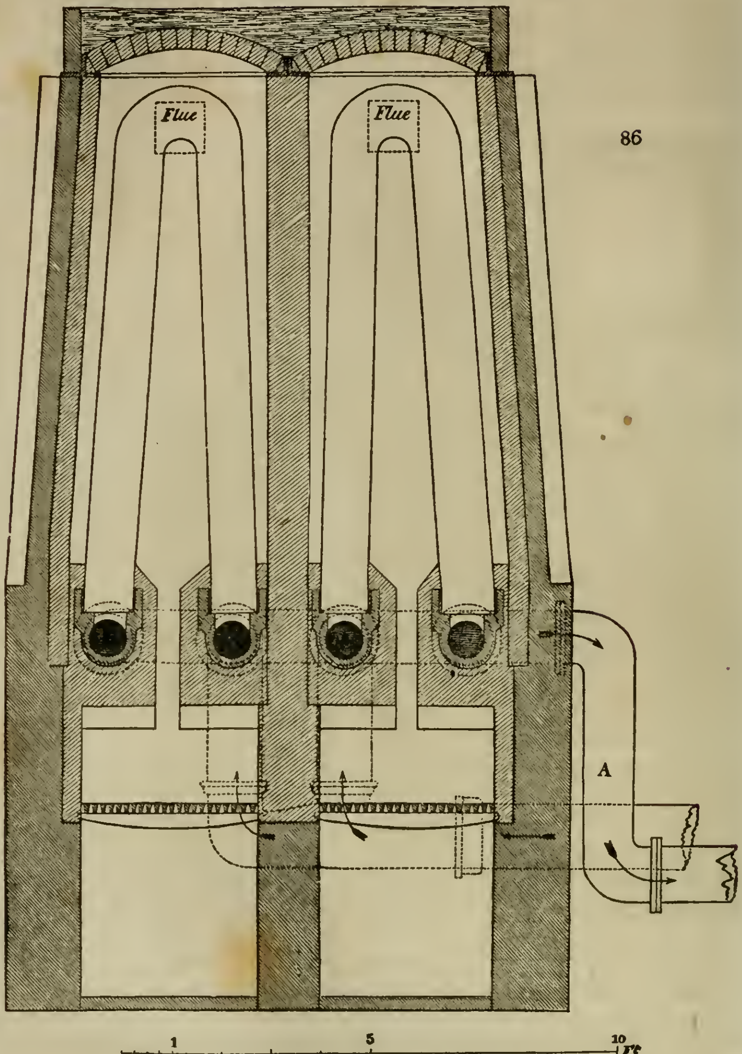
Figs. 85, 86, 87, exhibit the apparatus of the hot blast in every requisite detail. The smelting furnaces have now generally three tuvères, and three sets of air heating

85



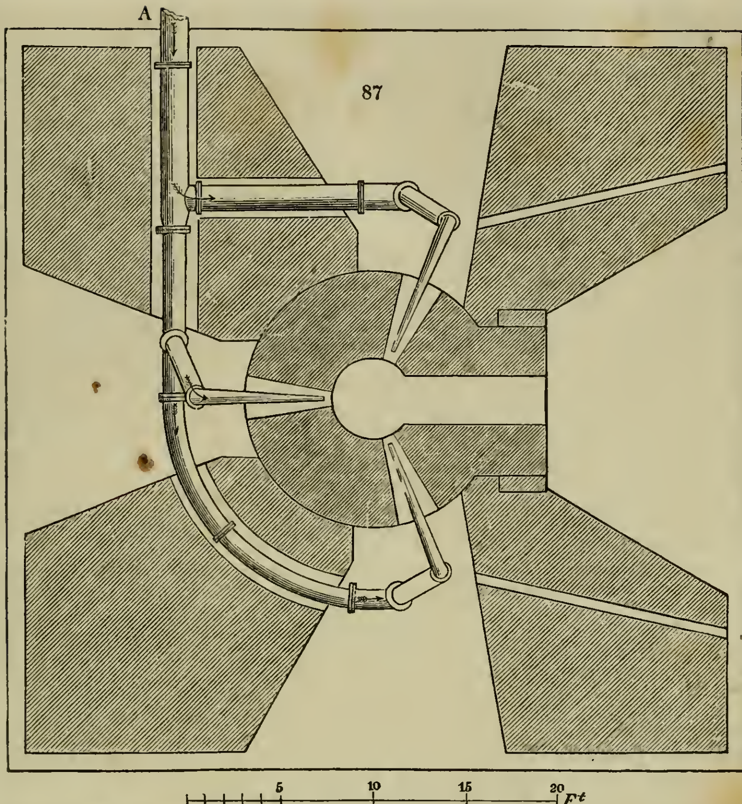
furnaces. The figures show two sets built together; the third set being detached on account of peculiar local circumstances. The air enters the horizontal pipe A, in the ground plan, *fig.* 85, on one side of the arched or syphon pipes, shown in upright section in *fig.* 86, and passes through these pipes to the horizontal pipe, B, on the other side; whence it proceeds to the blast furnace. These syphon pipes are flattened laterally, their section being a parallelogram, to give more heating surface, and also more depth of pipe (in the vertical plane), so as to make it stronger, and less liable to bend by its own weight when softened by the red heat. This system of arched pipe apparatus is set in a kind of oven, from which the flue is taken out at the top of it; but it thence again descends, before it reaches the chimney, entering it nearly at the level of the fire grate (as with coal gas retorts). By this contrivance, the pipes are kept in a bath of ignited air, and not exposed to the corroding influence of a current of flame. The places and directions of these oven flues are plainly marked in the drawing.

Fig. 87 is a plan of the blast furnace, drawn to a smaller scale than that of the preceding figures.



The three sets of hot-blast apparatus, all communicate with one line of conducting pipes, A, which leads to the furnace. Thus in case of repairs being required in one set, the other two may be kept in full activity, capable of supplying abundance of hot air to the blast, though of a somewhat lower temperature. See Smelting for constructions of different blast furnaces; also Puddling.

During a visit which I have recently made to Mr. Jessop, at Butterley, I found this eminent and very ingenious iron-master had made several improvements upon his hot-blast arrangements, whereby he prevented the alteration of form to which the arched pipes were subject at a high temperature, as also that he was about to employ five tuyères instead of three. For a drawing and explanation of his furnace-feeding apparatus, see Smelting.



ISINGLASS. Imported for home consumption in 1839, 1,644 cwts.: in 1840, 1,589 cwts. See GELATINE for excellent substitutes for isinglass in culinary operations. Were beer brewed by the Bavarian plan of fermentation, it would require no isinglass for fining it.

IVORY. Imported of elephant's teeth for home consumption in 1839, 3,929 cwts.; in 1840, 4,491 cwts. Duty 1*s*.

K.

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

L,

LAC DYE. Imported for home consumption in 1839, 532,881 pounds; in 1840, 644,092 pounds; 6*s*. per cwt. duty.

LACTIC ACID. See FERMENTATION.

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

"The *Vesta lamp*, burning with its utmost brilliancy, without smoke, emits a light equal to very nearly twelve wax or sperm candles of three or four to the pound; and in so doing, it consumes exactly one imperial pint of spirits of turpentine (value sixpence retail) in ten hours, hence the cost per hour for a light equal to ten such candles is one halfpenny; whereas that from wax candles would be nearly sixpence, from spermaceti ditto, fivepence; from stearine ditto, fourpence; from Palmer's spreading wick ditto, nearly threepence; from tallow moulds 2¼*d.*; from sperm oil in Carcel's Mechanical French Lamp, 1½*d.*

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

"The size of the flame from which so much light is emitted in the Vesta lamp, is greatly smaller than that of oil or gas argand flames of equal intensity; a circumstance to be accounted for from the difference in chemical composition, between spirits of turpentine and fat oils. The spirits consist entirely of carbon and hydrogen; in the proportion of 88½ of the former element, and 11½ of the latter, in 100 parts; and they consume 328 parts of oxygen; whereas, sperm and other unctuous oils consist of 78 parts of carbon, 11½ of hydrogen, and 10½ of oxygen, in 100 parts; and these consume only 287·2 of oxygen, in being burnt; because the oxygen already present in the oil neutralizes 2·6 parts of the carbon and 0·4 of the hydrogen, thus leaving only 85½ parts of the combustible elements for the atmosphere to burn. For this reason, 87½ parts by weight of spirits of turpentine, will consume as much oxygen as 100 parts of sperm oil; and will afford, moreover, a more vivid light, because they contain no oxide, as fat oils do, which serves to damp the combustion. In the spirits of turpentine, the affinity of its elements for oxygen is entire, whereas in fat oil the affinity is partially neutralized by the oxides it contains; somewhat as the flame of spirits of wine is weakened by their dilution with water.

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

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

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

"The cost, as compared with other Lamps or Candles, is as follows: viz.:—

	PER HOUR.
Paragon Camphine Lamp (equal to 11 wax candles) less than One Halfpenny.	
Wax Candles	6½*d.*
Spermaceti ditto	5¾
Adamantean wax (Stearic Acid)	4½
Palmer's Spread-Wick Candles	3¼
Cocoa Nut Candles	4¾
Moulds (Tallow)	2¾
Carcel's Lamp, with Sperm Oil	2"

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

LEAD. The total produce of the lead mines of Great Britain was estimated in 1822, at 31,900 tons, which were distributed as follows:—

Wales(Flintshire and Derbyshire)	7,500 tons.
Scotland	2,800
Cornwall and Devonshire	800
Shropshire	800
Derbyshire	1,000
Cumberland, Durham, and Yorkshire	19,000
	31,900

And in the year 1835, the total produce was estimated by Mr. John Taylor at 46,112 tons; of which 19,626 were furnished by Northumberland, Durham, and Cumberland; the mines of Mr. Beaumont alone yielding 10,000. See Solder.

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

The *bate* consists in steeping the haired hides in a solution of pigeons' dung, containing, Mr. Lee says, muriate of ammonia, muriate of soda, &c.; but most probably phosphates of ammonia and lime, with urate of ammonia, and very fermentable animal matter. The dry hides are often subjected first of all to the operation of the fulling-stocks, which opens the pores, but at the same time prepares them for the action of the liming and bate; as also for the introduction of the tanning matter. When the fulling is too violent, the leather is apt to be too limber and thin. Mr. Lee conceives that the liming is injurious, by carrying off more or less of the gelatine and albumen of the skin. High-limed leather is loose, weighs light, and wears out quickly. The subsequent fermentation in the bating aggravates that evil. Another process has therefore been adopted in New York, Maine, New Hampshire, and some parts of Philadelphia, called, but incorrectly, *cool sweating*, which consists in suspending the hides in a subterranean vault, in a temperature of 50° F., kept perfectly damp, by the trickling of cold spring-water from points in the roof. The hides being first soaked, are suspended in this vault from 6 to 12 days, when the hair is well loosened by the mere softening effects of moisture, without fermentation.

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

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

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

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

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

When the fermentation is completed, generally in about five days, the skins are removed to a beam, and there 'slimed'—that is, scraped on the flesh side, to remove a slimy substance which exudes from the pores. The wool is then taken off, cleaned, and sold to the hatters, for making the bodies of common hats. The stripped pelts are steeped in lime-water for about a week, to kill the grease; and are next "fleshed on the beam." After being placed in a "drench," or a solution of sour bran for some days to remove the lime and open the pores, the skins are alumed, and subjected to nearly the same processes as the true kidskins. (See LEATHER.) These Mediterranean lambskins do not in general measure more than about 20 inches by 12; and each one furnishes leather for two pairs of small gloves. These kinds of leather generally leave the leather-dresser in a white state; but undergo a process of dyeing, softening, "stroking," &c., before being cut up into gloves.

The tanning of one average-sized skin requires about $1\frac{1}{4}$ lbs. of good Sicilian sumach; but for leather which is to receive a bright scarlet dye, from one half to three quarters of a pound of gall-nuts are employed in preference. Inferior goatskins are tanned with a willow-bark infusion, in pits, in which they are turned repeatedly, and laid out to drain, as in tanning sole-leather. The finest skins for the brightest scarlet are cured with salt, to prevent their receiving damage in the transport, and are dyed before being tanned. This method is practised in Germany and France.

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

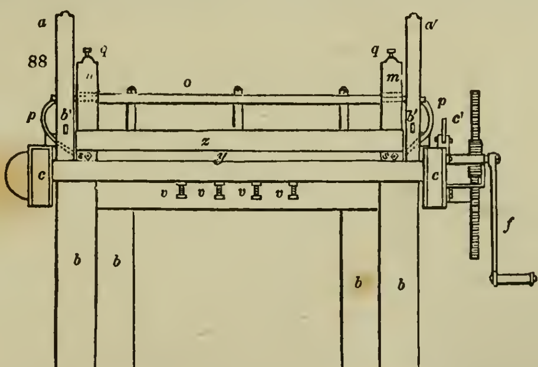
The quantity of hides and skins converted into leather yearly in England is almost incredibly large. At Messrs. Bevington's establishment alone there are about 250,000 skins annually converted into leather by the aluming or tawing process; 220,000 by the sumach tanning process; as also a small number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

In 1839, 5,149 Russian tanned hides were imported for home consumption; and in 1840, 4,664; of 5*s*. of duty on the entire hide; and pieces 2*s*. 6*d*. per lb.

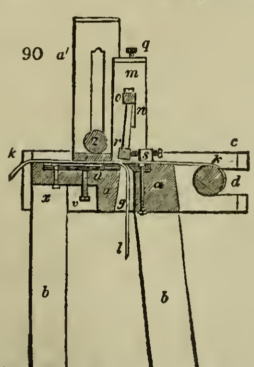
The declared value of leather exported in 1840 was 320,912*l*.; weight, 2,404,667 lbs. Saddlery and harness of 96,167*l*. declared value were exported.

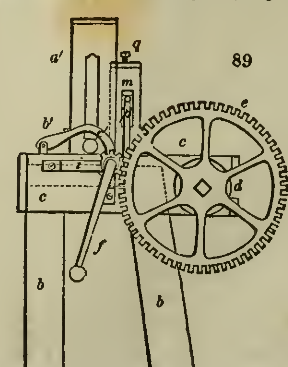
Leather gloves imported for home consumption in 1839, 991,623 pairs; in 1840, 1,503,862; average duty, 5*s*. a dozen.

LEATHER SPLITTING. This operation is employed sometimes upon certain sorts of leather for glovers, for bookbinders, sheath-makers, and always to give a uniform thickness to the leather destined for the cotton and wool card-makers.



Figs. 88, 89, 90, 91, represent a well contrived machine for that purpose; of which *fig*. 88, shows the front view, *fig*. 89, a view from the left side, *fig*. 91, a ground plan



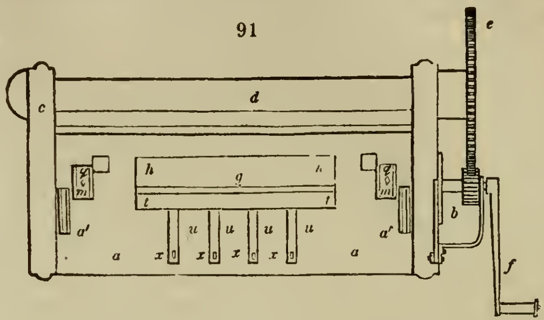


and *fig.* 90 a vertical section across the machine. *a* is a strong table, furnished with four legs *b*, which to the right and left hand bears two horizontal pieces *c*. Each of these pieces is cut out in front, so as to form in its substance a half-round fork, that receives a cylinder *d*, carrying on its end a toothed spur-wheel *e*. Motion is communicated to the wheel by means of the handle *f*, upon whose axis the pinion, *i*, is fixed, working into the wheel *d*, made fast to the end of the cylinder round which the leather is rolled. The leather is fixed at one of its ends or edges to the cylinder, either with a wedge pressed into a groove, or by a moveable segment of the cylinder itself.

The table, *a*, is cut out lengthwise with a slot, that is widened below, as shown in *fig.* 90.

The knife *h* (*figs.* 90 and 91) is fixed flat upon the table with screw bolts, whose

91



heads are countersunk into the table, and secured with taps beneath (*fig.* 90), the edge of the knife being placed horizontally over the opening, and parallel with it.

In *fig.* 90, the leather, *k*, is shown advancing against the knife, getting split, and has a portion coiled round the cylinder, which is made to revolve in proportion as the leather is cleft. The upper portion of the leather is rolled upon the cylinder *d*, while the under half, *l*, falls through the oblong opening upon the ground.

In regulating the thickness of the split leather, the two supports, *m*, act; they are made fast to the table *a* (one on each side of the knife), and are mortised into the table by two tenons secured beneath. These supports are furnished near their tops with keyed slots, by means of which the horizontal iron rod *o* (*figs.* 88, 90) is secured, and outside of the uprights they press upon the springs *p*, *p*, which tend to raise the rod, *o*, in its two end slots; but the adjusting screws *q*, which pass down through the tops of the supports into the mortise *n* (*fig.* 90) and press upon the upper half of the divided tenon, counteract the springs, and, accordingly, keep the rod, *o*, exactly at any desired height or level. The iron rod, *o*, carries another iron bar, *r*, beneath it, parallel and also rectangular, *fig.* 90. This lower bar, which is rounded at its under face lies upon and presses the leather, by the action of two screws, which pass through two upright pieces *s* (*figs.* 88 and 90), made fast to the table; thus the iron bar, *r*, may be made to press forward the edge of the knife, and it may be adjusted in its degree of pressure, according to the desired thickness of the leaf of split leather, that passes through under it.

Fig. 90 shows that the slant or obliquity of the knife is directed downward, over one of the edges of the oblong opening *g*; the other edge of this opening is provided with an iron plate *t* (*figs.* 90, 91), which serves to guide the blade in cutting the leather to the proper depth. For this purpose the plate is made adjustable by means of the four springs *u* (*figs.* 90, 91), let into the table, which press it downward. Four screws *v*, pass down through the table, each belonging to its respective springs *u*, and by means of these screws the plate, *t*, may be raised in any desired degree. Each of the screws, *u*, has besides a small rectangular notch, through which a screw bolt, *x*, passes, by which the spring is made fast to the table. Thus also the plate, *t*, may be made to approach to or recede from the knife.

y, in *figs.* 88 and 90, is a flat board, laid upon the leather a little behind the edge of the plate *t*; this board is pressed by the cylinder *z*, that lies upon it, and whose tenons rest in mortises cut out in the two supports *a′*. The cylinder, *z*, is held in its position by a wedge or pin *b* (*figs.* 88 and 89), which passes through the supports. When the leather has been split, these pins are removed, and the cylinder rises then by means of two counter weights, not shown in the figures.

The operation of the machine is as follows—The edge or end of the leather being secured to the cylinder *d*, the leather itself having the direction upon the table, shown in *fig.* 90, and the bar, *r*, its proper position over the knife, the edge begins to enters in this position into the leather, while the cylinder, *d*, is moved by the handle or winch, and the piece gets between the blade and the roller *d*. When the other end of the leather, *k*, advances to the knife, there is, consequently, one half of the leather split; the skin is to be then rolled off the cylinder *d* ; it is turned; the already split half, or the end of the leather *k*, is made fast into the wood of the cylinder, and the other half is next split; while the knife now acts from below, in an opposite direction to what it did at first.

That the unrolling of the leather from the cylinder, *d*, may not be obstructed by the pinion *i*, the stop-wedge *e* (*figs.* 88, 89) is removed from the teeth. In the process of splitting, the grain side of the leather is uppermost, and is therefore cut of a uniform thickness, but the under side varies in thickness with the inequality of the skin.

LINSEED. Imported for home consumption, in 1839, 3,852,359 bushels; in 1840, 3,256,257; $1\frac{1}{2}d.$ duty.

LODES. The name given by the Cornish miners to metallic veins: as, tin lodes, copper lodes, &c.

LOGWOOD; imported for home consumption in 1839, 17,209 tons; in 1840, 18,683 tons; duty 3*s*., foreign 4*s*. 6*d*.

M.

MACE. Imported for home consumption, in 1839, 21,154 pounds; in 1840, 16,813, duty 2*s*. 6*d*. per pound.

MADDER, GROUND; imported for home consumption in 1839, 96,702 cwts.; in 1840, 134,179 cwts.; duty 2*s*. per cwt.

MADDER ROOT; in 1839, 80,259 cwts.; in 1840, 112,714 cwts.; duty 6*d*. per cwt.

A patent was granted in August, 1843, to Mr. F. Steiner, for the manufacture of *Garancine* from used madder, formerly thrown away, as being exhausted of its dyeing principle. His process is as follows: "A large filter is constructed outside the building in which the dye-vessels are situated, formed by sinking a hole in the ground, and lining it at the bottom and sides with bricks without any mortar to unite them. A quantity of stones or gravel is placed upon the bricks, and over the stones or gravel common wrappering, such as is used for sacks. Below the bricks is a drain to take off the water which passes through the filter. In the tub adjoining the filter is kept a quantity of dilute sulphuric acid, of about the specific gravity of 105, water being 100. Hydrochloric acid will answer the several purposes, but sulphuric acid is preferred as more economical. A channel is made from the dye-vessels to the filter. The madder which has been employed in dyeing is run from the dye-vessels to the filter; and while it is so running, such a portion of the dilute sulphuric acid is run in and mixed with it as changes the color of the solution and the undissolved madder to an orange tint or hue. This acid precipitates the coloring matter which is held in solution, and prevents the undissolved madder from fermenting or otherwise decomposing. When the water has drained from the madder through the filter, the residuum is taken from off the filter and put into bags. The bags are then placed in an hydraulic press, to have as much water as possible expressed from their contents. In order to break the lumps which have been formed by compression, the madder or residuum is passed through a sieve. To 5 cwt. of madder in this state, placed in a wood or lead cistern, 1 cwt. of sulphuric acid of commerce is sprinkled on the madder through a lead vessel similar in form to the ordinary watering-can used by gardeners. An instrument like a garden spade or rake is next used, to work the madder about so as to mix it intimately with the acid. In this stage the madder is placed upon a perforated lead plate, which is fixed about five or six inches above the bottom of a vessel. Between this plate and the bottom of the vessel is introduced a current of steam by a pipe, so that it passes through the perforated plate and the madder which is upon it. During this process, which occupies from one to two hours, a substance is produced of a dark brown color approaching to black. This substance is garancine and insoluble carbonized matter. When cool, it is placed upon a filter and washed with clear cold water until the water passes from it without an acid taste. It is then put into bags and pressed with an hydraulic press. The substance is dried in a stove and ground to a fine powder under ordinary madder stones, and afterward passed through a sieve. In order to neutralize any acid that may remain, from 4 to 5 lbs. of dry carbonate of soda for every hundred weight of this substance is added and intimately mixed. The garancine in this state is ready for use.

MALT. The Quantity of Malt consumed by the undermentioned Brewers of London and its Vicinity, from 10th October, 1830, to 10th October, 1842.

	1831.	1832.	1833.	1834	1835.	1836	1837.	1838.	1839.	1840.	1841.	1842.
	Qrs.	Qrs.	Qrs.	Qrs.	Qrs.	Qrs.	Qrs.	Qrs.	Qrs.	Qrs.	Qrs.	Qrs.
Barclay and Co. - -	97,198	96,612	93,175	99,674	106,098	108,715	100.326	107,455	114,827	115,561	106,345	114,090
Hanbury and Co. -	50,724	58,512	58,497	74,982	78,087	89,303	81,440	90,140	91,069	98,210	88,132	92,466
Whitbread and Co. -	49,713	53.541	50,067	49,105	55,209	53,694	47.012	45,460	51,979	53,622	51,457	52,098
Reid and Co. - -	43,380	44,420	40,810	44,210	49,430	49.831	42,700	44,928	44,010	48,130	47,980	50,120
Meux and Co. - -	24,339	22,062	20,718	26,161	24,376	30,775	30,623	35,065	38,466	40,787	49,797	43,340
Combe and Co. - -	34,684	36,948	36,070	35,438	36,922	42,169	40,454	43,444	40,712	38,368	36,460	40,484
Calvert and Co. - -	30,525	32,812	31,433	31,460	33,263	30,859	32,325	31,529	31,028	30,872	30,614	30,660
Hoare and Co. - -	24,102	26,821	25,407	29,796	31,525	32,623	32,347	31,278	31,008	30,310	29,450	29,607
Elliot and Co. - -	19,441	20.061	19,899	25,009	28,728	28,338	24,150	22,486	22,990	25,367	25,379	27,050
Thorne, T. and Son -	1,445	2,543	5,136	8,496	10,913	12,657	16,404	18,545	19,578	20,864	22,413	22,022
Charrington and Co. -	10,531	9,648	15,617	18,197	19,213	19,445	18.842	20,290	18,688	18,328	17,840	20,423
Steward and Co. - -	8,116	6,872										
Taylor and Co. - -	21,845	21,735	21.115	20,835	23,885	24,971	23,556	27,320	25,955	27,300	21,424	19,430
Goding, J. and Co. -	16,307	14,874	14,279	15,256	16,312	1/4 3,321	1/12 14,023	14,028	12,145	18,517	16,018	17,071
Goding, Thomas - -	9,987	8,971	7,630	8,824	7,618	11,784	7,095	7,551	3/4 5,758			
Ramsbottom and Co. -	-	-	-	-	-	3/4 15,364	15,227	13,012				
Broadwood and Co. -	-	-	-	-	-	-	-	-	10,610	14,630	15,791	16,688
Gardner, H. W. and P.	6,666	5,904	7,471	11,429	14,699	15,369	15,256	16,921	17,504	15,559	13,126	14,546
Mann, James - .	-	1,056	1,332	1,757	2,780	4,840	6,588	10,326	11,599	11,679	12,111	13,539
Courage and Co. -	8,116	7,607	7,546	8,079	8,790	9,239	9,286	10,723	10,456	11,532	12,328	13,016
Wood and Co. - -	5,469	5,560	5,547	7,602	7,320	7,961	7,834	8,506	7,607	7,194	7,268	7,652
More, Robert - -	2,535	1,040	1.890	4,713	4,130	5,255	6.025	6,129	6,413	6,954	7,175	7,026
Harris, Thomas - -	4,778	4,780	4,540	4,940	4,964	4,998	5,042	5,888	5,256	5,152	5,291	6,022
Hazard and Co. - -	-	6,126	6,203	7,094	-	6,597	6,674	6,552	6,250	6,729	5,758	5,556
Tubb, William - -	-	-	-	80	200	1,516	2,826	3,365	4,060	4,478	4,944	5,503
Richmond and Co. -	3,785	3,503	3.256	3,520	3,268	3,551	3,174	4,058	4,536	4,964	5,030	5,424
Hodgson and Co. -	4,206	3,522	3,870	2,080	2,414	3,400	2,400	1,790	5,358	5,704	5,862	
Abbott, E. - - -	-	-	-	-	-	-	-	-	-	-	-	4,983
Manners and Co. -	-	-	-	-	-	-	4,552	6.121	7,030	5,334	4,819	4,831
Hale, George - -	4,584	4,322	3,623	3,281	3,466	3,768	4,547	5,039	4,816	4,443	4,418	4,468
Halford and Co.	3,215	3,187	3,330	3,545	-	3,763	3,786	4,685	3,967	3,585		
Kempson and Co.	-	-	-	-	-	-	-	-	-	-	3,155	3,878
Farren and Till - -	-	3,139	3,217	-	-	4,048	4,783	4,599	4,400	4,425		
Thorne, J. M. and Son	-	-	-	-	-	-	-	-	-	-	3,860	3,676
Duggan and Co. -	-	-	-	-	-	2,201	2,665	2,288	3,020	3,001	2,574	
Gaskell and Downs -	-	-	-	-	-	-	-	-	-	-	-	3,354
M'Leod, B. - - -	1,656	2,947	4,236	5,479	5,360	4,689	4,960	4,700	4,300	3,410	3,305	3,125
Plummer - - -	-	-	-	-	-	-	-	-	-	788	1,653	3,001
Laxton and Bryan -	4,048	3,020	2,911	3,508	4,187	3,573	3,583	3,167	3,213	2,658	2,579	2,797
Draper and Co. - -	-	-	-	-	-	-	-	-	1,658	1,711	1,787	2,777
Miller and Co. - -	-	-	-	-	-	-	-	-	855	1,167	1,740	2,685
Keene and Co. - -	-	-	-	-	-	-	-	-	2,326	2,345	2,645	2,445
Lane and Bowden -	-	-	-	-	-	-	88	393	1,275	1,964	2,010	2,432
Flemming and Co. -	-	-	-	-	-	-	-	1,787	1,795	2,159	2,417	2,256
Clarke, Charles - -	814	857	1,006	1,003	1,006	1,249	1,330	1,624	1,848	1,934	2,124	2,255
Gurney, J. and Co. -	-	-	-	-	-	-	-	-	5/12 614	1,903	2,597	2,211
Stains and Fox - -	2,235	1,832	2,163	2,266	3,106	3,738	3,783	3,749	3,072	2,406	2,528	2,050
Very, W. and G. - -	-	-	844	1,140	1,208	1,302	1,573	1,735	1,749	1,762	1,825	1,840
Jones, T. - - -	585	463	337	375	248	700	956	1,338	1,555	1,879	1,810	1,808
Herington and Wells -	-	-	-	-	-	-	-	-	1,538	1,905	1,746	1,806
Hill and Rice - -	2,910	1,748	1,974	1,963	2,042	1,872	1,853	1,911	1,835	1,677	1,697	1,628
Holt and Sons - -	1,113	754	717	794	734	813	756	846	807	1,093	972	1,583
Cox, John - - -	2,302	2,279	4,371	2,446	2,499	2,018	2,151	1,991	1,861	1,723	1,528	1,520
Griffith, P. - - -	2,146	1,530	1,063	1,693	2,120	2,394	2,221	1,884	1,553	1,916	1,419	1,429
Ufford and Co. - -	-	-	-	203	472	731	953	1,291	1,241	1,201	1,350	1,360
Masterman and Co. -	1,704	1,803	1,830	1,810	1,877	1,789	1,914	1,847	1,789	1,672	1,892	1,295
Johnson and Co. -	-	-	-	-	-	2,809	2,809	2,428	2,412	2,413	2,204	
Wyatt - -	-	-	-	-	-	-	-	-	-	-	-	1,267
Turner, R. - - -	98	128	218	341	531	716	712	897	1.013	1,077	1,219	1,254
Dickenson, G. - -	901	719	801	793	838	1,037	1,025	1,010	1,020	1,100	1,092	1,135
Honeyball, Edward -	-	-	269	471	800	1,103	1,512	1,714	1,402	1,155	1,053	1,087
Jenner, R. and H. -	-	202	355	529	734	772	833	925	856	929	955	1,067
Church, J. L. - -	-	-	-	-	-	756	742	672	975	949	1,049	1,065
Blogg, B. - - -	603	684	594	752	968	1,067	943	1,006	1,143	1,034	1,113	1,045
M'Leod, J. M. and Co.	-	-	-	-	-	748	820	978	877	782	797	1,025
Satchell and Son -	2,508	3,117	1,906	2,515	2,147	2,177	1,441	1,431	1,475	1,308	1,063	945
Knight - - -	-	-	-	-	-	-	-	-	-	78	883	865
Chadwick, W. - -	-	-	-	-	-	-	169	361	532	775	820	846
Turner, John - -	674	584	640	677	709	786	766	821	853	728	768	754
Lock, R. - - -	-	99	259	422	496	620	651	725	760	776	765	737
Hume, George -	1,018	985	975	1,427	1,256	1,235	1,126	1,160	812	791	718	708
Collins, W. L. - -	205	176	254	441	519	527	598	407	362	620	627	705
West, J. H. - - -	846	577	394	322	406	406	565	749	594	627	708	702
Mantell and Son - -	1,187	840	914	850	757	807	693	650	694	723	641	650
Addison - - -	756	590	596	653	671	619	768	812	637	72	638	642
Martin and Co. -	-	-	-	-	-	-	397	501	549	592		
Allan - - -	-	-	-	-	-	-	-	-	-	-	637	640
Hodd and Co. - -	-	-	271	488	671	839	649	531	504	594	644	624
Clarke, W. - - -	-	-	-	-	-	-	-	-	-	462	506	529
Clarke, S. - - -	722	841	876	938	793	837	741	768	547	450	502	520
Bye, W. and H. - -	-	-	-	-	-	-	201	260	346	433	489	510
Clark - - -	545	719	780	747	706	853	834	983				
Rudge - - -	-	-	-	-	-	-	-	-	886	555	449	501

	1831.	1832.	1833.	1834.	1835.	1836.	1837.	1838.	1839.	1840.	1841.
	Qrs.	Qrs.	Qrs.	Qrs.	Qrs.	Qrs.	Qrs.	Qrs.	Qrs.	Qrs.	Qrs.
Bricheno, Henry -	5,637	5,732	7,120	9,950	9,762	9,885	9,863	8,857	8,699		
Lamont and Co. -	1,646	356	883	657	403	2,085	3,600	5,251	7,638	13,475	13,087
Filmer and Gooding	- -	- -	- -	- -	- -	1,039	1,298	1,291	1,674	1,633	1,514
Wood and Co. -	-	- -	- -	- -	- -	- -	- -	- -	1,493	1,442	1,484
Brown, late Hicks -	- -	- -	- -	- -	- -	- -	- -	- -	1,351	1,450	1,300
Manvell, Isaac -	752	713	924	875	834	805	824	756	579	732	770
Abbott, E. - -	691	- -	525	634	654	2,305	560	441	312	487	490
Cooper, W. - -	244	- -	443	- -	199	310	315	370	434	503	485
Saunders - -	- -	- -	- -	- -	- -	- -	- -	81	311	362	471
West, J. W. - -	- -	- -	179	255	406	295	306	251	290	353	444
Harris, Robert -	- -	- -	451	490	557	497	470	456	405	447	441

Barrels of Beer brewed by each of the Twelve principal Brewers in London.

1782.		1808.	
Whitbread - - - - - - -	42,497	Meux - - - - - - - -	190,169
Calvert, Felix - - - - -	38,304	Barclay - - - - - - - -	184,196
Truman - - - - - - - -	32,134	Golden Lane - - - - - -	131,647
Calvert, John - - - - -	31,853	Hanbury - - - - - - -	117,574
Thrale, Mrs. - - - - - -	29,695	Whitbread - - - - - - -	112,472
Hammond - - - - - - -	28,715	Combe - - - - - - - -	70,547
Phillips - - - - - - - -	16,527	Goodwyn - - - - - - -	70,232
Goodwyn - - - - - - -	16,228	Calvert, Felix - - - - - -	68,894
Meux - - - - - - - -	14,969	Elliot . - - - - - - -	48,660
Jordan - - - - - - - -	11,246	Biley - - - - - - - -	38,029
Dawson - - - - - - - -	11,077	Harford - - - - - - -	32,800
Dickinson - - - - - - -	10,900	Calvert, John - - - - - -	32,022
	284,145		2,097,231

Quarters of Malt consumed in the undermentioned Years, ending 10th October.

By the Brewers of London and its Vicinity.											
1831	622,549	1833	578,588	1835	702,533	1837	714,488	1839	750,176	1841	734,295
1832	604,477	1834	662,713	1836	754,313	1838	742,597	1840	766,219	1842	741,651
By the Twelve principal Brewers of London.											
1831	432,521	1833	427,087	1835	503,018	1837	499,179	1839	528,259	1841	517,292
1832	438,046	1834	470,123	1836	526,092	1838	517,940	1840	547,908	1842	541,710

MANGANESE, OXIDE OF; for a simple method of ascertaining the value of this substance in the production of chlorine, and the manufacture of the chlorides and chlorates, see CHEMISTRY SIMPLIFIED, in the APPENDIX.

MANURE. A patent for an excellent article of this kind was obtained in May, 1842, by J. B. Lawes, Esq. He decomposes bones, apatite, and other subphosphates of lime, by mixing them in powder with as much sulphuric acid as will liberate enough of the phosphoric to dissolve the phosphate of lime. The free phosphoric acid is thereby ready to combine with the various alkaline earths contained in the soil, while the phosphate of lime is brought to a state of more minute division than is possible by mechanical means. Mr. Lawes also proposes to mix the above soluble superphosphate with such alkalies as are deficient in the soil, and thus to form a manure adapted to fertilize it. His third improvement in manure is the formation and application of a liquor of flints, for such soils as are deficient in soluble silica. The last compound he considers to be valuable for grounds much cropped with wheat and other cereals that require a good deal of silica for their growth.

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.

MATCHES, LUCIFER. According to Dr. R Boettger, in *Annalen der Chemie und Pharmacie*, vol. xlvii., p. 334, take

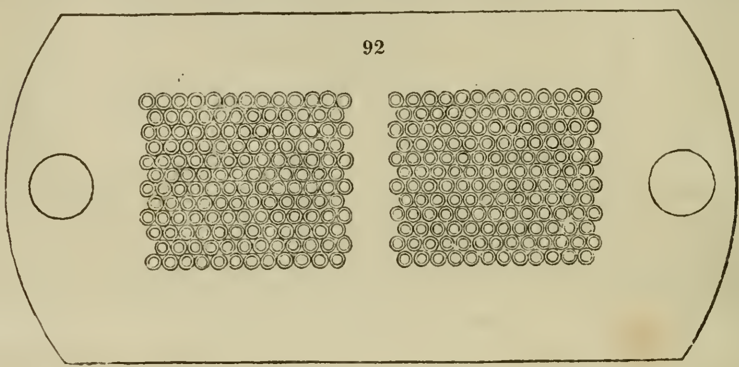
Phosphorus - - - - - -	4 parts.
Nitre - - - - - - -	10 —
Fine glue - - - - - -	6 —
Red ochre, or red lead - - - -	5 —
Smalt - - - - - - -	2 —

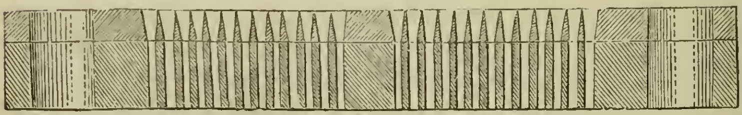
Convert the glue with a little water by a gentle heat into a smooth jelly, put it into a slightly warm porcelain mortar to liquify; run the phosphorus down through this gelatine at a temperature of about 140° or 150° Fahr.; add the nitre, then the red powder, and lastly the smalt, till the whole forms a uniform paste. To make writing-paper matches, which burn with a bright flame and diffuse an agreeable odor, moisten each side of the paper with tincture of benzoin, dry it, cut it into slips, and smear one of their ends with a little of the above paste by means of a hair pencil. On rubbing the said end after it is dry, against a rough surface, the paper will take fire without the intervention of sulphur.

To form lucifer wood matches, that act without sulphur, melt in a flat-bottomed tin pan as much white wax as will stand one tenth of an inch deep; take a bundle of wooden matches free from resin, rub their ends against a red hot iron plate till the wood be slightly charred; dip them now in the melted wax for a moment, shake them well on taking them out, and finally dip them separately in the above viscid paste. When dry, they will kindle readily by friction.

For the rapid manufacture of the wooden splints for lucifer matches, a patent was granted to Mr. Reuben Partridge, in March, 1842. He employs a perforated metallic plate, having a steel face, strengthened by a bell metal back; see *figs*. 92, 93. The size of the perforations must depend on that of the desired splints, but they must be as close together as possible, that there may be a very small blank space between them,

92





otherwise the plate would afford too great resistance to the passage of the wood. By this construction, the whole area of the block of wood may be compressed laterally into the countersunk openings, and forced through the holes, which are slighty countersunk to favor the entrance and separation of the wooden fibres. *Fig*. 92 represents the face of one of these plates; and *fig*. 93 is a rectangular section through the plate. A convenient size of plate is three inches broad, six inches long, and one thick. The mode of pressing is by fixing the back of the plate against a firm resisting block or bearing, having an aperture equal to the area of the perforations in the plate, and then placing the end of the piece or pieces of wood in the direction of the grain against the face of the plate within the area of the perforated portion. A plunger or lever or other suitable mechanical agent being then applied to the back or reverse end of the piece of wood, it may be forced through the perforations in the plate, being first split as it advances by the cutting edges of the holes, and afterward compressed and driven through the perforations in the plate, coming out on the opposite side or back of the plate in the form of a multitude of distinct splints, agreeably to the shapes and dimensions of the perforations.—(*Newton's Journal*, C. S. vol. xxii. page 268.)

MERCURY; imported for home consumption in 1839, 340,469 pounds; in 1840, 330,070 pounds; duty 1*d*. per pound.

METALLIC ANALYSIS. Professor Liebig has lately enriched this most useful department of practical chemistry, by the employment of the cyanide of potassium prepared in his economical method (see this article). This salt is the best re-agent for detecting nickel in cobalt. The solution of the two metals being acidulated, the cyanide is to be added until the precipitate that first falls is redissolved. Dilute sulphuric acid is then added, and the mixture being warmed and left in repose, a precipitate does not fail to appear sooner or later, which is a compound of nickel. Cyanide of potassium serves well to separate lead, bismuth, cadmium, and copper, four metals often associated in ores. On adding the cyanide in excess to the solution of these metals in nitric acid, lead and bismuth fall as carbonates, and may be parted from each other by sulphuric acid. Sulphuretted hydrogen is passed in excess through the residuary solution, and the mixture being heated, a small quantity of cyanide is added: a yellow precipitate indicates cadmium; and a black precipitate falls on the addition of hydrochloric acid, if copper be present.

If into a crucible (containing the cyanide fused by heat), a little of any metallic oxide be thrown at intervals, it will be almost immediately reduced to the reguline state. When the fluid mass is afterward decanted, the metal will be found mixed with the white saline matter, from which it may be separated by water.

Even metallic sulphurets are reduced to the state of pure metals by being projected in a state of fine powder into the fused cyanide. When an iron ore is thus introduced, along with carbonate of potash or soda, and the mixture is heated to fusion, which requires a strong red heat, the alumina and silica of the ore fuse into a slag; from which, on cooling, the metallic iron may be separated by the action of water, and then weighed. If manganese exist in the ore, it remains in the state of protoxide; to be determined by a separate process. When oxide of copper is sprinkled on the surface of the fused cyanide, it is immediately reduced, with the disengagement of heat and light. The mixture being poured out of the crucible and concreted, is to be ground and washed, when a pure regulus of copper will be obtained.

The process of reduction is peculiarly interesting with the oxide of antimony and tin; being accomplished at a low red heat, hardly visible in daylight. Even the sulphurets of these metals are immediately stripped of their sulphur, with the formation of sulpho-cyanide of potassium.

Cyanide of potassium, mixed with carbonate of soda, is an excellent re-agent in blow-pipe operations for distinguishing metals. The reductions take place with the utmost facility, and the fused mixture does not sink into the charcoal, as carbonate of soda alone is apt to do in such cases. Hence the grains or beads of metal are more visible, and can be better examined.

When the cyanide is heated along with the nitrates and chlorates (of potash), it causes a rapid decomposition, accompanied with light and explosions.

Arsenic may be readily detected in the commercial sulphuret of antimony, by fusing it with three fourths of its weight of the cyanide in a porcelain crucible over a spirit lamp, when a regulus of antimony is obtained. The metal may then be easily tested for arsenic, since none of this volatile substance can have been lost, owing to the low temperature employed.

When arsenious acid, or orpiment, or any of the arseniates, are mixed with six times their weight of the mixture of cyanide and carbonate of soda in a tube with a bulb at one end, and heat applied with a spirit lamp to the glass, very beautiful rings of metallic mirror are formed by the reduced arsenic. The arseniates of lead and peroxide of iron, however, do not answer to this test.

When sulphates of lead and barytes, along with silica, are mixed with four or five times their weight of the above mixed cyanide and carbonate, and fused, the sulphate of lead is reduced to the metallic state, the sulphate of barytes becomes a carbonate, and the silica gets combined with the alkali into a soluble glass.

METALLIC STATISTICS. By the returns to five several orders made by the house of commons, which were obtained by the exertions and perseverance of Sir J. J. Guest, Sir C. Lemon, and Mr. Evans (M. P. for North Derbyshire), we are enabled to lay before our readers a most correct account of the various exports and imports of iron and iron ore, hardware, cutlery, &c., copper ore, copper, tin, zinc, lead ore, and lead, for the year ending January 5, 1844.

Commencing with iron, it appears there was imported in the year, iron ore, 131 tons; chromate of iron, 1,393 tons; pig-iron, 243 tons; unwrought iron in bars, 12,795 tons; bloom, 563 tons; rod-iron, 12 tons; old, broken, and cast-iron, 286 tons; cast-iron, only 8 tons; steel, unwrought, 1,697 tons: of these, 97 tons only were entered by weight, the remainder by value—11,035*l.* 6*s.* 9*d.* Of the several countries from which these importations came, the principal is Sweden, whence we have received of iron 10,909 tons, and steel 1,558 tons, leaving but a small portion to divide between twenty other places. Our exports of foreign iron have been, unwrought in bars, 3,986 tons; rod, 10 tons; hoops, 2 tons; cast-iron, 11 cwt.; steel, unwrought, 1,456 tons. The total quantity of foreign iron retained for home consumption was

14,782 tons, upon which the net amount of duty was 14,563*l*. The exportation of that staple produce of our own country, British iron, was as follows: Bar-iron, 176,148 tons; bolt and rod, 22,625 tons; pig-iron, 154,770 tons; cast-iron, 16,449 tons; iron wire, 1,508 tons; wrought-iron, consisting of anchors, grapnels, &c., 3,058 tons; hoops, 14,591 tons; nails, 6,020 tons; and all other sorts, except ordnance, 44,577 tons; old iron for manufacture, 5,924 tons; and unwrought steel, 3,199 tons. Those places which have taken the greatest portions of this produce are—Russia, 10,963 tons of bar-iron; Denmark, 10,447 tons bar, and 7,010 tons pig; Prussia, 12,009 tons bar, 17,480 tons pig; Germany, 13,298 tons bar, 6,322 tons pig, 1,339 tons cast; Holland, 17,509 tons bar, 75,953 tons pig, 4,317 tons cast; Belgium, 4,279 tons cast; France, 4,237 tons bar, 22,103 tons pig; Italy, 21,930 tons bar, 3,982 tons bolt and rod, 3,005 tons pig; Turkey, and Continental Greece, 6,412 tons bar; East Indies and Ceylon, 20,620 tons bar, 2,967 tons bolt; British North American colonies, 6,837 tons bar, 1,995 tons cast; foreign West Indies, 5,043 tons bar, 1,646 tons cast; and to the United States, 21,336 tons bar, and 7,148 tons pig. The largest quantity of unwrought steel has been to the latter place—viz., 1,336 tons.

Of British hardware and cutlery, we exported in the year, 17,183 tons, valued at 1,745,518*l*.; the principal of which has been—to Germany, 1,237 tons, value 159,889*l*.; East Indies, 1,402 tons, value 142,607*l*.; British North American colonies, 1,129 tons, value 102,260*l*.; British West Indies, 997 tons, value 80,040*l*.; foreign West Indies, 657 tons, value 48,609*l*.; United States, 4,282 tons, value, 448,341*l*.; Brazil, 943 tons, value 80,070*l*.; and divers other places, varying from 100 to 500 tons.

We now come to copper. Of foreign copper ores, we have imported 55,720 tons; and of metallic copper, unwrought and wrought plates, and coins, 805 tons. Of the ores, the greatest quantities have come from Cuba and Chili.

We have exported 1,819 tons of British, and 650 tons of foreign tin; of which France has taken 626 tons, Russia 480 tons, Italy 183 tons, Turkey 250 tons, and the remainder distributed among twenty-seven places.

Of foreign zinc, we have imported as follows:—

Countries whence imported.	Tons.	cwt.	qrs.	lbs.
Denmark	268	19	2	21
Prussia	6,860	15	3	22
Germany	3,000	1	2	11
Holland	20	3	2	1
Belgium	21	9	0	9
Syria and Palestine	1	15	0	15
Total import of foreign zinc - - Tons	10,173	4	3	23

Of this, we retained for home consumption 4,102 tons, on which the net duty was 223*l*. 2*s*. 10*d*.; and we have exported 1,395 tons of British, and 6,445 tons of foreign spelter.

Of foreign lead, we have imported 2,863 tons—of which 2,775 tons were pig and sheet, 68 tons ore, and 19 tons white lead; 157 tons were retained for home consumption, on which the duty was 165*l*.; and we imported from the Isle of Man, duty free, 2,415 tons of lead ore. Our exportation of foreign lead amounted to 2,439 tons; while of British, we exported 176 tons of ore, 14,610 tons pig and sheet, 378 tons litharge, 707 tons red lead, and 1,224 tons of white lead: making a total of 17,097 tons.—*Railway and Commercial Gazette*, May 18, 1844.

METER, GAS. Since the article GAS was printed, I have had occasion to examine very carefully the construction, performance, and comparative merits, of the four gas-metres most generally used in Great Britain, and have been led to conclude that the surmises concerning the correctness of the indications of several of them are but too well founded. The instruments on which my observations were made were all new, and just out of the hands of their respective patentees.

1. The meter of Mr. West is, no doubt, accurate while the water-line is rightly adjusted; but as I find that it will admit an extra pint of water, it may be rendered unjust toward the consumers of gas; and then if it receives a little more water by condensation of vapor, or by accident, its siphon gets filled, which causes the extinction of the lights.

2. The meter of Mr. Bottom has also several defects, and occasions nuisance by letting its overflow-water trickle upon the floor.

3. The meter of Mr. Crossley may be made to err in its measurement fully 20 per cent. by dexterous repletion with water, and that in favor of the gas companies.

These three meters are furnished with the vertical float-valve, so apt to rust and stick;

they also allow gas to escape to the discharge plug, to the imminent risk of occasioning fire with ignorant or careless servants; and finally, they have the complex dial-plate indexes, so liable to misapprehension.

4. The meter of Mr. Edge. This instrument is quite exempt from all the above defects, and is equally delicate and just in its indications, being mounted with a lever valve of great mobility, and a new index which any one who knows numbers can not miscount. I have subjected this meter to every kind of test and find that it can not be made to give false indications, either by awkwardness or intention. Its inventor is therefore well entitled to the warm patronage both of the public and all gas companies who love their dealing.

MILK has been adulterated with a solution of potato starch, from which it derives a creamy consistence. This fraud may be detected by pouring a few drops of iodine water into it, which immediately causes it to assume a blue or purple tint. Emulsion of sweet almonds, with which the milk at Paris has been adulterated, may be readily detected by the taste.

MINES. The miner, in sinking into the earth, soon opens up numerous springs, whose waters, percolating into the excavations which he digs, constitutes one of the greatest obstacles that nature opposes to his toils. When his workings are above the level of some valley and at no great distance, it is possible to get rid of the waters by leading them along a *trench* or a *gallery of efflux*. This forms always the surest means of drainage; and notwithstanding the great outlay which it involves, it is often the most economical. The great advantages accruing from these galleries, lead to their being always established, and without risk, in mines which promise a long continuance. There are many galleries several leagues in length; and sometimes they are so contrived as to discharge the waters of several mines, as may be seen in the environs of Freyberg. Merely such a slope should be given them as is barely sufficient to make the water run, at the utmost from $\frac{1}{300}$ to $\frac{1}{400}$, so as to drain the mine at the lowest possible level.

Whenever the workings are driven below the natural means of drainage, or below the level of the plain, recourse must be had to mechanical aids. In the first place, the quantity of percolating water is diminished as much as possible by planking, walling, or calking up with the greatest possible care those pits and excavations which traverse the water levels; and the lower workings are so arranged that all the waters may unite into wells placed at the bottom of the shafts or inclined galleries; whence they may be pumped up to the day, or to the level of the *gallery of efflux*. In most mines, simple sucking pumps are employed, because they are less subject to give way, and more easy of repair; and as many of these are placed over each other, as the shaft is ten yards deep, below the point where the waters have a natural run.

These draining machines are set in motion by that mechanical power which happens to be the least costly in the place where they are established. In almost the whole of England, and over most of the coal-mines of France and Silesia, the work is done by steam-engines; in the principal metallic mines of France, and in almost the whole of Germany and Hungary, by hydraulic machines; and in other places, by machines moved by horses, oxen, or even by men. If it be requisite to lift the waters merely to the level of a *gallery of efflux*, advantage may be derived from the waters of the upper parts of the mine, or even from waters turned in from the surface, in establishing in the mine of the gallery-level, water-pressure machines, or overshot water-wheels, for pumping up the lower water. This method is employed with success in several mines of Hungary, Bohemia, Germany, Derbyshire, Cornwall, in those of Poullaouen in Brittany, &c. It has been remarked, however, that the copious springs are found rather toward the surface of the soil than in the greatest depths.

TRANSPORT OF ORES TO THE SURFACE.

The ore being extracted from its bed, and having undergone, when requisite, a first sorting, it becomes necessary to bring it to the day, an operation performed in different ways according to circumstances and localities, but too often according to a blind routine. There are mines at the present day, where the interior transport of ores is executed on the backs of men; a practice the most disadvantageous possible, but which is gradually wearing out. The carriage along galleries is usually effected by means of hurdles, barrows, or, still better, by little wagons. These consist of frames resting on four wheels; two larger, which are placed a little behind the centre of gravity, and two smaller, placed before it. When this carriage is at rest, it bears on its four wheels, and leans forward. But when the miner, in pushing it before him, rests on its posterior border, he makes it horizontal; in which case it rolls only upon the two larger wheels. Thus, the friction due to four wheels is avoided, and the roller or driver bears no part of the burden, as he would do with ordinary wheelbarrows. To ease the draught still more, two parallel rails of wood or iron are laid along the floor of the gallery, to which the wheels of the carriage are adjusted. It is especially in metallic mines, where the ore is heavy, and the galleries straight, that these peculiar wagons are employed. In coal mines, carriages formed with a much larger basket, borne on a railroad by four equal wheels, are preferred. Sometimes the above wain, called on the Continent a *dog* (*chien*), is merely a simple frame on four wheels, on which a basket is set. In the great mines, such as many of the coal and salt mines of Great Britain, the salt mines of Gallicia, the copper mines of Fahlun, the lead mines of Alston-Moor, horses and asses are introduced into the workings to drag heavier wagons, or rather a train of wagons attached to one another. These animals often live many years under ground, without ever revisiting the light of day. In other mines, such as those of Worsley, in Lancashire, subterranean canals are cut, upon which the ore is transported in boats.

When the workings of a mine are beginning, when they are still of little depth, and employ few hands, it is sufficient to place over the shaft a simple wheel and axle, by means of which a few men may raise the water-pails, and the baskets or tubs filled with ore; but this method becomes soon inadequate, and should be replaced by more powerful machines.

ACCESSORY DETAILS.

Few mines can be penetrated entirely by means of galleries. More usually there are shafts for mounting and descending. In the pits of many mines, the workmen go down and come up by means of the machines which serve to elevate the ores. In several mines of Mexico, and the north of Europe, pieces of wood, fixed on each side of the pit, form the rude steps of a ladder by which the workmen pass up and down. In other mines, steps are cut in the rock or the ore; as in the quicksilver mines of Idria and the Palatinate, in the salt mines of Wieliczka, and in some of the silver mines of Mexico. In the last they serve for the transport of the ore, which is carried up on men's backs. Lastly, certain mines are entered by means of slopes, some of which have an inclination of more than 30°. The workmen slide down these on a kind of sledge, whose velocity of descent they regulate by a cord firmly fixed at the upper end.

Miners derive light from candles or lamps. They carry the candles in a lump of soft clay, or in a kind of socket terminated by an iron point, which serves to fix it to the rock, or to the timbering. The lamps are made of iron, hermetically closed, and suspended, so that they can not droop, or invert and spill the oil. They are usually hung on the thumb by a hook. Miners also employ small lanterns, suspended to their girdles. Many precautions and much experience are requisite to enable them to carry these lights in a current of air, or in a vitiated atmosphere. It is especially in coal mines liable to the disengagement of carburetted hydrogen, that measures of safety are indispensable against the explosions. The appearance of any halo round the flame should be carefully watched as indicating danger; and the lights should be carried near the bottom of the gallery. The great protector against these deplorable accidents, is the safety lamp. See Lamp of Davy.

We can not conclude this general outline of the working of mines, without giving some account of the miners. Most men have a horror at the idea of burying themselves, even for a short period, in these gloomy recesses of the earth. Hence mining operations were at first so much dreaded, that, among the ancients, they were assigned to slaves as the punishment of their crimes. This dislike has diminished with the improvements made in mining; and finally, a profitable and respected species of labor has given mining its proper rank among the other departments of industry. The *esprit de corps*, so conspicuous among seamen, has also arisen among miners, and has given dignity to their body. Like every society of men engaged in perilous enterprises, and cherishing the hopes of great success, miners get attached to their profession, talk of it with pride, and eventually in their old age regard other occupations with contempt. They form, in certain countries, such as Germany and Sweden, a body legally constituted, which enjoys considerable privileges. Miners work usually 6 or 8 hours at a time. This period is called a *journey* (*poste*, in French).

Miners wear, in general, a peculiar dress, the purpose of which is to protect them, as much as possible, from the annoyances caused by water, mud, and sharp stones, which occur in the places where they work. One of the most essential parts of the dress of a German miner is an apron of leather fitted on behind, so as to protect them in sitting on moisture or angular rubbish. In England, the miners wear nothing but flannels; though they frequently strip off all their clothes except their trowsers. In many countries the mallet and the pick, or *pointerolle* (called in German, *Schegel* and *Eisen*), disposed in a Saint Andrew's cross, are the badge of miners, and are engraved on their buttons, and on everything belonging to mines.

Several of the enterprises executed in mines, or in subserviency to them, merit a distinguished rank among the history of human labors. Several mines are worked to a depth of more than 600 yards, some even to a thousand yards below the surface of the soil. A great many descend beneath the level of the ocean; and a few even extend under its billows, and are separated from them by a thin partition of rock, which allows their noise, and the rolling of the pebbles, to be heard.

In 1792, there was opened, at Valenciana, in Mexico, an octagonal pit, fully 7½ yards wide, destined to have a depth of 560 yards, to occupy 23 years in digging, and to cost 240,000*l.*

The great drainage gallery of the mines of Clausthal, in the Hartz, is 11,377 yards, or six and a half miles long, and passes upward of 300 yards below the church of Clausthal. Its excavation lasted from the year 1777 till 1800, and cost about 66,000*l.* Several other galleries of efflux might also be adduced, as remarkable for their great length and expense of formation.

The coal and iron mines subservient to the iron works of Mr. 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 upward of 100 English miles.

The carriage of the coal extracted from the mines in the neighborhood 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 upward of 500 miles.

There is no species of labor which calls for so great a development of power as that of mines; and accordingly, it may be doubted if man has ever constructed machines so powerful as those which are now employed for the working of some mineral excavations. The waters of several mines of Cornwall are pumped out by means of steam-engines, whose force is equivalent in some instances to the simultaneous action of many hundred horses.

Mines, General Summary of.

Mines may be divided into three great classes: 1. Mines in the gealogical formations anterior to the coal strata; 2. Mines in the secondary formations; 3. Mines in alluvial districts.

The first are opened, for the most part, upon veins, masses, and metalliferous beds.

The second, on strata of combustibles, as coal; and metalliferous or saliferous beds.

The last, on deposites of metallic ores, disseminated in clays, sands, and other alluvial matters, usually superior to the chalk; and even of far more recent formation.

The mines of these three classes, placed, for the most part in very different physical localities, differ no less relatively to the mode of working them, and their mechanical treatment, than in a gealogical point of view.

MINES OF FORMATIONS ANTERIOR TO THE COAL.

These mines are situated in a few mountainous regions, and their whole amount forms but a small portion of the surface of the earth. The most remarkable of these are—the Cordilleras of South America; the mountains of Hungary; the Altayan mountains; the Ural mountains; the Vosges and the Black Forest; the Hartz, and the east of Germany; the centre of France; the north of Portugal, and the adjacent portions of Spain; Britanny; the corresponding coasts of Great Britain and Ireland; the north of Europe; the Allegany chain; the south of Spain; the Pyrenees; the Alps; the schistose districts on the banks of the Rhine and the Ardennes; the calcareous mountains of England and of Daouria.

MINES OF THE CORDILLERAS OF SOUTH AMERICA.

Few regions are so celebrated for their mineral wealth as the great chain which, under the name of the Cordillera of the Andes, skirts the shores of the Pacific ocean, from the land of the Patagonians to near the northwest point of the American continent. Who has not heard of the mines of Mexico and Potosi? The mineral wealth of Peru has passed into a proverb.

The most important mines of the Cordilleras are those of silver; but several of gold, mercury, copper, and lead, have likewise been opened. These mountains are not equally netalliferous in their whole extent. The workings occur associated in a small number f districts far distant from each other.

In the Andes of Chili, particularly in the province of Coquimbo, some silver mines are explored, which afford chiefly ores of an earthy or ferruginous nature, mingled with imperceptible portions of ores with a silver base, known there under the name of Pacos. The same province also presents copper mines of considerable importance, from which are extracted native copper, orange oxide of copper, carbonate of copper (malachite), and copper pyrites, associated with some muriate of copper. In a few mines, masses of native copper of extraordinary magnitude have been found.

The second metalliferous region of the Andes occurs between the 21st aud 15th degrees of south latitude. It includes the celebrated mountain of Potosi, situated in nearly the 20th degree of south latitude, on the eastern slope of the chain, and several other districts, likewise very rich, which extend principally toward the northwest, as far as the two banks of the lake Titicaca, and even beyond it, through a total length of nearly 150 leagues. All these districts, which formerly depended on Peru, were united in 1778 to the government of Buenos Ayres. The mines of Potosi were discovered in 1545, and have furnished since that period till our days, a body of silver which M. Humboldt values at 230,000,000*l.* sterling. The first years were the most productive. At that time ores were often found which afforded from 40 to 45 per cent. of silver. Since the beginning of the eighteenth century, the average richness of the ore 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 deposite of ore in the world, it may, however, be still placed immediately after the famous vein of Guanaxuato. The ore lies in veins in a primitive clay state, which composes the principal mass of the mountain, and is covered by a bed of clay porphyry. This rock crowns the summit, giving it the form of a basaltic hill. The veins are very numerous; several, near their outcrop, were almost wholly composed of sulphuret of silver, antimoniated sulphuret of silver, and native silver. Others, which offered near the surface merely sulphuret of tin, became richer as they descended. In 1790, seven copper mines were known in the viceroyalty 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 harbor of Iquiqua, and forms a part of Peru, occur the silver mines of Huantajaya, celebrated for the immense masses of native silver which have been sometimes found in them. In 1758, one was discovered weighing eight cwts.

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

The silver mines of the district of Pasco are situated about 30 or 40 leagues north of Lima, in $10\frac{1}{2}$ degrees of south latitude, 4,400 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 Cero of Yauricocha, are actually the richest in all Peru. The ore is an earthy mass of a red color, containing much iron, mingled with particles of native silver, horn silver, &c., constituting what they call *Pacos*. At first, nothing but these *pacos* was collected; and much gray copper and antimoniated sulphuret of silver were thrown among the rubbish. The mean product of all the ores is $\frac{1}{1250}$; or an ounce and $\frac{28}{100}$ per cwt.; although some occur which yield 30 or 40 per cent. These rich deposites do not seem to be extended to a great depth; they have not been pursued further than 130 yards, and in the greater part of the workings only to from 35 to 45. Forty years ago, these mines, which produced nearly 2,000,000 of piastres annually, were the worst worked in all South America. The soil seemed as if riddled with an immense number of pits, placed without any order. The drainage of the waters was effected by the manual labor of men, and was extremely expensive. In 1816, some Europeans, among whom were several miners from Cornwall, mounted several high-pressure steam-engines, imported from England, which introduced a considerable improvement in the workings.

The mines of the province of Chota are situated in about seven degrees of south latitude. The principal ones are those of Gualcayoc, near Mecuicampa, discovered in 1771; their outcrop occurs at the height of 4,500 yards above the sea; the city of Mecuicampa itself has 4,000 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 primitive schistose mountains. The district of Huaailas contains, besides, lead mines. Peru possesses, moreover, some mines of copper.

The quicksilver mines of Huancavelica, the only important mine of this species which has been worked in the New World, occurs on the eastern flank of the Andes of Peru, in 13 degrees of south latitude, at upward of 6,000 yards above the level of the sea. It does not seem referrible to the same class of deposites with the mines hitherto mentioned.

Indications of mercurial deposites have been observed in several other points of the Andes of Northern Peru, and of the south of New Granada.

Lastly, mines of sal-gem are known to exist in Peru, especially near the silver mines of Huantajaya.

On receding from the district of Chota, the Cordilleras are very indifferently stored with metallic wealth, to the isthmus of Panama, and even far beyond it. The kingdom of New Granada offers but a very small number of silver mines. There are some auriferous veins in the province of Antioquia, and in the mountains of Guamoco. The province of Caracas, the mountains of which may be considered as a ramification of the Cordilleras, presents at Aroa a copper mine which furnishes annually from 700 to 800 metric quintals (1,400 to 1,600 cwt.) of this metal. Finally, we may state in passing, that there is a very abundant salt mine at Zipaquira, in the province of Sante Fé, and that between this point and the province of Santa-Fé-de-Bogota, a stratum of coal occurs at the extraordinary height of 2,700 yards.

Although Mexico presents a great variety of localities of ores, almost the only ones worked are those of silver. Nearly the whole of these mines are situated on the back or the flanks of the Cordilleras, especially to the west of the chain, nearly at the height of the great table land which traverses this region of the globe, or a little below its level in the chains which divide it. They lie in general between 2,000 and 3,000 yards above the sea; a very considerable elevation, which is favorable 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 4,000 to 5,000 deposites of ore exploited. The workings constituted 3,000 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, toward 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, toward the western slope of the great *plateau*.

3. The group of *Biscania*, about 20 leagues northeast 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 northwest of Mexico, toward the eastern slope of the plateau. Besides numerous silver mines, it includes abundant deposites 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 its southern extremity, and 60 leagues N. N. W. of Mexico. It comprises among others the famous mine districts of *Gnanaxuato, Catorce, Zacatecas, Sombrerete;* the richest in Mexico, and which alone furnish more than half of all the silver which this kingdom brings into circulation.

The district of *Guanaxuato* presents only one main vein, called the *Veta Madre*. This vein is enclosed principally in clay-state, to whose beds it runs parallel, but occasionally it issues out of them to intersect more modern rocks. The vein is composed of quartz, carbonate of lime, fragments of clay slate, &c.; and includes the sulphurets of iron, of lead, and of zinc in great quantities, some native silver, sulphuret of silver, and red silver; its power (thickness of the vein) is from 43 to 48 yards. It is recognised and worked throughout a length of upward of 13,000 yards; and contains 19 exploitations, which produced annually well on to 1,200,000*l.* in silver. One of the explorations, that of Valenciana, produces 320,000*l.*; being equal to about one fifteenth of the total product of the 3,000 mines of Mexico. Since 1764, the period of its discovery, its neat annual product has never been less than from two to three millions of francs (80,000*l.* to 120,000*l.*); and its proprietors, at first men of little fortune, became, in ten years, the richest individuals in Mexico, and perhaps in the whole globe.

The workings of this mine are very extensive, and penetrate to a depth of 550 yards. They employ a great many laborers.

The district of Zacatecas presents in like manner only a single vein in greywacke; which, however, is the seat of several workings.

The deposites 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 20,000*l.* There are also mines of antimony in the district of Catorce.

Toward 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 (orange copper), sulphuret of copper, and native copper. These mines produce about 2,000 metric quintals of copper annually (440,000 lbs. English). In the same district, ores of tin are collected in the alluvial soils, particularly near Mount Gigante. The concretionary oxide of tin, so rare in Europe, is here the most common variety. This metal occurs also in veins.

The central part of Mexico contains many indications of sulphuret of mercury (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 Balanos, one of the richest districts.

7. *The group of Durango and Sonora*, in the intendancies of the same name. It is very extensive. The mines are situated in part on the table land, and in part on the western slope. Durango is 140 leagues N. N. W. of Mexico.

8. *The group of Chinuahua.* It takes its name from the town of Chinuahua, situated 100 leagues N. of Durango. It is exceedingly extensive, but of little value; and terminates at 29° 10′ of north latitude.

Mexico possesses, besides, several mines which are not included in the eight preceding groups. Thus the new kingdom of Leon, and the province of New Saint-Ander, present abundant mines of lead. New Mexico contains copper mines, and many others.

Lastly, rock salt is mined in several points of New Spain; and coal seems to occur in New Mexico.

The richness of the different districts of the *silver mines* or *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 deposites. The ores of Mexico are principally veins; beds and masses are rare. The veins traverse chiefly, and perhaps only, primitive and transition rocks, among which certain porphyries are remarked as very rich in deposites of gold and silver. The silver ores are mostly sulphuret of silver, black antimoniated sulphuret of silver, muriate of silver (hornsilver), and gray copper. Many explorations are carried on in certain earthy ores, called *colloradas*, similar to the *pacos* of Peru. Lastly, there are ores of other metals, which are worked principally, and sometimes exclusively, for the silver which they contain; such are the argentiferous sulphuret of lead, argentiferous sulphuret of copper, and argentiferous sulphuret of iron.

Ores of very great richness occur in Mexico; but the average is only from 3 to 4 ounces per cwt., or from 18 to 25 in 10,000. There are some, indeed, whose estimate does not exceed $2\frac{1}{5}$ 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 art of mining was little advanced in this country at the period of Humboldt's journey; the workings presented a combination of small mines, each of which had only one aperture above, without any lateral communications between the different shafts.

The form of these explorations was too irregular to admit of their being called *workings by steps.* The shafts and the galleries were much too wide. The interior transport of the ores is generally effected on the back of men; rarely by mules. The machines for raising the ore and drawing off the water are in general ill combined; and the horse gigs for setting them in motion ill constructed. The timbering of the shafts is very imperfectly executed; the walled portions alone are well done. There are some galleries of drainage, but they are too few, and ill directed. Latterly, English capitalists and miners have formed companies for working the silver mines of Mexico; which will probably produce in time a happy revolution.

The silver ores of Spanish America are treated partly by fusion, and partly by amalgamation, but more frequently by the latter mode; hence the importation of mercury forms there an object of the highest importance, especially since the quicksilver mine of *Huancavelica* fell in, and ceased to be worked. This mine is the only one in Spanish America which belongs to the government. For the modern state of these mines, see Silver.

The following table shows, according to M. de Humboldt, what was the annual product of the silver mines of South America, at the beginning of this century. It is founded in a great measure, upon official documents:—

Mexico - - -	2,196,140 marcs, or	537,512 kil.,	worth £4,778,000
Peru - - - -	573,958	140,478	1,250,000
Buenos-Ayres - -	463,098	110,764	984,600
Chili - - - -	25,957	6,827	60,680
Total - - -	3,259,153	795,581	7,073,280

To complete our picture of the mineral wealth of Spanish America, it remains to speak of its principal *gold mines;* but these belong to a geological locality, alluvial sands and gravel, very different from that of our present objects. The most important of these gold sands are washed on the western slope of the Cordilleras; viz., in New Grenada, 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 libs. Eng.) of gold, worth 1,435,720*l.*

MINES OF HUNGARY.

The metallic mines of this kingdom, including those of Transylvania, and the Bannat of Temeschwar, form four principal groups, which we shall denote by the group of the N.W., group of the N.E., group of the E., and group of the S.E.

The group of the N.W. embraces the districts of Schemnitz, Kremnitz, Kœnigsberg, Neuhsohl, 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 1,130 yards above the ocean, are formed of barren trachytes (rough trap rocks); but at their foot below the trachytic formation, a formation is observed, consisting of green-stone porphyries, connected with syenites, passing into granite and gneiss, and including subordinate beds of mica-slate and limestone. It is in this formation that all the mines occur.

It has been long known that the green-stone porphyries of Schemnitz have intimate relations with the metalliferous porphyries of South America. M. Beudant, on comparing them with those brought by M. de Humboldt from Guanaxuato, Real del Monte, &c., has recognised an identity in the minutest details of color, structure, composition, respective situation of the different varieties, and even in the empirical character of effervescence with acids. The metalliferous rocks appear at Schemnitz only in a space of small extent, comprehended partly in a small basin, of which the city occupies the south border. They are traversed by veins which, for the most part, cut across the stratification, but which also are sometimes obviously parallel to it. These veins are in general very powerful; their thickness amounting even to more than 40 yards, but their extent in length seems to be usually inconsiderable. They are numerous and parallel to each other. It appears that they have no side plates of vein-stones (*sallebandes*), but that the metalliferous mass reposes immediately on the cheeks or sections of the rock, which is usually more or less altered, and includes always much pyrites near the point of contact, and even to a distance of several feet. The substances which constitute the body of these veins, are drusy quartz, carious quartz, ferriferous carbonate of lime, and sulphate of barytes, with which occur sulphuret of silver mixed with native silver containing more or less gold, which is rarely in visible scales; sulphuret of silver, argentiferous galena, blende, copper and iron pyrites, &c. The sulphuret of silver and the galena are the two most important ores. Sometimes these two substances are insulated, sometimes they are mixed in different manners so as to furnish ores of every degree of richness, from such as yield 60 per cent. of silver down to the poorest galena. The gold seldom occurs alone; it generally accompanies the silver in a very variable proportion, which most usually approaches to that of 1 to 30.

The ores of Schemnitz are all treated by fusion; the poor galenas at the smelting house of Schemnitz (bleyhutte), and the resulting lead is sent as working lead to the smelting-houses of Kremnitz, Neusohl, and Schernowitz, whither all the silver ores prepared in the different spots of the country are transported in order to be smelted.

The mines of Schemnitz, opened 800 years ago, have been worked to a depth of more than 350 yards. The explorations are in general well conducted. Excellent galleries of efflux have been excavated; the waters for impulsion are collected and applied with skill. It may be remarked, however, that these mines begin to decline from the state of prosperity in which they stood several years ago; a circumstance to be ascribed probably to the same pains being no longer bestowed on the instruction of the officers appointed to superintend them. Maria Theresa established in 1760, at Schemnitz, a school of mines. This acquired at its origin, throughout Europe, a great celebrity, which it has not been able to maintain.

Kremnitz lies about five leagues N.N.W. of Schemnitz, in a valley flanked on the right by a range of hills formed of rocks quite analogous to the metalliferous rocks of Schemnitz. In the midst of these rocks, veins are worked nearly similar to those of Schemnitz; but the quartz which forms their principal mass is more abundant, and contains more native gold. Here also are found sulphuret and hydrosulphuret of antimony, which do not occur at Schemnitz. The metalliferous district is of very moderate extent, and is surrounded by the trachytic district which overlies it, forming to the east and west considerable mountains.

The city of Kremnitz is one of the most ancient free royal cities of mines in Hungary. It is said that mines were worked there even in the times of the Romans; but it is the Germans who, since the middle ages, have given a great development to these exploitations. There exists at Kremnitz a mint-office, to which all the gold and silver of the mines of Hungary are carried in order to be parted, and where all the chemical processes, such as the fabrication of acids, &c., are carried on in the large way.

About six leagues N.N.E. from Schemnitz, on the banks of the Gran, lies the little village of *Neusohl*, founded by a colony of Saxon miners. The mountains surrounding it include mines very different from those of which we have been treating. At *Herrengrand*, two leagues from Neusohl, greywacke forms pretty lofty mountains; this rock is covered by transition limestone, and is supported by mica-slate. The lower beds contain bands of copper ores, chiefly copper pyrites. The mica-slate includes likewise masses of ore, apparently constituting veins in it. These ores have been worked since the 13th century. The copper extracted contains in a hundred weight six ounces of silver.

Eighteen or twenty leagues to the east of *Neusohl*, we meet with a country very rich in iron and copper mines, situated chiefly in the neighborhood of Bethler, Schmœlnitz, Einsiedael, Rosenau, &c. Talcose and clay slates form the principal body of the mountains here, along with horneblende rocks. The ores occur most usually in strata. Those of iron, or sparry ore, and especially hydrate of iron, compact and in concretions, accompanied with specular iron ore. They give employment to a great many large smelting-houses. The county of Gœmar alone contains 22 works; and that of Zips also a great number. The copper mines lie chiefly in the neighborhood of Schmœlnitz and Gœlnitz. The copper extracted contains about six or seven ounces of silver in the hundred weight. Near Zalathna there is a quicksilver mine nearly inactive; and near Rosenau one of antimony.

To conclude our enumeration of the mineral wealth of this country, it remains merely to state that there are *opal* mines in the environs of Czervenitza, placed in the trachytic conglomerate.

GROUP OF THE NORTHEAST, OR OF NAGABANYA.

The mines of this group lie in a somewhat considerable chain of mountains, which, proceeding from the frontiers of Buchowina, where it is united to the Carpathians, finally disappears amid the saliferous sandstones between the *Theiss*, *Lapos*, and *Nagy Szamos*, on the northern frontiers of Transylvania. These mountains are partly composed of rocks analogous to those of Schemnitz, traversed by veins which have much resemblance to the veins of this celebrated spot. Into these veins a great many mines have been opened, the most important of which are those of Nagabanya, Kapnick, Felsobanya, Miszbanya, Laposbanya, Olaposbanya, Ohlalapos. All these mines produce gold. Those of Laposbanya furnish, likewise, argentiferous galena; those of Olaposbanya contain copper and iron; and those of Kapnick copper. Realgar occurs in the mines of Felsobanya; and orpiment in those of Ohlalapos. Several of them produce manganese and sulphuret of antimony. Lastly, toward the north, in the county of Marmarosh, lies the important iron mine of *Borscha*, and on the frontiers of Buchowina the lead mine of *Radna*, in which also much zinc ore occurs.

The mines composing the group of the East, or of Abrudbanya, occur almost all in the mountains which rise in the western part of Transylvania, between *Lapos* and *Maros*, in the environs of *Abrudbanya*. M. Beudant notices in this region, limestones, sandstones, trachytes, basalts, and sienite porphyries, apparently quite analogous to the greenstone porphyries of Schemnitz. It seems to be principally in the latter rocks that the mines forming the wealth of this country occur; but some of them exist also in the mica-slate, the greywacke, and even in the limestone. The principal mines are at Nagyag, Korosbanya, Vorospatak, Boitza, Csertesch, Fatzbay, Almas, Porkura, Butschum, and Stonischa. There are, in all, 40 exploitations; the whole of which produce auriferous ores smelted at the foundry of Zalathna. These mines contain also copper, antimony, and manganese. They are celebrated for their *tellurium* ore, which was peculiar to them prior to the discovery of this metal a few years back in Norway. The auriferous deposites contained in the greenstone porphyry are often very irregular. The mines of Nagyag are the richest and best worked. The numerous veins occur partly in the sienite porphyry, and partly in the greywacke. The auriferous ore is accompanied with galena, realgar, manganese, iron, and zinc. There are iron mines in great beds near Vayda-Huniad and Gyalar. Some Cobalt mines are also noticed.

The group of the S. E., or of the Bannat of Temeschwar, occurs in the mountains which block up the valley of the Danube at Orschova, through a narrow gorge of which the river escapes. The principal mines are at Oravitza, Moldawa, Szaska, and Dognaaczka

They produce chiefly argentiferous copper, yielding a marc of silver (nearly ½ pound) in the hundred weight, with occasionally a little gold. Ores of lead, zinc, and iron, are also met with. The mines are famous for their beautiful specimens of blue carbonate of copper, and various other minerals. The mine of Moldawa affords likewise orpiment. These metallic deposites lie in beds and veins; the former occurring particularly between the mica-slate and the limestone, or sometimes between the limestone and the sienite porphyry. Well-defined veins also are known to exist in the sienite and the mica-slate. The Bannat possesses moreover important iron-mines at Domtrawa and Ruchersberg; near Dombrawa sulphuret of mercury is found. Cobalt mines occur likewise in these regions.

The mines constituting the four groups now described are not the sole metallic mines possessed by Hungary. A few others, but generally of little importance, are scattered over different parts of this kingdom. Several have been noticed in the portion of the Carpathians which separates Transylvania from Moldavia and Wallachia. Their principal object is the exploration of some singular deposites of galena.

Besides the mines just noticed, Hungary contains some coal mines, numerous mines of rock salt, and several deposites of golden sands situated chiefly on the banks of the Danube, the Marosch, and the Nera.

The mines of the kingdom of Hungary produce annually, according to M. Heron de Villefosse, 5,218 marcs, or 2,810 pounds English of gold, worth 175,976*l.*; and about 85,000 marcs, or 45,767 pounds of silver, worth 186,132*l.* The mines of Transylvania furnish nearly the half of the whole quantity of gold, and one seventeenth of the silver now stated. The other mines of Europe produce together nearly twice as much silver, but merely a few marcs of gold. Hungary affords besides from 18,000 to 20,000 metric quintals (about 4,000,000 libs. English) of copper annually, and a great deal of iron.

From these mines proceed likewise from 3,000 to 4,000 metric quintals (660,000 to 880,000 libs. Eng.) of lead; a quantity not more than is needed by the refining-houses for the ores of silver and gold.

MINES OF THE ALTAYAN MOUNTAINS.

At the western extremity of the chain of the Altayan mountains, which separate Siberia from Chinese Tartary, there exists a number of metalliferous veins, in which several important works have been established since the year 1742. They constitute the locality of the mines of Kolywan; the richest in the precious metals of the three districts of this kind existing in Siberia.

These mines are opened up in the schistose formations which surround to the N. and W. and to the S.W. the western declivity of the high granitic chain, from which they are separated by formations consisting of other primitive rocks. These schists alternate in some points with quartzose rocks, called by M. 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 Zmeinogarsk, in German Schlangenberg, situated to the N.W. of the high mountains in 51° 9′ 25″ N. L. and 79° 49′ 50″ long. east of Paris. It is opened on a great vein, which contains argentiferous native gold, auriferous native silver, sulphuret of silver, hornsilver, gray copper, sulphuret of copper, green and blue carbonated copper, red oxide of copper, copper pyrites, sulphuret of lead, and great masses of testaceous arsenic slightly argentiferous. There occur likewise sulphuret of zinc, iron pyrites, and sometimes arsenical pyrites. The gangues (vein-stones) of these different ores are sulphate of baryta, carbonate of lime, quartz, but rarely 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 superior portion, it has an inclination of about 50 degrees; but lower down it becomes nearly vertical. Its roof is always formed of clay-slate. On the floor of the vein, the slate alternates with hornstone. This vein pushes out branches in several directions; it is intersected by barren veins, and presents successive stages of different richness. The first years were the most productive. The German miners employed subsequently by the Russian government have introduced regularity into the workings; and have excavated a gallery of efflux 585 fathoms long.

The most important of the other silver mines of this department are those of Tcherepanofski, 3 leagues S.E. of Zméof; those of Smenofski, 10 leagues S.E.; those of Nicolaiski, 20 leagues to the S.S.W.; and of Philipofski, 90 leagues S.E. of the same place. The last mine lies on the extreme frontier of Chinese Tartary. It is not known whether the southern slope of the Altaic chain within the Chinese territories, contains metalliferous deposites.

The ores extracted from these different mines yield on an average per quintal an ounce of silver, which contains 3 per cent. of gold. Their annual product was toward 1786, according to M. Patrin, 3,000 marcs, or 1,615 libs. avoirdupois of gold, worth 101,151*l.*; and 60,000 marcs, or 31,020 libs. avoird. or silver, worth 130,520*l.*

The precious metals are not the sole product of this mineral district. There is an important copper-mine 15 leagues N.W. of Zméof, in a chain of hills formed of granitic rocks, schists, porphyries, and shell-limestone, graduating into the plain. The vein presents copper pyrites, sulphuret of copper, and native copper, disseminated in argillaceous substances, more or less ferruginous, and of different degrees of hardness. This mine, which bears the name of Aleiski-Loktefski, furnished annually at the date of 1782, 1,500 quintals (metric), or 330,000 libs. avoird. of copper, which was coined into money in the country itself.

At Tchakirskoy, on the banks of the Tscharisch, toward 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 color.

The northern flank of the Altaï mountains presents few mines. Some veins of copper exist 2,000 leagues east of Zméof, near the spot where the river Janissei issues from the Saianean mountains, which are a prolongation of the Altayan chain.

There is no lead-mine, properly so called, in the Altaï mountains. Almost all the lead which is required for the treatment of the silver and gold ores is obtained from the department of Nertchinsk, situated 700 leagues off, on the borders of the river *Amour.*

The first smelting-house erected in this district 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 neighborhood of the mines. The principal existing foundry it that of Bornaoul on the Ob, 50 leagues north of Zméof.

MINES OF THE URAL MOUNTAINS.

This chain of mountains, which begins on the coasts of the icy sea, and terminates in the 50th degree of latitude amid the steppes of the *Kerguis,* after having formed, through an extent of more than 40 leagues, the natural limit between Europe and Asia, contains very rich and very remarkable deposites of metallic ores, which have given rise to important mines of iron, copper, and gold. These explorations are situated on the two slopes, but chiefly on the one that looks to Asia, from the environs of Ekaterinbourg to about 120 or 130 leagues north of that city. They constitute the department of the mines of Ekaterinbourg, one of the three belonging to Siberia.

The copper-mines are pretty numerous, and lie almost wholly on the oriental slope of the chain. They are opened into veins of a very peculiar nature, and which although very powerful at the surface, do not extend to any considerable depth. These veins are in general filled with argillaceous matters, penetrated with red oxide of copper, and mingled with green and blue carbonated copper, sulphuret of copper, and native copper. The most important workings are those of *Tourinski* and *Goumechafski.*

The first are situated 120 leagues north of Ekaterinbourg, toward the 60th degree of N. latitude, at the eastern base of the Uralian mountains, near the banks of the *Touria.* They amount to three, opened in the same vein, which turns round an angle presented by the chain in this place. The ground is composed of a porphyry with a hornstone basis of clay-slate, and of a white or grayish limestone, which form the roof and floor of the vein. The ore yields from 18 to 20 per cent., and these mines produced annually in 1786, 10,000 metric quintals (2,200,000 libs. avoird.) of copper.

The mine of Goumechefski lies 12 or 15 leagues S.W. of Ekaterinbourg, near a lake bordered by primitive mountains, which form in this region the axis of the chain of the Urals. This mine is celebrated for the beautiful malachites that occur in it. It has furnished almost all the fine specimens of this substance employed in jewellery. The vein, of which the sides are calcareous, is vertical, and runs north and south. It does not sink deeper than about 50 yards, and is filled with a species of coarse pudding-stone, composed of masses of primitive rocks. The ore yields from 3 to 4 per cent. of copper, and the mine furnished about the year 1786, 4,400,000 libs. avoird. of this metal *per annum.*

The beds of iron ore occur generally at a certain distance from the axis of the central chain. Those of the western slope lie sometimes in a gray compact limestone, which contains *entrochi* and other petrifications, and whose geological age has not been ascertained, but it appears to be much more modern than the rocks of the central chain. Both the one and the other seem to form large veins, which extend little in depth, or rather fill irregular and shallow cavities. The most common ore is the hydrate of iron (bog ore), hematite, or compact iron ore, sometimes mixed or accompanied with hydrate of manganese, and occasionally with ores of zinc, copper, and lead. Black oxide of iron, possessing magnetic polarity, likewise frequently occurs, particularly in the mines of the eastern slope, on which, in fact, entire mountains of loadstone repose. All these ores, mixed with a greater or less quantity of clay differently colored, are worked by open quarries, and most usually without using gunpowder, or even iron wedges. They yield rarely less than 50 or 60 per cent., and keep in action numerous smelting-houses situated on the two flanks of the chain; the oldest of them have been established since 1628, but the greater number date only from the middle of the 18th century. The most celebrated mines are those of *Balgodat* and *Keskanar,* situated on the eastern slope from 30 to 50 leagues north of *Ekaterinbourg.* In the foundries of the eastern slope, anchors, cannons, bullets, &c., are fabricated; and in the whole a considerable quantity of bar iron. The products of the works on the western side are directly embarked on the different feeders of the Volga, from which they are at no great distance. Those of the eastern slope are transported during winter on sledges to the same feeder streams, after crossing the least elevated passages of the Urals.

The quantity of materials fabricated by the iron-works of both slopes, amounted annually, toward the year 1790, to more than 11,000,000 lbs. avoird. This country is peculiarly favored by nature for this species of industry; for vast deposites of excellent iron ores occur surrounded by immense forests of firs, pines, and birches; woods, whose charcoal is excellently adapted to the fabrication of iron.

The copper-mines of the Uralian mountains, and the greater part of the iron mines and foundries, form a portion of the properties of some individuals, who may be instanced as among the richest in Europe. The Russian government has neglected no opportunity of promoting these enterprises. It has established at Tourinsky a considerable colony, and at Irbitz a fair which has become celebrated.

There is only one gold mine in the Ural mountains, that of *Beresof,* situated three leagues N.E. of Elkaterinbourg, at the foot of the Urals, on the Asiatic side. It is famous for the chromate of lead, or red lead ore, discovered there in 1776, and worked in the following years, as also for some rare varieties of minerals. The ore of Beresof is a cavernous hydrate of iron (bog ore), presenting here and there some small striated cubes of hepatic iron, and occasionally some pyrites. It contains 5 parts of native gold in 100,000. This deposite appears to have a great analogy with the deposites of iron ore of the same region. It constitutes a large vein, running from N. to S., encased in a formation of gneiss, hornblende schists, and serpentine, and which does not appear to dip to any considerable depth. It becomes poor in proportion to its distance from the surface. The exploitation, which is in the open air, has dug down 25 yards; having been carried on since the year 1726. The gold is extracted from the ore by stamping and washing. In 1786, 500 marcs were collected; but the preceding years had furnished only 200, because they then worked further from the surface. German miners were called in to direct the operations. On some points of the Ural mountains, and the neighboring countries, deposites of an auriferous clay have been noticed; but they have not hitherto been worked.

Beds of chromate of iron have also been discovered in these mountains.

The beautiful plates of mica, well known in mineral cabinets, and even in commerce, under the name of Muscovy talc, or Russian mica, come from the Urals. There are explorations for them near the lake Tschebarkoul, on the eastern flank of this chain. From the same canton there is exported a very white clay, apparently a *kaolin.*

25 leagues north of Ekaterinbourg, near the town of Mourzinsk, there occur in a graphic granite, numerous veins, containing amethysts, several varieties of beryl, emeralds, topazes, &c.

Table of the Production of the Russian Mines during the years 1830, 1831, 1832, 1833, and 1834; by M. Teploff, one of their officers.

Substances.	1830.	1831.	1832.	1833.	1834.
	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 VOSGES AND THE BLACK FOREST.

These mountains contain several centres of exploration of argentiferous ores of lead and copper, iron ores, and some mines of manganese and anthracite.

At the *Croix-aux-mines*, department of the Vosges, a vein of argentiferous lead has been worked, which next to the veins of Spanish America, is one of the greatest known. It is several fathoms thick, and has been traced and mined through an extent of more than a league. It is partly filled with debris, among which occurs some argentiferous galena. It contains also phosphate of lead, antimoniated sulphuret of silver, &c. It runs from N. to S. nearly parallel to the line of junction of the gneiss, and a porphyroid granite, that passes into sienite and porphyry. In several points it cuts across the gneiss; but it probably occurs also between the two rocks. It has never been worked below the level of the adjoining valley. The mines opened on this vein produced, it is said, at the end of the 16th century, 26,000*l.* per annum; they were still very productive in the middle of the last century, and furnished, in 1756, 2,640,000 lbs. avoird. of lead, and 6,000 marcs, or 3,230 pounds avoird. of silver.

The veins explored at *Sainte Marie of the mines*, also traverse the gneiss; but their direction is nearly perpendicular to that of the vein of the *Croix*, from which they are separated by a barren mountain of sienite. They contain besides galena, several ores of copper, cobalt, and arsenic; all more or less argentiferous. There is found also at a little distance from *Saint Mary of the mines* a vein of sulphuret of antimony. The mines of *Sainte Marie*, opened several centuries ago, are among the most ancient in France; and yet they have been worked only down to the level of the adjoining valleys.

There has been opened up in the environs of *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; a system which has some analogy with the metalliferous district of Schemnitz. The workings have been pushed so far as 440 yards below the surface. These mines were in a flourishing state in the 14th and 16th centuries; and became so once more at the beginning of the 17th, when they were undertaken by the house of Mazarin. In 1743 they still produced 100 marcs, fully 52 libs. avoird. of silver in the month.

The mines of *La Croix*, 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, workings of lead in great activity. These form six distinct mines, and annually afford 88,000 libs. avoird. of lead, and 200 marcs of silver. In the Furstenberg near *Wolfach*, particularly at *Wittichen*, there are mines of copper, cobalt, and silver. The mines of Wittichen produced, some years ago, 1,600 marcs, or near 880 libs. avoird. of silver per *annum*. They supply a manufactory of smalt, and one of arsenical products. A few other inconsiderable mines of the same kind exist in the grand dutchy of Baden, and in the kingdom of Wurtemberg.

Several important iron mines are explored in the Vosges; the principal are those of *Framont*, in the department of the Vosges, whose ores are red oxide of iron and brown hematite, which appear to form veins of great thickness, much ramified, and very irregular, in a district composed of greenstone, limestone, and greywacke. The subterranean workings, opened on these deposites, 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 neighborhood 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 hematite and compact bog ore, accompanied with a little calamine, and a great deal of sand and debris. In some points of these veins, the iron ore is replaced by various ores of lead, the most abundant being the phosphate, which are explored at *Erlenbach* and *Katzenthal*. These veins traverse the sandstone of the Vosges, a formation whose geological position is not altogether well known, but which contains iron mines analogous to the preceding at *Langenthal*, at the foot of Mount Tonnerre, and in the palatinate. Many analogies seem to approximate to the sandstone of the Vosges, the sandstone of the environs of Saint Avold (Moselle), which include the mine of brown hematite 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 the Sarrebruck, mines of manganese are worked, famous for the good quality of their products. The deposite exploited at Cruttnich seems to be enclosed 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 deposites 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 deposites of the true coal formation on the flanks of the Vosges.

MINES OF THE HARTZ.

The name Hartz is given generally to the country of forests, which extends a great many miles round the *Brocken*, a mountain situated about 55 miles W.S.W. of Magdebourg, and which rises above all the mountains of North Germany, being at its summit 1226 yards above the level of the sea. The Hartz is about 43 miles in length from S.S.E. to N.N.W., 18 miles in breadth, and contains about 450 square miles of surface. It is generally hilly, and covered two thirds over with forests of oaks, beeches, and firs. This rugged and picturesque district corresponds to a portion of the *Silva Hercynia* of Tacitus. As agriculture furnishes few resources there, the exploration of mines is almost the only means of subsistence to its inhabitants, who amount to about 50,000. The principal cities. *Andreasberg*, *Clausthal*, *Zellerfeld*, *Altenau*, *Lautenthal*, *Wildemann*, *Grund*, and *Goslar*, bear the title of mine-cities, and enjoy peculiar privileges; the people deriving their subsistence from working in the mines of lead, silver, and copper, over which their houses are built.

The most common rock in the Hartz is greywacke. It encloses the principal veins, and is covered by a transition limestone. The granite of which the Brocken is formed supports all this system of rocks, forming, as it were, their nucleus. Trap and hornstone rocks appear in certain points.

The veins of lead, silver, and copper, which constitute the principal wealth of the Hartz, do not pervade its whole extent. They occur chiefly near the towns of Andreasberg, Clausthal, Zellerfeld, and Lautenthal; are generally directed from N.W. to S.E., and dip to the S.W., at an angle of 80° with the horizon.

The richest silver mines are those of the environs of Andreasberg, among which may be distinguished the Samson and Newfang mines, worked to a depth of 560 yards. In the first of them there is the greatest *step* exploitation to be met with in any mine. It is composed of 80 *direct steps*, and is more than 650 yards long. These mines were discovered in 1520, and the city was built in 1521. They produce argentiferous galena, with silver ores properly so called, such as red silver ore, and ore of cobalt.

The district which yields most argentiferous lead is that of Clausthal; it comprehends a great many mines, several of which are worked to a depth of 550 yards. Such of the mines as are at the present day most productive, have been explored since the first years of the eighteenth century. The two most remarkable ones are the mines of Dorothy, and the mine of Caroline, which alone furnish a large proportion of the whole net product. The grant of the Dorothy mine extends over a length of 257 yards, in the direction of the vein, and through a breadth of nearly 22 yards perpendicularly to that direction. Out of these bounds, apparently so small, but which however surpass those of the greater part of the *concessions* in the Hartz, there was extracted from 1709 to 1807 inclusively, 883,722 marcs of silver, 768,845 quintals of lead, and 2,385 quintals of copper. This mine and that of Caroline have brought to their shareholders in the same period of time, more than 1,120,000*l.*; and have besides powerfully contributed by loans without interest to carry on the exploration of the less productive mines. It was in order to effect the drainage of the mines of the district of Clausthal, and those of the district of Zellerfeld adjoining, that the great gallery of efflux was excavated.

Next to the two districts of Clausthal and Zellerfeld, and Andreasberg, comes that of Goslar, the most important working in which is the copper mine of Rammelsberg, opened since the year 968, on a mass of copper pyrites, disseminated through quartz, and mingled with galena and blende. It is worked by shafts and galleries, with the employment of fire to break down the ore. This mine produces annually from 1,200 to 1,300 metric quintals (about 275,000 libs. avoird.) of copper. The galena extracted from it yields a small quantity of silver, and a very little gold. The latter metal amounts to only the five-millionth part of the mass explored; and yet means are found to separate it with advantage. The mine of *Lauterberg* is worked solely for the copper, and it furnishes annually near 66,000 libs. avoird. of that metal.

Besides the explorations just noticed, there are a great many mines of iron in different parts of the Hartz, which give activity to important forges, including 21 smelting cupolas. The principal ores are sparry iron, and red and brown hematites, which occur in veins, beds, and masses. Earthy and alluvial ores are also collected.

The territory of Anhalt-Bernbourg presents, toward the southeast extremity of the Hartz, lead and silver mines, which resemble closely those of the general district. They produce annually 33,000 libs. avoird. of lead.

At the southern foot of the Hartz, at Ilefeld, there is a mine of manganese.

The exploration of the Hartz mines may be traced back for about 900 years. The epoch of their greatest prosperity was the middle of the eighteenth century. Their gross annual amount was in 1808 upward of one million sterling. Lead is their principal product, of which they furnish annually 6,600,000 libs. avoird., with 36,000 marcs, or 18,700 libs. avoird. of silver, about 360,000 libs. avoird. of copper, and a very great quantity of iron. They are celebrated for the excellence of the mining operations; and the activity, patience, and skill, of their workmen.

The Hartz is referred to especially for the manner in which the waters are collected and economized for floating down the timber, and impelling the machinery. With this view, dams or lakes, canals, and aqueducts, have been constructed, remarkable for their good execution. The water-courses are formed either in the open air round the mountain-sides, or through their interior as subterranean galleries. The open channels collect the rain-waters, as well as those proceeding from the melting of snows, from the springs and streamlets, or small rivers that fall in their way. The subterranean conduits are in general the continuation of the preceding, whose circuits they cut short. These water-courses present a development in whole of 125 miles. The banks of some of the reservoirs are of an extraordinary height. In the single district of Clausthal there are 34 tanks, which supply water to 92 wheels of nearly 30 feet diameter; 55 of these serve for the drainage of water, and 37 for the extraction of ores.

MINES OF THE EAST OF GERMANY.

We shall embrace under this head the mines opened in the primitive and transition territories, which constitute the body of a great portion of Bohemia, and the adjacent parts of Saxony, Bavaria, Austria, Moravia, and Silesia.

Among the several chains of small mountains that cross these countries, the richest in deposites of ore is the one known under the name of the *Erzgebirge*, which separate 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 twelfth century, and particularly those situated on the northern slope within the kingdom of Saxony, have been long celebrated. The school of mines established at Freyberg was at one time considered as the first in the world. This is a small city near the most important workings, 8 leagues W.S.W. of Dresden, toward the middle of the northern slope of the Erzgebirge, 440 yards above the level of the sea, in an agricultural and trading district, well cleared of wood. These circumstances have modified the working of the mines, and render it difficult to draw an exact parallel between them and those of the Hartz, which are their rivals in good exploration; they are peculiarly remarkable for the perfection with which the engines are executed both for drainage and extraction of ores, all moved by water or horses; for the regularity of almost all the subterranean labors; and for the beauty of their *walling* masonry. In the portion of these mountains belonging to Saxony, the underground workings employ directly from 9,000 to 10,000 men, who labor 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 *Guanaxuato*, *Schemnitz*, and *Zmeof*, present but a moderate thickness, never exeeeding a few feet. They form several groups, whose relative importance has varied very much.

For a long time back, those of the environs of Freyberg are much the most productive; and their prosperity has been always on the advance, notwithstanding the increasing depth of the excavations. The deepest of the whole is that of Kuhschacht, which penetrates to 450 yards beneath the surface, that is, nearly down to the sea-level. The most productive and the most celebrated is the mine of Himmelsfürst; that of Beschertgluck is also very rich.

Among the explorations at Erzgebirge, there are none which were formerly so flourishing as those of Marienberg, a small town situated 7 leagues S.S.W. of Freyberg. In the sixteenth century, ores were frequently found there, even at a short distance from the surface, which yielded 85 per cent. of silver. The disasters of the thirty years' war put a term to their prosperity. Since that period, they have continually languished; and their product now is nearly null.

Our limits do not permit us to describe in detail the silver mines that occur near

Ehrenfriedersdorf, Johanna-Georgenstadt, Annaberg, Oberwiesenthal, and *Schneeberg.* Those of the last three localities produce also cobalt.

The mines of Saint-Georges, near Schneeberg, opened in the fifteenth century as iron mines, became celebrated some time after as mines of silver. Toward the end of the fifteenth century, a mass of ore was found there which afforded 400 quintals of silver; on that lump, Duke Albert kept table at the bottom of the mine. Their richness in silver has diminished since then; but they have increased more in importance during the last two hundred years, as mines of cobalt, than they had ever been as silver mines. Saxony is the country where cobalt is mined and extracted in the most extensive manner. It is obtained from the same veins with the silver. Smalt, or cobalt-blue, is the principal substance manufactured from it. The lead and the copper are in this country only accessory products of the silver mines, from which 120,000 lbs. avoird. of the first of these metals are extracted, which are hardly sufficient for the metallurgic operations; and from 50,000 to 60,000 lbs. of copper. A little bismuth is extracted from the mines of Schneeberg and Freyberg. Some manganese is found in the silver mines of the Erzgebirge, and particularly at Johanna-Georgenstadt.

The mines of Saxony produce a little argentiferous galena, and argentiferous gray copper; the minerals with a base of native silver are the principal ores; they are treated in a great measure by amalgamation. All those of Freyberg are carried to the excellent smelting-house of Halsbrück, situated on the Malde, near that city. The average richness of the silver ores throughout Saxony is only from 3 to 4 oz. per quintal: viz., nearly equal to that of the ores of Mexico, and very superior to the actual richness of the ores of Potosi. The silver extracted from them contains a little gold. The Saxon mines produce annually 52,000 marcs of silver. Of these, the district of Freyberg alone furnishes 46,000; and among the numerous mines of that district, that of Himmelsfurst of itself produces 10,000 marcs.

Silver mines exist also on the southern declivity of the Erzgebirge, which belongs to Bohemia, at *Joachimsthal* and *Bleystadt*, to the northeast of Eger. Argentiferous galena is chiefly extracted from these. The mines of Joachimsthal have been explored to a depth of 650 yards. They were formerly very flourishing; but in 1805 they were threatened with an impending abandonment. The ancient mines of Kuttenberg, situated in the same region, have been excavated, according to Agricola, to upward of 1,000 yards from the surface soil.

The southern slope of the Erzgebirge possesses cobalt mines like the northern slope; but they are of much less importance. Some occur, particularly in the neighborhood of Joachimsthal. Lastly, on the same slope, slightly-productive copper mines are mentioned at Gröslitz, near Joachimsthal; at Catharineberg, 8 leagues north of Saatz; and at Kupferberg, lying between the two. At Gröslitz, the ore is a cupreous pyrites, accompanied by blende. The ores of Catharineberg are argentiferous.

Next to the silver mines, the most important explorations of the Erzgebirge are those of tin. This metal occurs in veins, massive, and disseminated in masses of hyalin gray quartz, imbedded in the granite; it is also found in alluvial sands. The most important tin mine of the Erzgebirge is that of Altenberg, in Saxony, which has been under working since the fifteenth century. Some tin is mined also near Gayer, Ehrenfriedersdorf, Johanna-Georgenstadt, Scheibenberg, Annaberg, Seiffen, and Marienberg, in Saxony. At Zinnwald it is also found; where the stanniferous district belongs partly to Saxony and partly to Bohemia; as also important mines occur in the latter territory at Schlackenwald and Abertham, and slightly-productive ones at Platten and Joachimsthal. In several of these mines, particularly at Altenberg and Gayer, fire is employed for attacking the ore, because it is extremely hard. In almost the whole of them, chambers of too great dimensions have been excavated, whence have arisen, at different epochs, vexatious sinkings of the ground. One of these may still be seen at Altenberg, whihh is 130 yards deep, and nearly 50 in breadth. The mines of Abertham are explored to a depth of 550 yards, and those of Altenberg to 330. The tin mines of the Erzgebirge produce annually 484,000 lbs. avoird. of this metal.

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

The Erzgebirge presents also a great many iron mines, particularly in Saxony, at *Rodenberg*, near Cradorf, in the county of Henneberg, where the workings penetrate to a depth of 220 yards, and in Bohemia, at *Platten*, where may be remarked especially the great explorations opened on the vein of the *Irrgang*.

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

Argentiferous lead mines have been mentioned at *Miess*, 25 leagues W.S.W. of Prague, at the N.E. base of the western part of *Bomerwaldgebirge*, a chain of mountains which separate Bohemia from Bavaria. There are some also at *Prszibram*, 12 leagues S.W. of Prague, at the extremity of the mountains which separate Behrun from Moldau. In the latter, the argentiferous galena is accompanied by blende, in which the presence of cadmium has been observed. These mines, and those of Joachimsthal and of Bleystadt, furnish annually at present 220,000 lbs. avoird. of lead, and from 2,000 to 3,000 marcs of silver. The circle of Behrun, to the S.W. of Prague, contains some inconsiderable mines of mercury. The eastern part of the Bomerwaldgebirge, which separates Bohemia from Austria and Moravia, presents some mines on its southeast slope. Those of the environs of *Iglau*, in Moravia, and some others situated in Austria, produce annually from 4,000 to 5,000 marcs of silver. The mines of these two countries yield also copper, and in several the copper ores are argentiferous. Moravia comprehends several iron works, which are in part supplied by magnetic iron ores analogous to those of Sweden.

The northeast 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; as also the cobalt mine of Maria-anna Querback, the whole in the circle of Quaer; and the mines of arsenical pyrites at Reichenstein, in the circle of Glatz. A mine of chrysoprase exists in the mountain of Kosennitz.

MINES OF THE CENTRE OF FRANCE.

The ancient formations, principally granitic, which constitute the ground of several departments of the centre and south of France, are hardly any richer in explorations than the districts mentioned at the end of the Black Forest. Only some insulated mines are to be observed here, of which a very few possess any importance. These all occur toward the eastern border of the mass of primitive formations, in a zone characterized by a great abundance of schistose rocks.

At Villefort and at Viallaze, in the department of the Lozère, and in some places adjoining, several veins of argentiferous galena are worked which traverse the gneiss and the granite. These mines, remarkable at present for the regularity of their workings, employ 300 laborers, and produce annually about 220,000 lbs. avoird. of lead, and 1,600 marcs of silver.

The city of Vienne, in Dauphiny, is built on a hill of gneiss separated by the Rhone from the main body of the primitive formations, and in which veins of galena occur, which are now imperfectly mined. Other lead mines of less importance are observed at *St. Julien-Molin-Molette*, department of the Loire, and at *Joux*, department of the Rhone.

At Chessy, a village situated 7 leagues northwest of Lyons, there occur in a talcose schist very extensive veins of cupreous pyrites, by no means rich, but which have, nevertheless, been worked successfully during the latter part of the eighteenth century, and several years of the present; at that period, there was found in a sandstone which covers the talcose schist, and which appears referrible to the red sandstone or the variegated sandstone, a bed containing a great quantity of blue carbonate of copper and protoxide of copper, to the working of which the miners have since directed their principal attention. There exists at Saint-Belle, 2 leagues to the south of Chessy, a deposite of copper pyrites like that of Chessy, which was at one time worked, but is now standing still. At Romanèscho, in the department of Saone et Loire, a very abundant deposite of oxide of manganese is observed, apparently forming a mass in the granite, or perhaps above it. The workings are very irregular.

In the mountain of Ecouchettes, near Couches, in the same department, an ore of oxide of chrome has been occasionally worked.

At Malbose, in the department of the Lozère, a feeble vein of sulphuret of antimony is mined.

There are also in the centre of France some explorations of galena, antimony, and manganese, which appear to be of too little importance to be noticed in detail.

Some years ago a tin ore was discovered at Vaubry, 6 leagues N.N.W. of Limoges. At present, researches are making with a view of discovering deposites of such magnitude as to pay the expense of working it.

MINES OF THE NORTH OF PORTUGAL AND THE ADJOINING PARTS OF SPAIN.

The Carthaginians appear to have worked tin mines in this part of the peninsula. It is said that some formerly existed in Portugal in the environs of Viscu, a province of Beira, at a place called *Burraco de Stanno.* Some veins of the same metal were discovered in 1787, near Monte-Rey, in the south of Gallicia. They were fully two yards thick, and were incased in granite. This province presents also deposites of sulphuret of antimony. Some analogous ores are found in Castille and Estremadura. Lead ores were worked in the last century not far from Mogadouro, on the banks of the Sabor, in the province of Tras-los-Montes, and near Longroiva on the banks of the Rio-Prisco. Mines of plumbago occur near Mogadouro. There are also some iron mines in the same country near Felguiera and Torredemnacorvo. They supply the iron-works of Chapa-cunha. Two very ancient establishments of the same kind exist in the Estremadura of Portugal; the one in the district of Thomar, and the other in that of Figuiero dos Vinhoss: they are supplied by mines of red oxide of iron, situated on the frontiers of this province and of Beira. One deposite of quicksilver ore occurs at Couna in Portugal. At Rio Tinto in Spain, on the frontiers of Portugal, there is a copper mine which produces about 33,000 libs. avoird. of this metal per annum. The ore is a copper pyrites. The mountains in the environs of Oporto present everywhere indications of the ores of copper and other metals; and it appears that all this part of the peninsula is in general rich in metallic treasures, but that the want of wood prevents their being mined to advantage.

Besides, many of the deposites which originally existed there must be in a great measure exhausted. It was in these countries chiefly that the gold and silver mines lay, which the Carthaginians and Romans worked with so much advantage, and contested in so keen a manner. Near Loria (the ancient Numantium), Azagala, and Burgos, considerable vestiges of the ancient workings may still be seen.

MINES OF BRITANNY.

Britanny has hardly a better share in mineral wealth than the countries we have just passed in review. There exist in it at this moment only two important exploitations; which are, the lead mines of *Poullaouen* and *Huelgoat*, situated near Carhaix. The mine of Huelgoat, celebrated for the plomb-gomme (hydro-aluminate) discovered in it, is opened on a vein of galena, which traverses transition rocks. The workings have subsisted for about three centuries, and have attained to a depth of 220 yards. The vein of Poullaouen, called the New Mine, was discovered in 1741. It was powerful and very rich near the surface; but it became subdivided and impoverished with its depth, notwithstanding which the workings have been sunk to upward of 180 yards below the surface. In these mines there are fine hydraulic machines for the drainage of the waters, with wheels from 14 to 15 yards in diameter; and water-pressure machines have been recently constructed. The mines employ more than 900 workmen, and furnish annually more than 1,200,000 lbs. avoird. of lead, several thousand pounds of copper, and 2,000 marcs, or 1,034 lbs. avoird. of silver. These are the most important metallic mines of France. Several veins of galena exist at *Chateläudren*, near Saint-Briex, but they are not worked at present. There is also one at Pompean, near Rennes, which has been worked to a depth of 140 yards, but is in like manner now abandoned. It affords, besides the galena, a very large quantity of blende (sulphuret of zinc), of which attempts are making to take advantage. There occurs, also, a lead mine at Pierreville, department of the Channel, in a formation connected with the system of Britanny. It is opened on a vein which traverses a limestone pretty analogous to that of Derbyshire. The same department presents a deposite of sulphuret of mercury at Ménildot. A few years ago, some tin ore was discovered at Pyriac, near Guérande, in the department of the Loire Inférieur, but the researches since made to find workable deposites have been unsuccessful. A mine of antimony was worked at La Ramée, department of La Vendée. Several of the coal deposites lately mined in the departments of La Sarthe, La Mayenne, and Mayenne-et-Loire, ought probably to be regarded as more ancient than the genuine coal measures.

Table of the production of the French mines, during the year 1832.*

Species of Mine.	Number of mines.	Extent of surface conceded.	Number of workmen.	Production is in 10ths of a ton.	Value of the rough product in francs
Metallic Substances.		*Kilom. carrēs.*			
Antimony -	16	93,8954	130	Melted antim. 1·030,98	71·232,75
Copper - -	8	274,18	258	Black copper 1·376	247.680
Iron - -	131	1·051,391	8917	Rough ore 15·814,690	3,630·806,81
Manganese -	8	16,54	66	6·087	66·849,88
Gold - -	1	0·49			
Lead and silver	33	614,23	1259	8·505	742·051
Zinc - -	1	6,80			

* (*Annales des Mines*, tom. v., 1834, p. 676.)

MINES OF THE CORRESPONDING COASTS OF GREAT BRITAIN AND IRELAND.

The mines comprehended in this section are situated, 1, in Cornwall and Devonshire; 2, in the S.E. of Ireland; 3, in the island of Anglesey and the adjoining part of Wales 4, in Cumberland, Westmoreland, and the north of Lancashire, and the Isle of Man, 5, in the south of Scotland; 6, in the middle part of the same country.

Cornwall and Devonshire present three principal mining districts; viz., the portion of Cornwall situated in the environs and S.W. of Truro, the environs of St. Austle, and the environs of Tavistock.

The first of these districts is the most important of the three in the number and richness of its mines of copper, tin, and lead. The ores of copper, which consist almost entirely of copper pyrites and common sulphuret of copper, constitute very regular veins running nearly from east to west, and incased most frequently in a clay-slate of a talcose or hornblende nature, called *killas*, and sometimes in granite, which forms protuberances in the middle of the schists. The tin occurs principally in veins, which, like the preceding, traverse the killas and the granite. They are also very often directed nearly from east to west, but they have a different inclination, or dip, from that of the copper veins, which cut them across and interrupt them, and are consequently of more recent formation. The tin ore forms also masses, which appear most usually attached to the veins by one of their points. Lastly, it is found in small veins which traverse the granite, principally near the points where this rock touches the killas. Certain veins present the copper and tin ores together; a mixture which occurs chiefly near the points of intersection of the two metallic veins. Certain mines furnish at once both copper and tin; but the most part produce in notable quantity only one of these metals. The most important copper mines are situated near Redruth and Camborn; among which may be noted particularly those called *Consolidated Mines*, *United Mines*, Huel-Alfred, Dolcoath, Poldice, &c. The principal tin mines are situated still farther to the southwest, near Helston, Saint-Yues, &c. Those called Huel Vor, Great Huas, are particularly noticed. There are several mines in Cornwall of which the crossing veins which at once intersect and throw out the veins of copper and tin, contain argentiferous galena and several ores of silver. There existed formerly mines of argentiferous lead near Helston and Truro. There may be now seen near Saint Michael an ore which, melted and cupelled on the spot, yields from an ounce and a half to two ounces of silver per quintal. Near Calstock a silver mine is worked, called *Huel-Saint-Vincent*, which has afforded, it is said, in some months, from 900 to 1,000 lbs. avoird. of that metal. The ore, consisting of hornsilver and native silver, is treated on the spot.

In the environs of Saint Austle, the copper mines of *East Crinnis* and *West Crinnis* deserve to be noticed, as well as the tin mine of Polgooth, opened on a tin vein; and the mine of Carclaise, explored in the open air on a system of small veins of this metal.

Near Tavistock there occur mines of copper, tin, and lead. Among the last may be remarked particularly that called *Huel Betsey*, of which the ores melted and cupelled on the spot, afford an ounce and a half of silver per cwt.; and that of Beeralston, whose ore is sent to Bristol to be smelted there. It yields from four to five ounces of silver per cwt.

There are mines of antimony at *Huel-Boys* in Devonshire, and at Saltash in Cornwall.

The tin and copper ores of Cornwall are accompanied with arsenical pyrites, which is turned to some account by the fabrication of white arsenic (arsenious acid).

Cornwall and Devonshire produce annually about 6,160,000 lbs. avoird. of tin; 18,700,000 lbs. avoird. of copper; and 1,760,000 lbs. avoird. of lead. See Copper and Tin.

The tin is treated at the mine localities: but the copper ores are sent in their natural state to Swansea in South Wales, to be smelted.

Wood and labor being very dear in Cornwall and Devonshire, the mineral deposites of these counties can not be worked out so completely, nor can the mechanical preparation of the ore be so far pushed, as in several other parts of the world. But all the operations which appear advantageous are conducted in the most judicious, most economical, and most expeditious manner. Steam-engines are erected there, some of them possessing the power of several hundred horses. Many of the mines are explored to a depth of upward of 400 yards; and several are celebrated for the boldness of their workings. The one called *Botallock* Mine, situated in the parish of St. Just, near the Cornwall cape, is opened amid rocks which form the seacoast, and stretches several hundred yards under the sea, and upward of 200 yards beneath its level. In some points so small a thickness of rock has been left to support the weight of the waters, that the rolling of pebbles on the bottom is distinctly heard by miners during a storm. The mine of Huel-werry, near Penzance, was worked by means of a single shaft opened on the coast, in a space left dry by the sea only for a few hours at every ebb. A small wooden tower was built over the mouth of the shaft, which, being carefully calked, kept out the waters of the ocean when the tide rose, and served to support the machines for raising the ore and drainage. A vessel driven by a storm overturned it during the night, and put a period to this hazardous mode of mining, which has not been resumed.

The most considerable mines of Ireland are those of Cronebane and Tingrony, and of Ballymartagh, situated three leagues S.W. of Wicklow, in the county of the same name. Their object is to work the copper pyrites, accompanied with some other ores of copper, galena, sulphuret of antimony, as well as pyrites of iron, which forms several flattened masses in the clay-slate. Pretty extensive workings have been made here; and the ore was transported in its natural state to Swansea. Veins or masses of copper pyrites and galena are mined in some other points of the southeast of Ireland, but none of them with any notable advantage. The principal is the lead mine situated in the county of Tipperary, near the village called Silver Mines, absurdly enough, because, though silver was sought for in the lead, none was extracted. Many iron mines anciently existed in Ireland, but the destruction of the forests has considerably diminished their number and activity, so that only a few remain in Kilkenny, Wicklow, and Queen's County.

The isle of Anglesey is celebrated for its copper mines, the principal of which are Mona-mine and Parys-mountain. The ore is a copper pyrites, sometimes of considerable volume, lying in masses in a formation containing serpentines and different talcose rocks. For a long time the workings were carried on in the open air, but the exterior exploration has been thereby compromised. The neighboring coasts of Wales present some mines of the same nature. All the ores are treated in a smelting-house established in the isle of Anglesey. The formation of slate-clay and greywacke, which constitutes the greater part of Wales, and some of the adjoining districts of England, includes several lead mines, of which we shall presently speak in noticing those of far greater importance contained in the more recent limestone formations of the same regions.

Pretty important mines of copper pyrites and red hematitic iron are worked in Westmoreland, and in the neighboring parts of Cumberland and Lancashire. The copper ores, and a portion of the iron ones, are embarked for Swansea. The rest of the iron ore is treated on the spot in blast furnaces supplied with wood charcoal. The isle of Man affords indications of lead, copper, and iron, in the mountains of Snafle, which constitute its centre. At Borrowdale in Westmoreland, a mine of graphite (plumbago) has been worked for a long period. It furnishes the black lead of the English pencils, so celebrated over the world. The mineral occurs in mass in a talcose formation.

There are famous lead mines in the south of Scotland, at Leadhills in Lanarkshire; the veins of which are incased in greywacke. Some manganese has also been found. At Cally, in Kirkcudbrightshire, a copper mine has been lately discovered; and a mine of antimony has been known for some time at West Kirk in Dumfriesshire; but neither has been turned to good account.

In the middle part of Scotland, the lead mines of Strontian in Argyleshire deserve to be noticed, opposite to the northeast angle of the isle of Mull. They are opened on veins which traverse gneiss. According to Mr. John Taylor, these mines and those of Leadhills produce annually 5,610,000 lbs. avoird. of lead.

Explorations of manganese were begun at Grantown on the banks of the Don, a river which falls into the German ocean at Aberdeen. A mine of coarse graphite has also been worked at Huntley.

A copper mine was discovered some years back in one of the Shetland isles; and chromate of iron is now extensively worked there in serpentine and talc.

MINES OF THE NORTH OF EUROPE.

These mines are situated for the most part in the south of Norway, toward the middle of Sweden, and in the south of Finland, a little way from the shortest line drawn from the lake Onega to the southwest 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 gulf of Christiania, and on the side facing Jutland, principally at Arendal, at Krageroe, and the neighborhood. The ores consist almost solely of black oxide of iron, which forms beds or veins of from 4 to 60 feet thick, incased in gneiss, which is accompanied with pyroxène (augite), epidotes, garnets, &c. These iron ores are reduced in a great many smelting forges, situated on the same coasts, 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 toward the south and the centre of the country, but the most considerable occur in the north, at *Quikkne*, *Læken*, *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 in the open air since 1664. It has poured into the market from that time, till 1791, 77 millions of pounds avoird. of copper. In 1805, its annual production was 864,600 libs.; while all the other mines of Norway together do not furnish quite one fourth of that amount.

Norway comprehends also some celebrated silver mines. They are situated from 15 to 20 leagues S.W. of Christiania, in a mountainous country near the city of Kongsberg, which owes to them its population. Their discovery goes back to the year 1623, and their objects are veins of carbonate of lime, accompanied with asbestos and other substances in which native silver occurs, usually in small threads or networks, and sometimes in considerable masses, along with sulphuret of silver. These veins are very numerous, and run through a considerable space, divided into four districts (arrondissements), each of which contains more than 15 distinct explorations. When a new mine is opened, an excavation in the open air is first made, which embraces several veins, and they then prosecute by subterranean workings only those that appear to be of consequence. The workings do not exceed 1,000 feet in depth. Fire is employed for attacking the ore. In 1782, the formation of a new gallery of efflux was commenced, destined to have a length of 10,000 yards, and to cost 60,000*l*. These mines, since their discovery till 1792, have afforded a quantity of silver equivalent to four millions of pounds sterling. The year 1768 was the most productive, having yielded 38,000 marcs of silver. At present they give but a very slender return; in 1804 they were threatened with a complete abandonment. The ore is treated by fusion; the lead necessary for this operation being imported from England. There are, however, lead and silver mines in the county of Jarlsberg, but they are very slenderly worked.

At *Edswald*, 50 leagues N. of Christiania, a mine is worked of auriferous pyrites, with a very inconsiderable product.

Cobalt mines may be noticed at Modum or Fossum, 8 leagues W. of Christiania; they are extensive, but of little depth.

Lastly, graphite is explored at *Englidal;* and chromite of iron deposites 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 deposites of iron ore are placed amid immense forests of birches and resinous trees, whose charcoal is probably the best for the reduction of iron. The different groups of iron mines and forges form small districts of wealth and animation in the midst of these desolate regions.

The province of Wermeland, including the north bank of the lake Wener, is one of the richest of Sweden in iron mines. The two most important are those of Nordmarck, 3 leagues N. of Philipstadt, and those of Persberg, 2½ leagues E. from the same city. Philipstadt is about 50 leagues W. ¼ N.W. from Stockholm. Both mines are opened on veins or beds of black oxide of iron several yards thick, directed from N. to S. in a ground composed of hornblende, talcose, and granitic rocks. These masses are nearly vertical, and are explored in the open air to a depth of 130 yards. Formerly this exploitation was effected by iron wedges and pickaxes; but they have been superseded by gunpowder, since 1650. The province of Wermeland, and that of Dahl which adjoins it, forming the west border of the Wener lake, contained in 1767, 48 smelting cones, each going from 4 to 5 months every year.

The principal iron mines of Rosslagie (part of the province of Upland) are those of Dannemora, situated 11 leagues from Upsal. They stand in the first rank of those of Sweden, and even of Europe. The masses worked upon are flattened and vertical, running from N.E. to S.W., and are incased in a ground formed of primitive rocks, among which gneiss, petrosilex and granite are most conspicuous. They amount to three in number, very distinct, and parallel to each other; and are explored through a length of more than 1,500 yards, and to a depth of above 80, by the employment of fire, and blasting with gunpowder. The explorations are mere quarries; each presenting an open trench 65 yards wide, by a much more considerable length, and an appalling depth. Magnetic iron ore is extracted thence, which furnishes the best iron of Sweden and Europe; an iron admirably qualified for conversion into steel. In 1767, these minings supplied for a long time, 15 smelting cones situated in Rosslagie, at a distance of 10 leagues.

The island of Utoe, situated near the coast of the province of Upland, presents also rich iron mines. The protoxide of iron there forms a thick bed in the gneiss. It is worked in trenches far below the level of the sea. The ore can not 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 reposing on gneiss.

In several parts of Lapland, the protoxide of iron occurs in great beds, or immense masses. At Gellivara, 200 leagues N. of Stockholm, toward the 67th degree of latitute, it constitutes a considerable mountain, into which an exploitation has been opened. The iron is despatched on small sledges drawn by reindeer to streams which fall into the Lutea; and thence by water carriage to the port of Lutea, where it is embarked for Stockholm.

There are a great many iron works in Dalecarlia, but a portion of the ores are got from alluvial deposites. Similar deposites exist also in the provinces of Wermeland and Smoland.

The mines and forges of Sweden produce annually about 165 millions of pounds avoird. (74,000 tons nearly) of cast iron or bar iron; of which two thirds are exported chiefly from the harbors of Stockholm, Gottenburg, Geffle, and Norkoping.

The copper mines of Sweden are scarcely less celebrated than its iron mines. The principal is that of Fahlun or Kopparberg, situated in Dalecarlia, near the town of Fahlun, 40 leagues N.W. of Stockholm. It is excavated in an irregular and very powerful mass of pyrites, which in a great many points is almost entirely ferruginous, but in others, particularly near the circumference, it includes a greater or less portion of copper. This mass is enveloped in talcose or hornblende rocks. More to the west there are three other masses almost contiguous to each other, which seem to bend in an arc of a circle around the principal mass. They are explored as well as the last. This was at first worked in the open air; but imprudent operations having caused the walls to crumble and fall in, since 1647 the excavation presents near the surface nothing but frightful precipices. The workings are now prosecuted by shafts and galleries into the lower part of the deposite, 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 produeed 11 millions of pounds avoird. of copper per annum, or about 5,000 tons. It furnishes now about the seventh part of that quantity; yielding at the same time about 70,000 lbs. of lead, with 50 marcs of silver, and 3 or 4 of gold. The ores smelted at Fahlun produce from 2 to 2½ of copper per cent. But the extraction of the metal is not the sole process; the sulphur is also procured; and with it, or the pyrites itself, sulphuric acid and other chemical products are made. Round Fahlun, within the space of a league, 70 furnaces or factories of different kinds may be seen. The black copper obtained at Fahlun is converted into rose copper, in the refining hearths of the small town of *Ofwostad*.

In the copper mine of *Garpenberg*, situated 18 leagues from Fahlun, there occur 14 masses of ore quite vertical, and parallel to each other, and to the beds of mica-slate or talc-slate, amid which they stand. This mine has been worked for more than six hundred years.

The mine of *Nyakopparberg*, in Nericia, 20 leagues W. of Stockholm, presents masses of ores parallel to each other, the form and arrangement of which are very singular. It is worked by open quarrying, and with the aid of fire.

We may notice also the copper mines of Atwidaberg, in Ostrogothia, which furnish annually the sixth part of the whole copper of Sweden.

There are several other copper mines in Sweden. Their whole number is ten; but it was formerly more considerable. They yield at the present day in all, about 2,420,000 libs. avoird. (1000 tons) of copper.

The number of the silver mines of Sweden has in like manner diminished. In 1767 only 3 were reckoned under exploration, viz., that of *Hellefors*, in the province of Wermeland; that of *Segersfors*, in Nericia; and that of *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 4,000 to 5,000 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 deposites 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 mines and smelting works of Sweden gave annually, in 1809, a gross product worth 1,463,600*l*.

The south of Finland and the bordering parts of Russia contain some mines, but they are far from having any such importance as those of Sweden.

At Orijerwy, near Helsingfors, a mine of copper occurs whose gangue is carbonate of lime, employed as a limestone.

Near Cerdopol, a town situated at the N.W. extremity of the Ladoga lake, veins of copper pyrites were formerly mined.

Under the reign of Peter the Great, an auriferous vein was discovered in the granitic mountains which border the eastern bank of the lake Ladoga, near Olonetz. It was rich only near the surface; and its working was soon abandoned.

Latterly an attempt has been made to mine copper and iron ores near Eno, above and to the N.W. of Cerdopol, but with little success.

Some time ago rich ores of iron, lying in veins, were worked near the lake Shuyna, N.W. from Cerdopol; but this mine has been also relinquished.

On the west bank of the Onega lake, there is an iron work at Petrazavodsk, called a *zavode*, which is the greatest establishment of this kind existing in the north of Russia.

Nothing is now reduced there except bog iron ore, or swamp ore extracted from small lakes in the neighborhood.

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 ALLEGANY MOUNTAINS.

The chain of the Alleganys, which traverses the United States of North America from N.W. to S.E. parallel to the coasts of the Atlantic ocean, includes a considerable number of deposites of iron, lead, and copper ores; along with some ores of silver, plumbago, and chromite of iron. Attempts have been made to mine a great many of these deposites; but most of these have been unsuccessful.

A bed of black oxide of iron occurs in gneiss near Franconia in New Hampshire. It has a power of from 5 to 8 feet; and has been mined through a length of 200 feet, and to a depth of 90 feet. The same ore is found in veins in Massachusetts and Vermont, accompanied by copper and iron pyrites. It is met with in immense quantities on the western bank of the lake Champlain, forming beds of from 1 to 20 feet in thickness, almost without mixture, encased in granite. It is also found in the mountains of that territory. These deposites appear to extend without interruption from Canada to the neighborhood of New York, where an exploration on them may be seen at Crown Point. The ore there extracted is in much esteem. Several mines of the same species exist in New Jersey. The primitive mountains which rise in the north of this state near the Delaware, include a bed almost vertical of black oxide of iron, which has been worked to 100 feet in depth. In the county of Sussex the same ore occurs, accompanied with Franklinite. At New Milford, in Connecticut, a pretty abundant mine of sparry iron occurs; the only one of the kind known in the Alleganys. The United States contain a great many iron works, some of which prior to the year 1773, sent over iron to London. They are principally supplied from alluvial iron ore.

The most remarkable lead mines of the Alleganys are those of Southampton, in Massachusetts, and of Perkiomen creek, in Pennsylvania, 8 leagues from Philadelphia. The first furnishes a galena, slightly argentiferous; an ore accompanied with various minerals, with base of lead, copper, and zinc, and with *gangues* (vein-stones) of quartz, sulphate of baryta, and fluor spar. These substances form a vein which traverses several primitive rocks, and is said to be known over a length of more than 6 leagues. At Perkiomen creek a vein of galena is mined which traverses a sandstone, referred by many geologists to the old red sandstone. Along with galena a great variety of minerals is found with a basis of lead, zinc, copper, and iron. The mines of lead worked in Virginia, on the banks of the Kanahwa, deserve also to be mentioned.

None of the copper mines actually in operation in the United States seem to merit particular attention. The mine of Schuyler, in New Jersey, had excited high hopes, but after the workings had been pushed to a depth of 300 feet, they have been for some years abandoned. The ore, which consisted of sulphuret of copper, with oxide and carbonate of copper, occurred in a red sandstone.

In some points of the Alleganys, deposites have been noticed of chromite of iron and graphite.

Coal-measures occur in several points of the United States, especially on the N.W.

slope of the Allegany mountains. The coal is mined successfully on the banks of the Ohio, toward the upper part of its course. See ANTHRACITE.

MINES OF THE SOUTH OF SPAIN.

The mountains which separate Andalusia from Estremadura, Leon and La Mancha, and those of the kingdoms of Murcia and Grenada, include some celebrated mines.

We shall mention first the silver mines of *Guadalcanal* and *Cazalla*, situated in the Sierra-Morena, 15 leagues north of Seville. Among the ores, red silver and argentiferous gray copper have been specified. Their product is inconsiderable; but this territory presented formerly much more important mines at Villa-Guttiera, not far from Seville. At the beginning of the seventeenth 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 north of Jaen. The veins are very rich near the surface, which causes them not to be mined much in depth; so that the ground is riddled, as it were, with shafts. More than 5,000 old and new pits may be counted, the greater part of which is ascribed to the Moors. Six of these mines are now explored on account of the crown, and they produce on an annual average, according to M. Laborde, 1,320,000 libs. avoird. (about 600 tons) of lead, which is too poor in silver for this precious metal to be extracted with advantage. Bowles states that there was found at the mines of Linares, a mass of galena, whose dimensions were from 21 to 24 yards in every direction. Abundant mines of zinc occur near Alcaras, 15 leagues northwest of Linares, which supply materials to a brass manufactory established in that town. There are also lead mines in the kingdoms of Murcia and Grenada. Very productive ores have been worked for some time near Almeira, a harbor situated some leagues to the west of the cape of Gates. The ore is in part treated on the spot with coal brought from Newcastle, and in part sent to Newcastle to be reduced there. The kingdoms of Murcia, Grenada, and Cordova, include several iron mines. Near Cazalla and Ronda, in the kingdom of Grenada, mines of plumbago are explored.

On the northern flank of the Sierra-Morena, lie the famous quicksilver mines of Almaden, situated near the town of the same name in La Mancha. They consist of very powerful veins of sulphuret of mercury, which traverse a sandstone, evidently of a geological age as old at least as the coal formation. Hard by, beds of coal are mined.

MINES OF THE PYRENEES.

The Pyrenees, and the mountains of Biscay, of the Asturias, and the north of Galicia, which are their prolongation, are not very rich in deposites of ores : the only important mines that occur there, are of iron; which are widely spread throughout the whole chain, except in its western extremity. We may mention particularly in Biscay, the mine of *Sommorostro*, opened on a bed of red oxide of iron; and in the province of Guipuscoa, the mines of Mundragon, Oyarzun, and Berha, situated on deposites 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 deposite of hydrate of iron, worked for an immemorial time at Rancié, in the valley of Viedessos, department of the Arriège, occurs in a similar position. The ancient workings have been very irregular and very extensive; but the deposite is still far from being exhausted. There are also considerable mines of sparry iron at *Lapinouse*, at the tower of Batera, at Escaron, and at Fillols, at the foot of the *Canigou*, in the department of the Oriental Pyrenees. The iron mines of the Pyrenees keep in activity 200 Catalanian forges. Although there exists in these mountains, especially in the part formed of transition rocks, a very great number of veins of lead, copper, cobalt, antimony, &c., one can hardly mention any workings of these metals; and among the abandoned mines, the only ones which merit notice are—the mine of argentiferous copper of *Baygorry*, in the department of the Low Pyrenees, the lead and copper mine of *Aulus*, in the valley of the Erce, department of the Arriège, and the mine of cobalt, of the valley of Gistain, situated in Aragon, on the southern slope of the Pyrenees. It is asserted, however, that a lead mine is in actual operation near Bilboa, in Biscay. The mines of plumbago opened at Sahun, in Aragon, should not be forgotten. Analogous deposites are known to exist in the department of the Arriège, but they are not mined.

MINES OF THE ALPS.

The mines of the Alps by no means correspond in number and richness with the extent and mass of these mountains. On their eastern slope, in the department of the high and the low Alps, several lead and copper mines are mentioned, all inconsiderable and abandoned at the present time, with the exception of some workings of galena, which furnish also a little graphite.

During some of the last years of the eighteenth century, there was mined at *la Gardette* in the *Oisans*, department of the Isère, a vein of quartz which contained native gold and auriferous pyrites; but the product has never paid the expenses, and the mine has been abandoned. The *Oisans* presented a more important mine, but it also has been given up; it was the silver mine of *Allemont* or *Chalanches* The ore consisted of different mineral species more or less rich in silver, disseminated in a clay which filled the clefts and irregular cavities in the middle of talcose and hornblende rocks. This mine yielded annually toward the conclusion of the eighteenth century, so much as 2,000 marcs of silver, along with some cobalt ore. Among the great number of mineral species, which occurred in too small quantities to be worked to advantage, there was native antimony, sulphuret of mercury, &c. The *Oisans* present, moreover, some rather unproductive mines of anthracite. Mines of an analogous nature, but more valuable, are in activity at the western foot of the Alps, at *la Mothe, Notre-des-Vaux et Putteville,* a few leagues southeast of Grenoble.

From the entrance of the valley of the *Oisans* to the valley of the *Arc* in Savoy, there occur on the N.W. slope of the Alps, a great many mines of sparry iron. The locality of this ore is here very difficult to define. It appears to form sometimes beds or masses, and sometimes veins amid the talcose rocks. Some is also found in small veins in the first course of the calcareous formation which covers these rocks. These mines are very numerous; the most productive occur united in the neighborhood 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 mentioned. The irregularity of the mining operations surpasses that of the deposites; 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 prearrangement, or other rule than following the masses of ore which excite hopes of the most considerable profit in a short space of time. What occurs in almost every mine of sparry iron, is also to be seen here—most imprudent workings. The mine called the *Grand 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 deposite, which amounts in this place to from 8 to 13 yards; thus a void space is exhibited of nearly 300,000 square yards. The sparry iron extracted from these different mines supplies materials to 10 or 12 smelting-furnaces, the cast-iron of which, chiefly adapted for conversion into steel, is manufactured in part in the celebrated steel works of *Rives,* department of the Isère. There occurs in some parts of the mines of *Saint Georges d'Huretières* copper pyrites, which is smelted at *Aiguebelle.*

Savoy presents celebrated lead mines at *Pescy* and at *Macot,* 7 leagues to the east of Moutiers. Galena, accompanied with quartz, sulphate of baryta, and ferriferous carbonate of lime, occurs in mass in talcose rocks. The mine of Pescy had been restored to activity by the French government, which established there a practical school of mines; and in its hands the mine produced annually as much as 440,000 libs. avoird. of lead, and 2,500 marcs of silver. It is now explored on account of the king of Sardinia; but it begins to be exhausted, and yields less products. That of *Macot,* opened a few years ago, begins to give considerable returns. The mine of copper pyrites of Servoz, in the valley of the Arve, may also be mentioned. The ore occurs both in small veins, and disseminated in a clay slate; but the exploration is now suspended. Lastly, slightly-productive workings of anthracite are mentioned in several points of these mountains, and in the conterminous portions of the Alps.

There exist in Piedmont some small mines of argentiferous lead. The copper mines of *Allagne,* and those of Ollomont, formerly yielded considerable quantities of this metal. Their exploration is now on the decline. The manganese mines of Saint-Marcel have few outlets; whence they have been feebly developed. Mines of plumbago, little worked, occur in the neighborhood 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 one fourth of its weight of silver; they became less rich in proportion as they receded from the surface. The explorations of auriferous pyrites in Piedmont are now abandoned, or nearly so. The only important mines in this country are those of iron. These generally consist of masses of black oxide of iron, of a nature analogous to those of Sweden; the principal ones being those of Cogne and Traverselle, which are worked in open quarries. Some others, less considerable, are explored by shafts and galleries. These ores are reduced in 33 smelting-cupolas, 55 Catalan forges, and 105 refinery-hearths. The whole produce about 10,000 tons of bar-iron.

There is a mine of black oxide of iron, at present abandoned, at *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 has been 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*.

The mountain of Falkenstein, in the Tyrol, formed of limestone and clay-slate, not far from Schwatz, a little below Inspruck, in the valley of the Inn, contains mines of argentiferous copper. At one of them, that of Kütz-Pühl, the workings reached, in 1759, according to the report of MM. Jars and Duhamel, nearly 1,100 yards in depth; and were reckoned the deepest in Europe. But it was intended to abandon them. Analogous ores are explored in several other points of the same country. The most part of the products of these mines are carried to the foundry of Brixlegg, 4 leagues from Schwatz. The mines of the Tyrol furnished, on an average of years, toward 1759, 10,000 marcs of silver; at anterior periods, their products had been double; but now it is a little less. This region contains also gold mines whose exploration goes back a century and a half. They occur near the village of Zell, 8 leagues from Schwatz; the auriferous veins traverse clay-slates and quartz rocks. Lastly, a deposite of oxide of chrome, similar to that of the *Ecouchets* (Saône and Loire) has been discovered in the Tyrol. An unimportant mine of mercury has also been mentioned in that country, near *Brenner.*

In the territory of Saltzburg there are some copper mines. In the environs of Muerwinkel and of Gastein some veins are worked for the gold they contain; of which the annual return is valued at 118 marcs of this metal. There is an inconsiderable mine of quicksilver at Leogang.

In the Tyrol and in Saltzburg there are iron mines in a very active state, principally those of Kleinboden, near Schwatz. But the portion of the Alps most abundant in mines of this metal, is the branch stretching toward Lower Austria. We find here, both in Styria and in Austria, a very great number of explorations of sparry iron. The deposites of the ores of sparry iron of Eisenerz, Erzberg, Admont, and Vordenberg, deserve notice. The latter are situated about 25 leagues southwest of Vienna.

The southern flank of the Alps contains also a great many mines of the same kind, from the Lago Maggiore to Carinthia. Those situated near Bergamo, and those of Huttenberg and Waldenstein, in Carinthia, are especially mentioned.

All these mines of sparry iron are opened in the midst of rocks of different natures, which belong to the old transition district of the Alps. They seem to have close geological relations with those of Allevard.

The branch of the Alps which extends toward Croatia, presents important iron mines, in the mountains of Adelsberg, 10 leagues southwest from Laybach, in Carniola.

The iron mines just now indicated in the part of the Alps that forms a portion of the Austrian states, supply materials to a great many smelting-works. In Styria and in Carinthia, more than 400 furnaces or forges may be enumerated, whose annual product is nearly 25,000 tons of iron. These two provinces are famous for the steel which they produce, and for the steel tools which they fabricate, such as sythes, &c. Carniola contains also a great many forges, and affords annually about 5,000 tons of iron.

There are mines of argentiferous copper, analogous to those of the Tyrol, at Schladming in Styria, at Kirchdorf in Carinthia, at Agordo in the territory of Venice, and at Zamabor in Croatia. The latter are remarkable for the great irregularity of the deposites, and for the richness of the copper pyrites that is mined; which produces 12 and sometimes 27 per cent. of copper. There are some deposites of antimony, mined to a trifling extent in Carinthia; and there are a few cobalt mines in Styria, not more actively worked. In the environs of *Raibel*, in Carinthia, mines of calamine exist, yielding annually about 200 tons of this substance. Of late, some of it has also been explored in Styria.

The limestones that cover the northern slopes of the Alps, present, like those of the departments of the lower and upper Alps, several lead mines of little consequence; they also include several celebrated mines of rock salt.

The analogous limestones which repose on the slopes of the Alps in Carinthia, and in the neighboring provinces, afford likewise lead mines, especially near Willach and Bleyberg. These mines are very numerous, forming more than 500 *arrondissements* of concessions. They furnish annually about 1,800 tons of a lead too poor in silver to pay the expense of extracting that precious metal. At the mines of Bleyberg, the galena forms 14 beds or strata, inclined at an angle of from 40 to 50 degrees from the horizon, and alternating with a like number of calcareous strata. The latter are extremely full of shells. They of course belong to secondary limestone.

The limestones surmounting the southern slope of the Alps, contain also some lead mines; but the quicksilver mines of Idria, situated at the foot of the Alps, 10 leagues N.W. of Trieste, is worthy of particular notice; it lies in a limestone which everything leads us to refer to the *zechstein*, the most ancient of the secondary limestones.

The Apennines, which may be considered as a dependance of the Alps, present a small number of mines. At Chiavary and Pignone, manganese is mined; and at the beginning of the eighteenth century a vein of mercury was worked at Levigliani in Tuscany. An antimonial mine is mentioned at Pereta in the marshes of Sienna.

Before quitting these regions, we ought to notice the iron mines of the isle of Elba. They have been famous for 18 centuries; Virgil denotes them as inexhaustible, and supposes them to have been open at the arrival of Æneas in Italy. They are explored by open quarries, working on an enormous mass of specular iron ore, perforated with cavities bespangled with quartz crystals. The island possesses two explorations, called Rio and Terra-Nuova; the last having been brought into play at a recent period. The average amount extracted per annum is 15,000 tons of ore, which are smelted in the foundries of Tuscany, Liguria, the Roman states, the kingdom of Naples, and the island of Corsica.

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

MINES SITUATED IN THE SCHISTOSE FORMATIONS OF THE BANKS OF THE RHINE, AND IN THE ARDENNES.

The transition lands, which form, in the northwest of Germany and in Flanders, a pretty extensive range of hills, include several famous mines of iron, zinc, lead, and copper. The latter lie on the right bank of the Rhine, in the territories of Nassau and Berg, at Baden, Augstbach, Rheinbreitenbach, and near Dillenburg. That of Rheinbreitenbach yielded formerly 110,000 libs. avoirdupois of copper per annum, and those of the environs of Dillenburg now furnish annually 176,000 libs. There are also some mines of argentiferous lead in the same regions. The most remarkable are in the territory of Nassau, such as those of Holzapfel, Pfingstiviese, Lœwenburg, and Augstbach on the Wiede, and Ehrenthal on the banks of the Rhine, which all together produce 600 tons of lead, and 3,500 marcs of silver. To the above, we must add those of the environs of Siegen and Dillenburg, in the territories of Berg. A little cobalt is explored in the neighborhood of Siegen, and some mines of the same nature are mentioned in the grand dutchy of Hesse-Darmstadt, and in the dutchy of Nassau Usingen.

But iron is the most important product of the mines on the right bank of the Rhine. Veins of hydrate of iron, or brown hematite, are explored in a great many points of Hessia, and the territory of Nassau, Berg, Marck, Tecklenbourg, and Siegen, along with veins or masses of sparry iron, and beds of red oxide of iron. We may note particularly—1. The enormous mass of sparry iron, known under the name of Stahlberg, mined since the beginning of the fourteenth century in the mountain of Martinshardt, near Müssen, where improvident excavations have occasioned, at several times, considerable downfallings of rubbish; 2. The abundant and beautiful mines of hydrate of iron and sparry iron on the banks of the Lahn and the Sayn, and among those of the mine of Bendorf; 3. The mine of Hohenkirchen in Hessia, where a powerful bank of manganiferous ore is worked, and where the mines are kept dry by a gallery more than 1,000 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, sythes, &c., fabricated there.

The Prussian provinces of the left bank of the Rhine, the dutchy of Luxembourg, and the Low Countries, include also many iron furnaces, of which a great number are supplied, in whole or in part, by ores of hydrate of iron, occasionally zinciferous, extracted from the transition rocks, where they form sometimes veins, and sometimes also very irregular deposites. A portion is explored by open quarrying, and a portion by underground workings. Some of these mines penetrate to a depth of 87 yards, and galleries may be observed in them cut in the form of vaults, and timbered with hooped stays. The Hundsrück, the Eiffel, and the territory of Luxembourg, present a great many of them.

The Eiffel formerly possessed important lead mines. Some still exist, which are feebly worked at Berncastle, 8 leagues below Trèves, on the banks of the Moselle. Those of Trarbach, situated 2 leagues lower, are now completely abandoned; the same holds with those of Bleyalf, which were opened on veins incased in the greywacke-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.

More to the north a great many deposites of calamine occur. The most considerable, and the one explored with most activity, is situated in the territory of Limburg (kingdom of the Netherlands), and known under the name of the *Great mountain*. It presents a mass about 45 yards wide, from 400 to 550 long, and of an unknown depth. The first labors, undertaken several centuries ago by the Spaniards, were executed by open quarrying, and pushed down 32 yards from the surface. The miners were obliged to renounce this mode of operation, and have since penetrated to the depth of 88 yards by means of subterranean workings. From 50 to 60 men work in this excavation, and exact annually from 700 to 800 tons of calamine, worth from 2,400*l.* to 2,700*l.* In the adjacent parts of the Prussian territory, not far from Aix-la-Chapelle, calamine is also mined, with ores of lead and iron, with which it is associated, in deposites regarded by M. Bouesnel, as analogous to the vein of Vedrin, to be noticed presently. The exploration is effected by means of small round shafts, from 34 to 44 yards deep, which are often wooded only with flexible branches of trees, or a kind of barrel-hoops. These workings may furnish annually from 1,500 to 2,000 tons of calamine, to the brass factories of Stollberg. On the right bank of the Rhine, in the country of la Marck, several small zinc mines furnish annually about 130 tons of calamine to the brass manufactures of Iserlohn.

The lead mine of Fedrin, alluded to above, lies at some distance N. of Namur. It is opened on a vein of galena nearly vertical, which crosses from N. to S. a limestone in nearly vertical strata, probably analogous into the limestone of Derbyshire. The vein is from 4 to 15 feet thick, and is recognised through a length of half a league. The mine, worked for two centuries, presents very extensive excavations; particularly a fine gallery of efflux. It has produced annually 900 tons of lead. At the present day the mine of Vedrin, and some adjoining exploitations, afford per annum only about 200 tons of lead, and 700 marcs of silver.

MINES OF THE CALCAREOUS MOUNTAINS OF ENGLAND.

The limestone formation immediately subjacent to the coal measures, or the mountain limestone, constitutes almost alone several mountainous regions of England and Wales; in which three districts very rich in lead mines deserve to be noted.

The first of these districts comprehends the superior parts of the valleys of the Tyne, the Wear, and the Tees, in the counties of Cumberland, Durham, and York. Its principal mines are situated near the small town of Alston-Moor, in Cumberland. The veins of galena which form the object of the workings, traverse alternate beds of limestone and sandstone; and are very remarkable for their becoming suddenly thin and impoverished on passing from the limestone into the sandstone; and for resuming their richness, and usual size, on returning from the sandstone into the limestone. The exploitations are situated in the flanks of considerably high hills, bare of wood, and almost wholly covered with marshy heaths. The waters are drawn off by galleries of efflux; and the ores are dragged out by horses to the day. The galena extracted from these mines is smelted by means of coal and a little peat, in furnaces of the Scotch construction. The lead is very poor in silver; and there is hardly a single hearth for the purpose of eliminating this metal by cupellation. The mines of this district produce annually 17,200 tons of lead, according to Mr. Taylor's statement, published in the Geology of England and Wales, by Messrs. Conybeare and Phillips. There is more over a copper-mine 2 leagues S.W. of Alston-Moor. The ore is a copper pyrites, accompanied with galena in a very extensive vein, which does not appear to belong to the same formation as the other veins of this region.

The second metalliferous district lies in the northern part of Derbyshire, and in the conterminous parts of the neighboring counties. The districts called the Peak and King's-Field are the richest in workable deposites. The mines of Derbyshire are getting exhausted; they are very numerous, but in general inconsiderable. The galena extracted from them is treated with coal in reverberatory furnaces; but the silver is not sought for. They yield annually 900 tons of lead; with a certain quantity of calamine, and a little copper ore. A vein of copper pyrites occurs at Ecton, in Staffordshire, on the borders of Derbyshire. The veins of Derbyshire are famous for the beautiful minerals which they have produced; and particularly for the interruption which they almost constantly suffer at the contact of the trap-rock, called toadstone, which is intruded among the limestone.

The third metalliferous district is situated in Flintshire and Denbighshire, counties forming the N.E. part of Wales. Next to Alston-Moor this is the most productive; furnishing annually 6,900 tons of lead, and a certain quantity of calamine. The galena is smelted in reverberatory furnaces, and affords a lead far from rich in silver, which is therefore seldom subjected to cupellation. The mines occur partly in the metalliferous limestone, and partly in several more ancient rocks.

To the S.E. of this district there exist still some lead mines in Shropshire. They lie, like the preceding, partly in the metalliferous limestone, and partly in the subjacent rocks. They yield annually from 700 to 800 tons of lead.

Some mines of galena and calamine are mentioned in the Mendip hills, to the south of Bristol; but they seem to be for the present abandoned.

Besides the metallic mines just enumerated, the formation of the metalliferous limestone presents, in England, especially in the counties of Northumberland and Cumberland, several coal mines, opened on coal strata included by the sandstone, which alternates with the limestone.

MINES OF DAOURIA.

The name Daouria is given to a great region wholly mountainous, which extends from the Baikal Lake to the eastern ocean. There is, perhaps, no other country in the world so rich in deposites of lead ores, as the part of this district which extends from the junction of the rivers Chilca and Argoun, whose united waters form the river Amour, belonging to Russia. The mines opened here constitute the third arrondissement of the Siberian mines, called that of Nertchinsk, from the name of its capital, which lies more than 1,800 leagues east of Saint Petersburg.

The ground of the metalliferous portion of Daouria is formed of granite, hornschiefer, and schists, on which reposes a gray limestone, sometimes siliceous and argillaceous, which contains a small number of fossils, and in which the veins of lead occur. The plains of these regions, often salt deserts, exhibit remarkable sandstones and pudding-stones; as also vesicular rocks of a volcanic aspect. It appears that the metalliferous limestone is much dislocated, and the lead veins are subject to several irregularities, which render their exploitation difficult and uncertain. The mines lie chiefly near the banks of the Chilca and the Argoun, in several cantons, at a considerable distance from one another; wherefore it was requisite to build a great number of smelting furnaces. The want of wood has placed difficulties in the working of some of them. The ore is galena, sometimes occurring in masses of several yards in diameter; having commonly for vein-stones ores of iron and zinc, of which no use is made. The galena itself, furnished by these mines in enormous quantities, receives a very different treatment from what it would do in a civilized country; for, though the lead which it produces contains only from 6 to 10 gros (1 to 1½ ounce) of silver per quintal, it is for it alone that these mines are worked. The litharge produced by the cupellation is thrown away as useless; so that heaps of it exist near the smelting-furnaces, says M. Patrin, higher than the houses. Only an insignificant quantity of it is reduced to lead for the uses of the country, or for those of the foundries in the arrondissement of Kolywan. The silver extracted from the mines of Daouria, contains a very small proportion of gold. M. Patrin says that their annual product was, toward the year 1784, from 30,000 to 35,000 marcs of silver. The exploitation of some of the mines of Daouria goes back to the end of the 17th century. It has been commenced in some points by the Chinese, who were not entirely expelled from this territory till the beginning of the following century. A great part of the mines, however, has been opened up since 1760.

Besides the lead mines, there are some unimportant mines of copper in Daouria, and in different explorations of this region, arsenical pyrites, from which arsenious acid is sublimed in factories established at Jutlack and at Tchalbutchinsky.

About 45 leagues to the south of Nertchinsk, the mountain of Odon-Tchelon occurs, celebrated for the different gems or precious stones extracted from it. It is formed of a friable granite, including harder nobules or balls which enclose topazes; it is very analogous to the topaz rock of Saxony. In this granite there are several veins filled with a ferruginous clay, which contains a great quantity of wolfram, and many emeralds, aqua-marines, topazes, crystals of smoked quartz, &c. Multitudes of these minerals have been extracted by means of some very irregular workings. The mountain of Toutt-Kaltoui, situated near the preceding, offers analogous deposites. The presence of wolfram had excited hopes that tin might be found in these mountains; hopes which have not hitherto been realized. There are some unworked deposites of sulphuret of antimony in this country.

ON SOME OTHER LESS KNOWN MINE COUNTRIES.

There seem to exist in Brazil, besides the washings of the sands that produce the diamonds, the precious stones, the platinum, and almost all the gold of this country, some mines of gold, lead, and iron, opened up in very ancient geological formations; but there is no silver mine, which indicates a great difference between the metalliferous deposites of this district and those of Spanish America. The lead mines occur particularly in the captainry of Minas-Geraes, canton of Abaité. Their exploitation has been undertaken within a few years. The captainry of Minas-Geraes contains extremely abundant deposites of black oxide of iron, and specular iron, which constitute beds or enormous masses, forming sometimes entire mountains; along with numerous veins of hematite and red oxide of iron. Lately these have been opened up, and smelting-houses have been established at Gaspar-Saarez. There are also iron mines and foundries in the captainry of Saint-Paul. A mine of antimony occurs near Sabara, in the captainry of Minas-Geraes.

In Africa, the inhabitants of the countries adjoining to the cape of Good Hope mine and smelt copper and iron; and the Congo produces considerable quantities of these two metals. It is asserted that a great deal of copper exists in Abyssinia. On the banks of the Senegal the Moors and the Pouls fabricate iron in travelling forges. They employ as the ore the richest portions of a ferruginous sandstone, which seems to be a very modern formation. Lastly, the kingdoms of Morocco and Barbary appear to include several copper and iron mines.

The islands of Cyprus and Negropont, in the Mediterranean, were celebrated, in former times, for their copper mines; and several islands of the Archipelago presented gold mines, now abandoned. The same thing may be said of Macedonia and Thrace. The mountains of Servia and Albania contain iron mines; and lead mines occur in Servia. Natolia possesses iron and copper mines in the neighborhood of Tokat. Some also occur in Arabia and in Persia; and in the territories round Caucasus, the kingdom of Imeretta is distinguished for its iron mines. The celebrity of the Damascus sabres attests the good quality of the products of some of the mines. Persia includes, besides, mines of argentiferous lead at *Kervan*, a few leagues from Ispahan; and Natolia furnishes orpiment.

Some iron and copper mines have been mentioned in Tartary. Thibet passes for being rich in gold and silver mines. China produces a great quantity of iron and mercury, as well as white brass (*tombac*), which is much admired. The copper mines of this empire lie principally in the province of Yu Nan and the island of Formosa. Japan, likewise, possesses copper mines in the provinces of Kijunack and Sarunga. They seem to be abundant; at a period not far back, they exported their products to Europe. Japan presents, moreover, mines of quicksilver. China and Japan contain also mines of gold, silver, tin, red sulphuret of arsenic, &c. Large deposites 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; but the iron and steel recently manufactured upon a great scale, near Madras, by Messrs. Heath and Co., from the crystallized magnetic ore of that country, will probably ere long rival, and eventually supersede in Europe the product of the Dannemara forges. The islands of Macassar, Borneo, and Timor, include copper mines. As to the tin obtained from the island of Banca, from the peninsula of Malacca, and several other points of southern Asia, it proceeds entirely from the washing of sands. The same is undoubtedly true of the gold furnished by the Philippine isles, Borneo, &c. It appears, however, that mines of gold and silver are worked in the island of Sumatra.

MINES OF THE SECONDARY ROCK FORMATIONS.

The most important mines of the secondary rocks, and perhaps of all minerals whatsoever, are those worked in the most ancient of these strata, in the coal-measures.

The British islands, France, and Germany, present several groups of small mountains primitive on the ridge, and transition on the flanks; in the sinuosities between which deposites of coal occur. The principal of these have become great centres of manufactures; for Glasgow, Newcastle, Sheffield, Birmingham, Saint-Etienne, &c., owe their prosperity and their rapid enlargement to the coal, raised, as it were, at their gates in enormous quantities. Wales, Flanders, Silesia, and the adjacent parts of Gallicia, owe equally to their extensive collieries a great portion of their activity, their wealth, and their population. Other coal districts, less rich, or mined on a less extended scale, have procured for their inhabitants less distinguished, but by no means inconsiderable, advantages; such, for examples in Great Britain, are Derbyshire, Cheshire, Lancashire, Shropshire, Warwickshire, the environs of Bristol &c.; some parts of Ireland; in France, Litry department of Calvados, Comanteric, Saint-Georges-Chatelaison, Aubin, Alais, le Creusot; Ronchamps, in the Prussian provinces of the left bank of the Rhine; the environs of Saarebrück; several points of the north of the territory of Berg and Lamarck, of Mansfeld, of Saxony, Hungary, Spain, Portugal, the United States, &c.

We need not enter here into ampler details on coal mines, reserving these particulars for the article PITCOAL.

Nature has deposited alongside of coal an ore whose intrinsic value alone is very small, but whose abundance in the neighborhood of fuel becomes extremely precious to man; we allude to the clay-ironstone of the coal-measures. It is extracted in enormous quantities from the coal-basins of Scotland, Yorkshire, Staffordshire, Shropshire, and South Wales.

Much of it is also raised from the coal strata of Silesia; and the French entertain hopes of finding a supply of this necessary ore in their own country. The iron-works of England, which are supplied almost entirely from this iron-stone reduced with the coke or coal, pour annually into commerce more than one million tons of cast and bar iron, the value of which has been estimated at eight millions sterling; an amount fully equal to the product of all the mines of Spanish America.

The shale or slate-clay of the coal-measures contains sometimes a very large quantity of pyrites, which, decomposing by the action of air, with or without artificial heat, produces sulphate of iron and sulphate of alumina; whence copperas and alum are manufactured in great abundance.

The lead mines of Bleyberg and Gemünd, near Aix-la-Chapelle, are explored in a sandstone referred by many geologists to the red sandstone. The ore consists principally of nodules, of galena disseminated in this rock. They are very abundant, and of very easy exploration. These mines produce annually from 700 to 800 tons of lead, which does not contain silver in sufficient proportion to be worth the extracting. 2,000 tons of ore are prepared and sold in the form of black lead dust (*alquifoux*).

The manganese mines worked in the open air near Exeter, in England, occur in a sandstone analogous to the red.

The calcareous formation which surmounts the coal-sandstone, called by geologists *zechstein*, magnesian limestone, and older alpine limestone, contains different deposites of metallic ores; the most celebrated being the cupreous schist of Mansfeldt, a stratum of calcareous slate from a few inches to two feet thick, containing copper pyrites in sufficient quantity to afford 2 per cent. of the weight of the ore of an argentiferous copper. This thin layer displays itself in the north of Germany over a length of eighty leagues, from the coasts of the Elbe to the banks of the Rhine. Notwithstanding its thinness and relative poverty, skilful miners have contrived to establish, on different points of this slate, a number of important explorations, the most considerable being in the territory of Mansfeldt, particularly near Rottenburg. They produce annually 2,000 tons of copper, and 20,000 marcs 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 8,700 yards, and penetrate downward to a very great depth. Three galleries of efflux are to be observed; two of which pour their waters into the Fulde, and the third into the Verra. One of them runs about 20 yards below the most elevated point of the workings. These mines have been in activity since the year 1530. Analogous mines exist near Saalfeld, in Saxony.

To the same geological formation must probably be referred the limestone which contains the sparry iron mine of Schmlacalden, at the western foot of Thuringerwald, where there has been explored from time immemorial a considerable mass of this ore known by the name of *Stahlberg*. The working is executed in the most irregular manner, and has opened up enormous excavations; whence disastrous ruins have taken place in the mines. It furnishes annually 4,500 tons of ore, which keep in play a great number of furnaces, where a deal of iron and steel is manufactured.

At Tarnowitz, 14 leagues S.E. of Oppeln, in Siberia, the zechstein contains, in some of its strata, considerable quantities of galena and calamine; into which mines have been opened, that yield annually from 600 to 700 tons of lead, 1,000 to 1,100 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. Their position seems to indicate that they belong to the same formation; and possibly those of Willach and Bleyberg in Carinthia have the same locality.

There has been discovered lately near *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*, deposites of galena, blende, and calamine, occur in a secondary limestone. At *la Voulte*, on the banks of the Rhone, there is mined, in the lower courses of the limestones that constitute a great portion of the department of the Ardèche, a powerful bed of iron ore.

It is in the zechstein, or in the sandstones, and trap rocks of nearly the same age, that the four great deposites of the sulphuret of mercury, of *Idria*, the *Palatinate*, *Almaden*, and *Huancavelica*, are mined.

The formation which separates the *zechstein* from the lias (*calcaire a gryphites*), called new red sandstone and red marl in England, and bunter-sandstein, muschelkalk, and quadersandstein. in Germany, presents hardly any important mines except those of rock salt; which enrich it, not only in the centre of Europe, as in Cheshire, at Vic, Wieliczka, Bochnia, and Salzbourg, but in many other parts of the world.

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

The oolitic limestones contain strata of iron ore, which are mined in some districts of France.

The iron sand (Hastings sand) beneath the chalk formation, is often so strongly imbued with iron as to be worth the working.

The lowest beds of the chalk contain iron pyrites, which has become the object of an important exploration at *Vissans,* on the southern coast of the *Pas-de-Calais,* where it is converted into sulphate of iron. The waves turn the nodules out of their bed, and roll them on the shore, where they are picked up.

If the chalk be poor in useful minerals, this is not the case with the plastic clay formation above it; for it contains important mines. In it are explored numerous beds of lignite (wood-coal), either as fuel or a vitriolic earth. From these lignite deposites, also, the yellow amber is extracted.

The other tertiary formations present merely a few mines of iron and bitumen.

Several of the secondary or tertiary strata contain deposites 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.

MORTAR, HYDRAULIC. Professor Kuhlmann, of Lisle, obtained a patent in April, 1841, in the name of Mr. Newton, for certain improvements in the manufacture of lime-cement and artificial stone; and of which he gave me a sample, possessed of a hardness and solidity fit for the sculptor.

In operating by the dry method, instead of calcining the limestone with sand and clay alone, as has been hitherto commonly practised, the inventor introduces a small quantity of soda, or, preferably, potash, in the state of sulphate, carbonate, or muriate; salts susceptible of forming silicates when the earthy mixture is calcined. The alkaline salt, equal in weight to about one fifth that of the lime, is introduced in solution among the earths.

All sorts of lime are made hydraulic, in the humid way, by mixing slaked lime with solutions of common alum or sulphate of alumina; but the best method consists in employing a solution of the silicate of potash, called liquor of flints, or soluble glass, to mix in with the lime, or lime and clay. An hydraulic cement may also be made which will serve for the manufacture of architectural ornaments, by making a paste of pulverized chalk, with a solution of the silicate of potash. The said liquor of flints will likewise give chalk and plaster a stony hardness, by merely soaking them in it after they are cut or moulded to a proper shape. On exposure to the air, they get progressively indurated. Superficial hardness may be readily procured by washing over the surface of chalk, &c., with liquor of flints, by means of a brush. This method affords an easy and elegant method of giving a stony crust to plastered walls and ceilings of apartments; as also to statues and busts, cast in gypsum, mixed with chalk.

The essential constituents of every good hydraulic mortar, are caustic lime and silica; and the hardening of this compound under water consists mainly in a chemical combination of these two constituents through the agency of the water, producing a hydrated silicate of lime. But such mortars may contain other bases besides lime, as for example clay and magnesia, whence double silicates of great solidity are formed; on which account dolomite is a good ingredient of these mortars. But the silica must be in a peculiar state for these purposes; namely, capable of affording a gelatinous paste with acids; and if not so already, it must be brought into this condition, by calcining it along with an alkali or an alkaline earth, at a bright red heat, when it will dissolve, and gelatinize in acids. Quartzose sand, however fine its powder may be, will form no water mortar with lime; but if the powder be ignited with the lime, it then becomes fit for hydraulic work. Ground felspar or clay forms with slaked lime no water cement; but when they are previously calcined along with the lime, the mixture becomes capable of hardening under water.

The *mastic* called *Hamelin's,* and so much employed in London, is composed of ground Portland stone (roe stone), sand, and litharge, in the proportion of 62 of the first, 35 of the second, and 3 of the third, in 100 parts; but other proportions will also answer the purpose. I find that chalk will not make a good mastic; being too compact to permit the air to insinuate between the pores, and to produce the concretion of the linseed oil, with which the above mixture is worked up and applied. This mastic soon acquires great hardness, and is totally impervious to water. The surface to which it is to be applied must be dry, and smeared over with linseed oil. Considerable dexterity is required to make good work with it. The fine dust of sandstone alone, mixed with 10 or 12 per cent. of litharge, and 7 per cent. of linseed oil, forms an excellent mastic.

Limestone, which contains so much as 10 per cent. of clay, comports itself after calcination, if all the carbonic acid be expelled, just as pure limestone would do. When it is less strongly burned, it affords, however, a mass which hardens pretty speedily in water. If the argillaceous proportion of a marl amounts to 18 or 20 per cent., it still will slake with water, but it will absorb less of it, and forms a tolerably good hydraulic mortar, especially if a little good Roman cement be added to it. When the proportion of clay is 25 or 30 per cent. after burning, it heats but little with water, nor does it slake well, and must therefore be ground by stampers or an edge millstone, when it is to be used as a mortar. This kind of marl yields commonly the best water cement without other addition. Should the quantity of clay be increased further, as up to 40 per cent., the compound will not bear a high or long-continued heat without being spoiled for making hydraulic mortar after grinding to powder. When more strongly calcined, it forms a vitriform substance, and should, after being pulverized, be mixed up with good lime, to make a water mortar. If the marls, in any locality, differ much in their relative proportions of lime and alumina, as may be readily ascertained by the use of my lime-proof apparatus (see *Appendix*), then the several kinds should be mixed in such due proportions as to produce the most speedily-setting and most highly-indurating hydraulic cement.

MUNDICK. The name given by the Cornish miners to iron or arsenical pyrites.

MUSK. 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 Altai, on the river Irtish, extending eastward as far as the river Jenesi and Lake Baikal; and generally of the mountains of eastern Asia, between 30° and 60° of N. L. 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. Petersburgh, 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, gelatin; 13, albumen; 14, fibrin; 15, carbonaceous matter soluble in water; 16, calcareous salt; 17, carbonate of lime; 18, hairs and sand.

From June, 1841, to June, 1842, a duty of 6*d.* per ounce was paid at the port of London alone upon 969 ounces of musk. The prices of grain musk of the best quality (the matter without the bag) varies from 60*s.* to 95*s.* per ounce.

There is a superior musk imported now from the United States, which is nearly free from the carbonate of lime, so abundant in the bags of the Siberian musk.

MUSQUET. It is now fourteen years since the Hon. Board of Ordnance, with the view of introducing the use of percussion firearms into the British army, employed me to investigate experimentally the best mode of preparing the priming powder for that purpose. The result of these experiments was presented in a report, the substance of which is given under the article "Fulminate" in the Dictionary. During this long interval, Mr. Lovell, inspector of small-arms for her majesty's service, and director of the Royal Manufactory, at Enfield Chase, has directed his ingenious mind to the construction of a sure, simple, and strong musquet, with which, under his able superintendence, the whole of her majesty's soldiers are now provided. He has also furnished them with a short, but clear set of instructions, for the cleaning and management of these excellent arms, illustrated by a series of wood engravings. From this little work the following notice is copied:—

Fig. 94. The barrel, reduced to one-seventh size. *a*, the breach; *b*, the nipple-seat or lump; *c*, the back-sight; *d*, the back loop; *e*, the middle loop; *f*, the swivel-loop; *g*, the front-loop with the bayonet-spring attached; *h*, the front sight; *i*, the muzzle.

Fig. 95. The breech-pin, half size. *a*, the tang; *b*, the neck; *c*, the screw-threads; *d*, the face.

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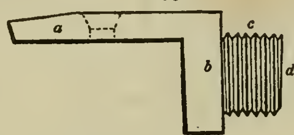

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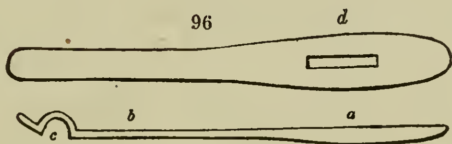

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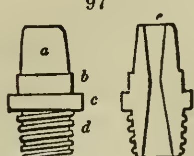

Fig. 96. The bayonet-spring, two ways, half size. *a*, the shank; *b*, the neck; *c*, the hook; *d*, the mortice.

Fig. 97. The nipple, full size. *a*, the cone; *b*, the squares; *c*, the shoulder; *d*, the screw-threads; *e*, the touch-hole.

Fig. 98. The rammer, reduced to one-seventh size. *a*, the head; *b*, the shaft; *c*, the screw-threads.

Fig. 99. The lock outside, half size. *a*, the plate; *b*, the cock; *c*, the tumbler-pin; *d*, the hollow for the nipple seat.

99

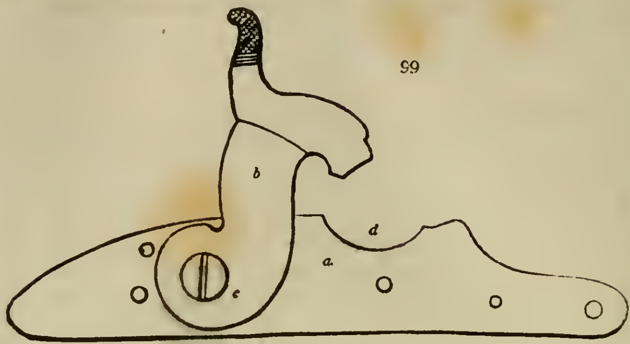

Fig. 100. The lock inside, half size, showing all the parts in their places with the cock down at bearer. *a*, the main-spring; *b*, the sear-spring; *c*, the sear; *d*, the tumbler;

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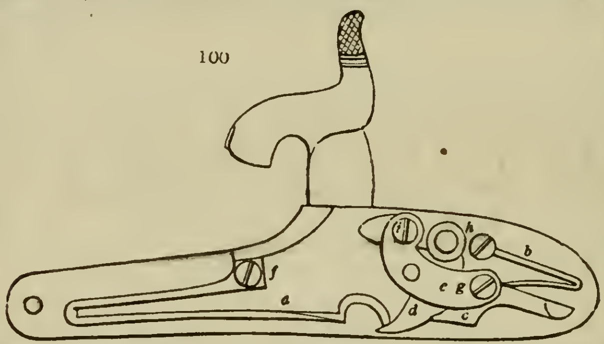


e, the bridle; *f*, the main-spring; *g*, the sear-pin; *h*, the sear-spring-pin; *i*, the bridle-pin.

N.

NITRE (*Saltpetre*), and NITRATE OF SODA (*Cubic nitre*), imported for home consumption in 1839, 314,543 cwts.; in 1840, 369,204; duty 6*d*. per cwt.

NITROMETER. See *Appendix*.

NUTMEGS; imported for consumption in 1839, 133,470 lbs.; in 1840, 118,554; duty from British possessions, 2*s*. 6*d*.; from foreign, 3*s*. 6*d*. per lb.

O.

OIL, COCOA-NUT; imported for consumption in 1839, 15,153 cwts.; in 1840, 37,269; duty, 1*s*. 3*d*. per cwt.

OIL, OLIVE; imported for consumption in 1839, 1,806,178 gallons; in 1840, 1,985,902; duty 8*d*. per gallon.

OIL, PALM; imported for consumption in 1839, 262,910 cwts.; in 1840, 314,881; duty, 1*s*. 3*d*. per cwt.

OIL, *train*, *spermaceti*, and *blubber;* imported for consumption in 1839, 21,438 tuns; in 1840, 19,955, of British fishing 1*s*. per tun; of foreign fishing, 26*l*. 12*s*. per tun.

The numerous uses of unctuous oils give importance to their preparation, as articles of food, or for burning in lamps, and for the manufacture of soaps, &c. The seeds most productive of oil are those of colza (a species of cabbage, *brassica arvensis*), rape, mustard, sesamum, poppy, linseed, hemp, and beechmast. Nuts afford an oil that is much esteemed for certain purposes, and may be easily obtained by pressure. The following table indicates the quantities of oil which can be extracted from different fruits, and some other substances :—

100 Parts of each	Oil per Cent.	100 Parts of each.	Oil per Cent.
Walnuts - - -	40 to 70	Wild mustard seed - -	30
Castor-oil seeds - -	62	Camelina-seed - -	28
Hazel-nuts - - -	60	Weld-seed - - -	29 to 36
Garden cress seed - -	56 to 58	Gourd-seed - - -	25
Sweet almonds - -	40 to 54	Lemon-seed - - -	25
Bitter almonds - -	28 to 46	Onocardium *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	Beechmast - - -	15 to 17
Cabbage-seed -	30 to 39	Sunflower-seeds - -	15
White mustard r- -	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
Beechmast - - -	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

Colza, rape-seed, and cameline oils are employed for lamps; poppy, *madia sativa*, are employed, when recent, as articles of food—or for soaps and paintings; hemp-seed and linseed for painting, soft soaps, and for printers' ink; walnut oil, for food, painting, and lamps; olive oil, for food, soaps, lamps.

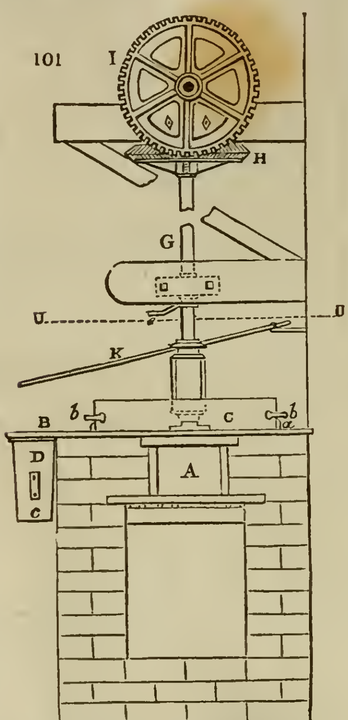
In extracting oil from seeds, two processes are required—1st, *trituration*; 2d, *expression*; and the steps are as follows :—

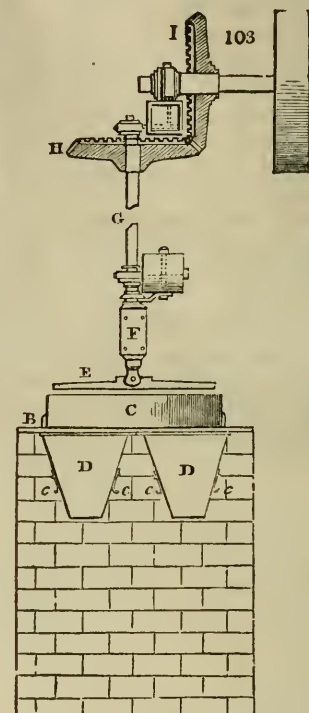
1. Bruising under revolving heavy-edge millstones, in a circular bed, or trough of iron, bedded on granite.
2. Heating of the bruised seeds, by the heat either of a naked fire or of steam.
3. First pressure or crushing of the seeds, either by wedges, screw, or hydraulic presses.
4. Second crushing of the seed cakes of the first pressure.
5. Heating the bruised cakes; and 6. A final crushing.

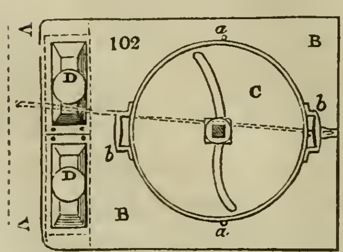
The seeds are now very generally crushed, first of all between two iron cylinders revolving in opposite directions, and fed in from a hopper above them; after which they yield more completely to the triturating action of the edge stones, which are usually hooped round with a massive iron ring. A pair of edge millstones of about 7 or 7½ feet in diameter, and 25 or 26 inches thick, weighing from 7 to 8 tons, can crush, in 12 hours, from 2½ to 3 tons of seeds. The edge-millstones serve not merely to grind the seeds at first, but to triturate the cakes after they have been crushed in the press. Old dry seeds sometimes require to be sprinkled with a little water to make the oil come more freely away; but this practice requires great care.

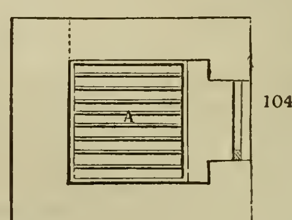
The apparatus for heating the bruised seeds consists usually of cast-iron or copper pans, with stirrers moved by machinery. *Figs.* 101, 102, 103, 104, represent the heaters by naked fire, as mounted in Messrs. Maudsley and Field's excellent seed crushing mills, on the wedge or Dutch plan.

Fig. 101 is an elevation, or side view of the fireplace of a naked heater; *fig.* 102 is a plan, in the line UU of *fig.* 101. *Fig.* 103, is an elevation and section parallel to the line VV of *fig.* 102. *Fig.* 104, is a plan of the furnace, taken above the grate of the fireplace.









A, fireplace shut at top by the cast-iron plate B; called the fireplate.

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*.

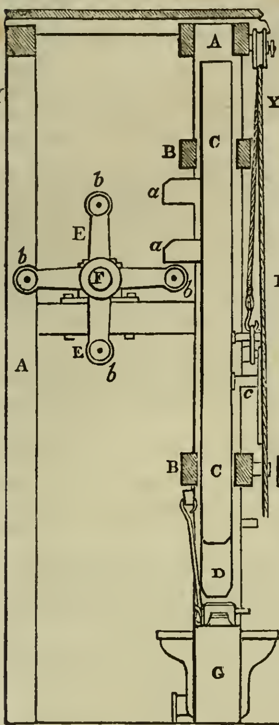
D, funnels, *britchen*, into which by pulling the ring-case *c*, by the handles *b*, *b*, the seeds are made to fall, from which they pass into bags suspended to the hooks *c*.

E, *fig*. 103, 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. *e*, a catch for holding up the lever K, when it has been raised to a proper height.

Fig. 105, front elevation of the wedge seed-crushing machine, or wedge-press. *Fig.* 106, section, in the line XX, of *fig.* 107.

106



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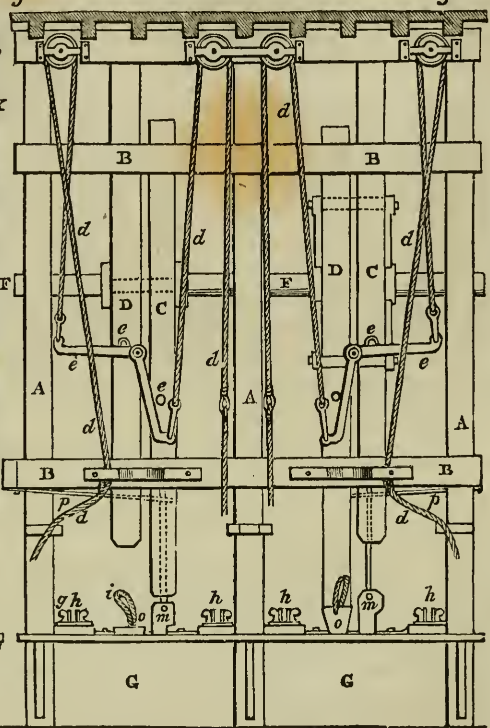
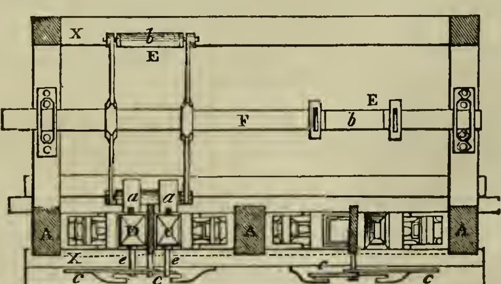


Fig. 107, horizontal section, in the line YY, of *fig.* 106.

107



A, A, Upright guides, or frame-work 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.* 106, which lift the stampers by the cams, *a*, *a*, *fig.* 106. 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*. 105 and 108; the spring, or relieving wedge.
e, lighter rail; *d*, lifting-rope to ditto.
f, *f*, *f*, *f*, flooring overhead.
g, *figs*. 105 and 108; the back iron, or end-plate minutely perforated.
h, the horse-hair bags (called hairs), containing the flannel bag, charged with seed; *i*, the dam-block; *m*, the spring wedge.

Fig. 107, A, upright guides; C, and D, spring and driving stampers; E, lifting roller; F, lifting shaft; *a*, *a*, cams of stampers.

Fig. 108, a view of one set of the wedge-boxes, or presses; supposing the front of them to be removed.

108

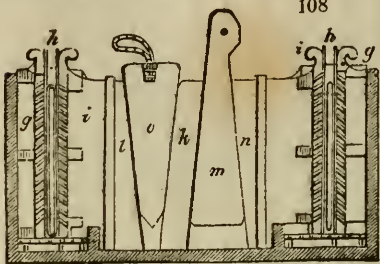


Fig. 108; *o*, driving wedge; *g*, back iron; *h*, hairs; *i*, dam-block; *k*, speering or oblique block, between the two stampers; *l*, ditto; *n*, ditto; *m*, spring wedge.

When in the course of a few minutes the bruised seeds are sufficiently heated in the pans, the double door FF is withdrawn, and they are received in the bags, below the aperture 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 first pressure requires only a dozen blows of the stamper, after which the pouches are left alone for a few minutes till the oil has had time to flow out; in which interval the workmen prepare fresh bags. The former are then unlocked, by making the stamper fall upon the loosening wedge or key, *m*.

The weight of the stampers is usually from 500 to 600 pounds; and the height from which they fall upon the wedges is from 16 to 21 inches.

Such a mill as that now described, can produce a pressure of from 50 to 75 tons upon each cake of the following dimensions: 8 inches in the broader base, 7 inches in the narrower, 18 inches in the height; altogether nearly 140 square inches in surface, and about $\frac{3}{4}$ of an inch thick.

OILS, ADULTERATION OF. M. Heidenreich has found in the application of a few drops of sulphuric acid to a film of oil, upon a glass plate, a means of ascertaining its purity. The glass plate should be laid upon a sheet of white paper, and a drop of the acid let fall on the middle of ten drops of the oil to be tried.

With the *oil of rape-seed* and *turnip-seed*, a greenish blue ring is gradually formed at a certain distance from the acid, and some yellowish brown bands proceed from the centre.

With *oil of black mustard*, in double the above quantity, also a bluish green color.

With *whale and cod-oil*, a peculiar centrifugal motion, then a red color, increasing gradually in intensity; and after sometime, it becomes violet on the edges.

With *oil of cameline*, a red color, passing into bright yellow.

Olive-oil, pale yellow, into yellowish green.

Oil of poppies and sweet almonds, canary yellow, passing into an opaque yellow.

Of *linseed*, a brown magma, becoming black.

Of *tallow* or *oleine*, a brown color.

In testing oils, a sample of the oil imagined to be present should be placed alongside of the actual oil, and both be compared in their reactions with the acid. A good way of approximating to the knowledge of an oil is by heating it, when its peculiar odor becomes more sensible.

Specific gravity is also a good criterion. The following table is given by M. Heidenreich :—

	Sp. Gr.	Gay-Lussac's Alcoholm.
Oleine or Tallow Oil - - - - -	0·9003	66
Oil of Turnip Seed - - - - -	0·9128	60·75
Rape Oil - - . - - - - -	0·9136	60·20
Olive Oil - - - - - - -	0·9176	58·40
Purified Whale Oil - - - - -	0·9231	55·80
Oil of Poppies - - - - - -	0·9243	55·25
Oil of Camelina - - - - - -	0·9252	54·75
Linseed Oil - - - - - - -	0·9347	50
Castor Oil - - - - - - -	0·9611	33·75

M. Laurot, a Parisian chemist, finds that colza oil (analogous to rapeseed oil) may be tested for sophistication with cheaper vegetable oils by the increase of density which it therefrom acquires, and which becomes very evident when the several oils are heated to the same pitch. The instrument, which he calls an *oleometer,* is merely a hydrometer, with a very slender stem. He plunges it into a tin cylinder, filled with the oil, and sets this cylinder in another containing boiling water. His oleometer is so graduated as to sink to zero in pure colza oil so heated; and he finds that it stops at 210° in linseed oil, at 124° in poppy-seed oil, at 83° in fish oil, and at 136° in hemp-seed oil—all of the same temperature. By the increase of density, therefore, or the ascent of the stem of the hydrometer in any kind of colza oil, he can infer its degree of adulteration.

The presence of a fish oil in a vegetable oil is readily ascertained by agitation with a little chlorine gas, which blackens the fish oil, but has little or no effect upon the vegetable oil.

I find that lard oil, and also hogs' lard, are not at all darkened by chlorine.

A specific gravity, bottle or globe, having a capillary tube-stopper, would make an excellent oleometer, on the above principle. The vessel should be filled with the oil, and exposed to the heat of boiling water, or steam at 212°, till it acquires that temperature, and then weighed. The vessel with the pure colza oil will weigh several grains less than with the other oils similarly treated. Such an instrument would serve to detect the smallest adulterations of sperm oil. Its specific gravity at 60° when pure is only 0·875; that of southern whale oil is 0·922, or 0·925; and hence their mixture will give a specific gravity intermediate, according to the proportion in the mixture. Thus I have been enabled to detect sperm oil in pretended lard oil, in my examination of oils for the customs.

OPIUM. Imported for consumption in 1839, 41,632 lbs.; in 1840, 46,736; duty, 1*s*. per lb.

P.

PAPER. The construction of wire-web cylinders for paper-making machines, and the combination of two such cylinders in one machine, by the use of which two distinct thicknesses of paper pulp are obtained, and applied face-wise, to form one thick sheet, were made the subject of a patent under the name of John Donkin. Two cylinders are so placed in a vat that their circumferences are nearly in contact, and by being turned in opposite directions, they bring two sheets of paper pulp into contact, and incorporate them into one, by what is technically termed *couching*.

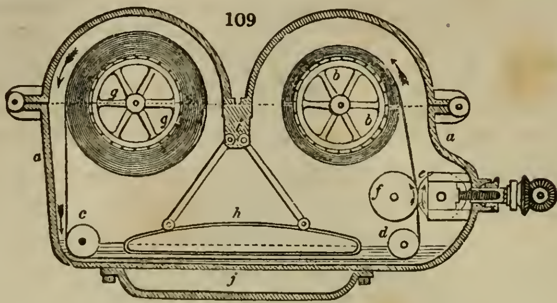
An extensive patent for improvements in the manufacture of paper was granted to Charles Edward Amos in 1840. These consist, first, in gradually lowering the roll of the engine in which the rags are prepared and converted into pulp; secondly, in a mode of regulating the supply of pulp to the paper-making machine, in order to produce papers of any required thickness; thirdly, in an improved sifter or strainer through which the pulp is passed for clearing it of knobs and lumps; fourthly, in certain modifications of the parts of the machine in which the pulp is deposited and moulded into continuous lengths of paper; fifthly, in an improved method of heating the cylinders of the drying apparatus; and, sixthly, in improvements of the machinery for cutting the paper into sheets of any required dimensions. The details of these ingenious contrivances, illustrated with engravings, are given in *Newton's Journal*, xx., p. 153., C. S.

Henry Crossley purposes to manufacture paper from waste tan, and spent hops—with what success I have not heard. Joseph Hughes gives a higher finish to the long web of paper by friction between two cylinders, the one of which moves much quicker than the other, both being covered with felt or not, at pleasure.

Mr. John Dickinson, the eminent paper manufacturer, obtained a patent in 1840 for a new mode of sizing paper continuously, in an air-tight vessel (partly exhausted of air), by unwinding a scroll of dried paper from a reel, and conducting it through heated size; then, after pressing out the superfluous size, winding the paper on to another reel.

A longitudinal section of the apparatus employed for this purpose is represented *fig*. 109; where *a* is the air-tight vessel; *b*, the reel upon which the paper to be sized is wound; whence it proceeds beneath the guide-roller *c*, and through the warm size to another guide-roller *d*. It thence ascends between the press-rolls, *e*, *f* (by whose revolution the paper is drawn from the reel *b*), and is wound upon the reel *g*. A float *h* is suspended from the cross-bar *i*, of the vessel *a*, for the purpose of diminishing the surface of size exposed to evaporation; and beneath the bottom of the vessel is an enclosed space *j*, into which steam or hot water is introduced for maintaining the temperature of the size.—*Newton's Journal*, xxiii. 20.

109

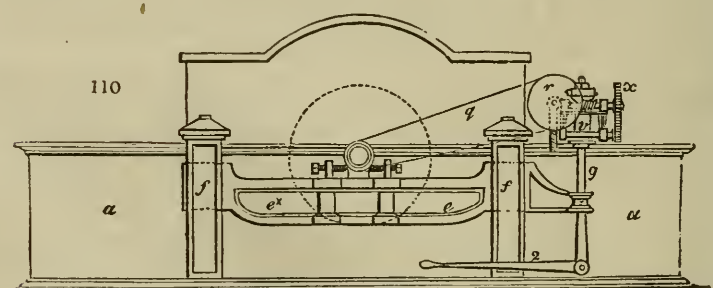


Messrs. Charles Cowan and Adam Ramage, paper-makers, patented, in 1840, improved rag machinery; in which a cylindrical sieve or strainer of wire-cloth, of a peculiar construction, is substituted for the ordinary strainers, by which the dirty water is separated from the pulp. They do not claim the cylindric form or sieve, but "the adding or applying, and combining within the interior of such drum, scoops, or buckets, for the purpose of elevating the water, which has entered into it through its wire circumference, so that the water when elevated may be able to run by its own gravity out of the hollow around the central axis of the drum into any suitable shoot or trough, and escape at a level above the surface of the water and rags or material contained in the paper-machine."

Thomas Barrett claims, in his patent of 1841, "a mode of drying paper by applying streams of air to its two surfaces, as it passes over the steam cylinders, whether in the state of engine size or water leaf, or after sizing; as also, the application of currents of air to the surfaces of paper, after sizing, in order to cool the size; as the paper is passing to the drying cylinders."

The improvements in paper-making, for which T. W. Wrigley, of Bridge Hall Mills, Bury, obtained a patent in 1842, relate to the rag engine, *figs.* 110, 111, 112,

110



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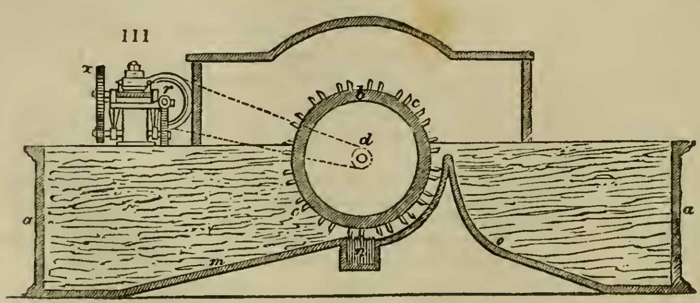
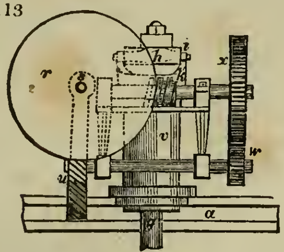


113. *Fig.* 110 is a side elevation; *fig.* 111, a transverse section, taken lengthwise through nearly its middle; *fig.* 112, a plan view of the apparatus detached upon a

113



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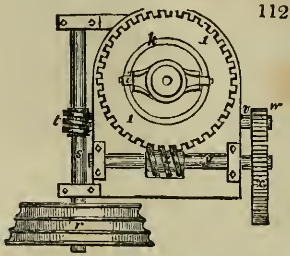


larger scale; and *fig.* 113 is an elevation. The vessel in which the rags are placed is shown at *a a*, and in about the centre of this vessel the beating or triturating roll, *b*, *b*, is placed: it is surrounded with the blades or roll bars, *c c*, *fig.* 111. The roll is mounted upon a shaft, *d d*, one end of which is placed in a pedestal or bearing on the further side of the chamber *a*, and the other in a bearing upon the arm or level *e e**, *fig.* 110, which is supported by its fulcrum, at the end *e**, in one of the standards, *f f*, and at the other end by a pin fixed in the connecting rod, g g. At the upper end of this connecting rod there is a cross-piece, or head *h*, having turned pivots at each end upon which are placed small rollers, *i i*, resting upon a horizontal cam, *k k*, which is made to revolve. This cam, *k k*, by means of its gearing, causes the roll *b* first of all to wash the rags a short time, then to be lowered at whatever rate is desired for breaking the fibres; to be maintained at the lowest point for the required number of revolutions for beating; and to be raised and retained, as required, for the final purpose of clearing the pulp. The upper or working edge of this cam is to be shaped exactly according to the action required by the engine roll; as, for instance, suppose the previous operation of washing to be completed, and the time required for the operation of the rag machine to be three hours, one of which is required for lowering the roll, that, or the first division of the working surface of the cam, *k k*, must be so sloped or inclined, that, according to the speed at which it is driven, the rollers upon the cross-head shall be exactly that portion of the time descending the incline upon the cam, and consequently lowering the roll upon the plates *n*, *fig.* 111; and if the second hour shall be required for the roll to beat up the rags, the roll revolving all the time in contact with the plates, the second division of the cam, *k k*, must be so shaped (that is, made level), that the roll shall be allowed to remain, during that period, at its lowest point; and if the third portion of the time, or an hour, be required for raising the roll again, either gradually or interruptedly, then the third division of the cam, *k*, must be suitably shaped or inclined, so as to cause the cross-head to lift the roll during such interval or space of time; the particular shape of the inclined portions of the cam depending on the manner in which the manufacturer may wish the roll to approach to or recede from the bottom plates, during its descent and ascent respectively.

Its mode of connexion and operation in the rag engine is as follows: supposing that the rags intended to be beaten up are placed in the vessel *a*, *fig.* 111, and motion is communicated, from a steam-engine or other power, to the farther end of the shaft *d*, the roll *b*, will thus be caused to revolve, and the rags washed, broken, and beaten up, as they proceed from the front weir *m*, over the bottom plates *n*, and again round by the back weir *o*. There is a small pulley *p*, upon the near end of the shaft *d*, round which a band *q* passes, and also round another pulley *r*, upon the cross shaft *s*; upon this shaft is a worm *t*, gearing into a worm-wheel *u*, fixed upon another shaft *v*, below; upon the reverse end of which is a pinion *w*, gearing into a spur-wheel *x*, upon the end of a shaft *y*; and upon the centre of this shaft *y*, there is another worm *z*, gearing into a horizontal worm-wheel 1, upon which the cam, *k k*, is fixed. Thus it will be seen, that the requisite slow motion is communicated to the cam, which may be made to perform half a revolution in three hours; or it will be evident, that half a revolution of the cam, *k k*, may be performed in any other time, according to the calculation of the gearing employed. The shaft may also be driven by hand, so as to give the required motion to the cam. Supposing, now, at the beginning of the operation, the cross head bearing the lever and roll, to be at the highest point upon the cam, *k k*, as its revolution commences, the roll will revolve for a short time on the level surface of the cam, and will then be lowered until the cam, *k k*, has arrived at that point which governs the time that the roll remains at the lowest point, for the purpose of beating the rags into pulp, and as the cam, *k k*, continues to revolve, and thus brings the opposite slope upon the third portion of its working surface into action upon the cross head, the roll will be raised, in order to clear the pulp from knots and other imperfections, and thus complete the operation of the engine. In order to raise the cross head and roll to the height from which it descended without loss of time, or to lift the cross-head entirely from off the cam when requisite; a lever 2, or other suitable contrivance may be attached to the apparatus, also a shaft may be passed across the rag-engine, and both ends of the roll may be raised instead of one only, as above described.

The patentee does not claim as his invention the lowering and raising the roll of the rag engine, nor the lowering of it by mechanism, as this was effected in Mr. Amos's patent of 1840; but he claims the above peculiar apparatus for this purpose.—*Newton's Journal*, xxiii. 254. C. S.

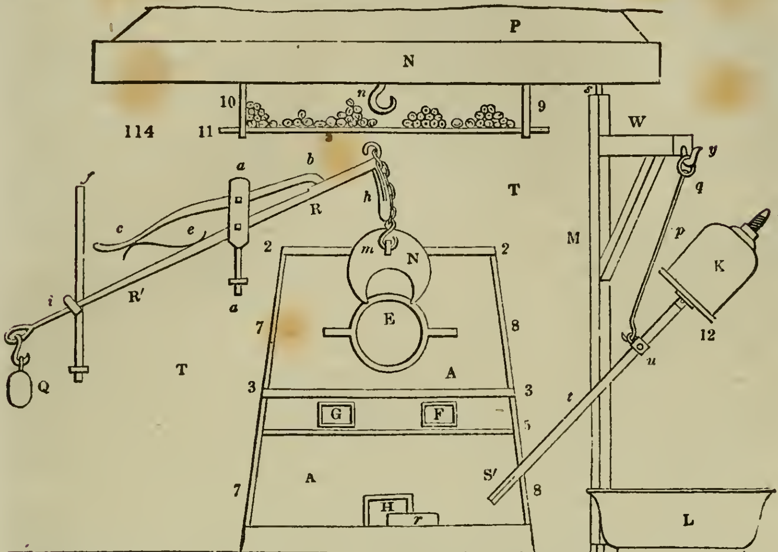
PAPER—*Gross produce of revenue from.* In 1831, 723,248*l.*; 1836, 812,782*l.*; 1837, 555,943*l.*; 1840, 626,663*l.*

PAPER CLOTH. The preparation of this fabric is thus described in the specification of Mr. Henry Chapman's patent of January, 1843. A suitable quantity of canvass, gauze, muslin, calico, linen, &c., is wound upon a roller, which is introduced between the third press felt of a Fourdrinier paper machine; and between the above roller and the endless felt a trough is introduced, containing a solution of gum, glue, &c., with a roller partially immersed in it. Pulp being now allowed to flow upon the endless wire wheel of the machine, paper is made in the ordinary way; and when the endless sheet of paper has been led through the machine, the end of the cloth is brought over the upper part of the roller in the trough, and moved onward in the direction the paper is proceeding. The motion of the cloth causes the roller to revolve, and the adhesive material carried upon its surface is imparted to the cloth, which is then laid upon the paper, as it passes over the roller immediately preceding the third or last press-roller. By passing between these rollers, the cloth and paper are firmly united, and being dried by the steam cylinders, form the compound fabric. If required, a paper surface may be applied to the other side of the cloth, by repeating the operation. If the cloth be dressed with strong starch, the bath of adhesive solution may be dispensed with. The following prescription is given for making that solution:—

Dissolve in 15 parts of water, 4 of soda, and combine with this solution, by means of heat, 9 parts of yellow rosin; boil for an hour, adding a little linseed oil to prevent frothing, and add 1 part of glue to the mixture; after which dilute the whole with one and a half times its weight of water, and strain through flannel. Thirty parts of this composition are to be mixed with one part of flour-paste, and six parts of paper-pulp, which mixture is to be used warm.

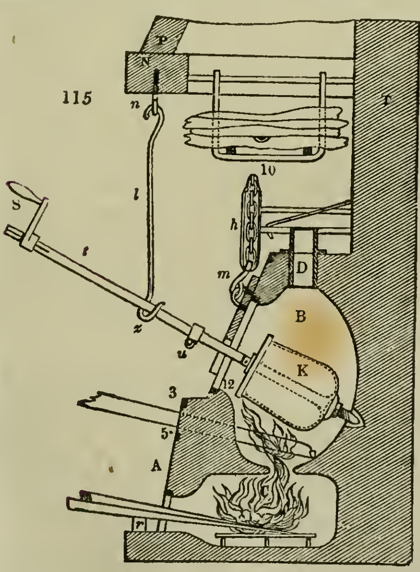
PEARLS, ARTIFICIAL, and BEADS. The material out of which these are formed are small glass tubes like those with which thermometers are made. The tubes for the bright red pearls consist of two layers of glass, a white opaque one internally, and a red one externally; drawn from a ball of white enamel, coated in the Bohemian method with ruby-colored 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 afterward 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. 114, 115, represent a new apparatus for rounding the beads; *fig.* 114, is a front view of the whole; *fig.* 115, 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.* 115), 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.* 114. 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 fireplace. All these four openings are, as shown in *fig.* 114, 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 B 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.* 114) rests during the working in a conical iron step of the laboratory, *fig.* 115. 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.* 114). 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.* 114, 115.



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 toward K a projection at *u*. Alongside the furnace (*fig.* 114) there is a crane, M, that turns upon the step *s*, *s*, on the ground. The upper pivot turns in a hole of the mantel-beam, N. Upon the perpendicular arm, W, of the crane there is a hook, *y*, and a ring, *q*, in which the iron rod, *p*, is moveable in all directions. When the drum is to be removed from the furnace, the crane, with its arm, W, must be turned inward, 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.* 114, 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.* 115.

The now well-rounded beads are separated from the pulverulent substance with which they were mixed, by careful agitation in sieves; and they are polished finally and cleaned by agitation in canvass-bags.

PENS, STEEL. When these 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 with 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* in the DICTIONARY); and then the pens would acquire a definite degree of flexibility or stiffness, adapted to the wants and wishes of the consumers. They are at present tempered too often at random.

PEPPER. The unripe grains or corns are known under the name of black pepper; the ripe ones, deprived of their epidermis, constitute white pepper. The latter are very generally bleached by steeping for a little while in a solution of chloride of lime, subsequent washing and drying; a process which improves their aspect, but not their flavor. 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 a 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 color which these assumed when moistened with iodine water. No allegation could be more frivolous. Bruised corns of genuine white pepper certainly acquire as deep a tint with iodine as any species of starch whatever. But the characters of sago, optical and chemical, are so peculiar, as to render the above surmise no less preposterous, than the prosecution of respectable merchants, for such a cause, was unjustifiable. A particle of sago appears in the microscope, by reflected light, to be a spherule of snow, studded round with brilliants; whereas the rounded particles of the *seized* pepper seem to be amorphous bits of gray clay. Had the pepper been adulterated with such a quantity of sago, or anything else, as was alleged, it could not have afforded me, by digestion in alcohol, as much of the spicy essence as the bruised genuine pepper-corns did.

Moreover, sago, steeped for a short time in cold water, swells and softens into a pulpy consistence, whereas the particles of the seized pepper, rounded by attrition in the mill, retain, in like circumstances, their hardness and dimensions. Sago, being pearled by heating and stirring the fine starch of the sago palm in a damp state, upon iron or other plates, acquires its peculiar somewhat loose aggregation and brilliant surface; while, in pepper, the starchy constituent is compactly condensed, and bound up with its ligneous matter.

The Excise laws are sufficiently odious and oppressive in themselves without being aggravated by the servile sophistry of pseudo-science.

Four pounds of black pepper yield only about one ounce of piperine, or one 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 afterward, by potash.

PERFUMERY, INDIAN. The natives place on the ground a layer of the scented flowers, about 4 inches thick and 2 feet square; cover them with a layer 2 inches thick of *Tel* or Sesamum seed wetted; then lay on another 4-inch bed of flowers, and cover this pile with a sheet, which is pressed down by weights round the edges. After remaining in this state for 18 hours, the flowers are removed and replaced by a similar fresh layer, and treated as before; a process which is repeated a third time, if a very rich perfumed oil be required. The sesamum-seeds thus imbued with the essential oil of the plant, whether jasmine, Bela, or Chumbul, are placed in their swollen state in a mill, and subjected to strong pressure, whereby they give out their bland oil strongly impregnated with the aroma of the particular flower employed. The oil is kept in prepared skins called *dubbers*, and is largely used by the Indian women. The attar of roses is obtained by distillation at a colder period of the year.

PHOTOGRAPHY is the art of making pictorial impressions of objects by the action of light upon paper, &c., prepared with certain substances, and exposed to the sun or in the focus of a camera obscura to the image of the object to be represented; which impressions are then fixed by other chemical re-agents. Photographic paper may be made by dipping Whatman's glazed post paper into brine containing 90 grains of common salt dissolved in an ounce of water, wiping it with a towel, brushing over one side of it with a broad camel-hair brush, a solution of nitrate of silver, containing 50 grains to the ounce of distilled water, and drying it in the dark. The paper may be rendered more sensitive by repeating the above operation; drying it between each step. It affords perfect images of leaves and petals laid upon it, and exposed simply to the sunbeams. A solution of 100 grains of bromide of potassium in an ounce of distilled water answers still better than brine. The paper, when dry, is to be brushed over on one side with a solution containing 100 grains of nitrate of silver to an ounce of water; the paper being brushed, and dried in the dark. If the application of the nitrate of silver be repeated, it will render the paper more sensitive. The silvered side should be marked. This paper laid flat under painted glass, lace, leaves, feathers, ferns, &c., and exposed to the light of day, takes the impression of the objects. It is to be then washed with lukewarm water, and finally dipped in a solution containing one ounce of hyposulphite of soda, in about a pint of distilled water. The design of the object is necessarily reversed: the light parts forming the dark shades of the photogenic impression, and the dark parts the lighter ones. But a direct picture may be obtained by applying that paper, rendered transparent with white wax (see CALOTYPE), upon a sheet of white photogenic paper, and exposing it to the sunbeams, or bright daylight.

A modification of Photography, called Chrysotype by its inventor, Sir John Herschel, consists in washing the paper in a solution of ammonia-citrate of iron, drying it, and brushing it over with a solution of ferro-*sesquicyanure* of potassium. This paper, when dried in a perfectly dark room, is ready for use, the image being finally brought out by a neutral solution of silver.

Another modification by Sir John, called Cyanotype, is as follows: Brush the paper with the solution of the ammonia-citrate of iron, so strong as to resemble sherry-wine in color; expose the paper in the usual way, and pass over it very sparingly and evenly a wash made by dissolving common ferro-cyanide of potassium. As soon as this liquid is applied, the negative picture vanishes, and is replaced by the positive one, of a violet blue color, on a greenish yellow ground, which at a certain time possesses a high degree of sharpness, and singular beauty of tint.

The improved process of photography recently contrived by Mr. Robert Hunt is performed by washing over good letter-paper with the following liquid:—

A saturated solution of succinic acid - - -	2 drams.
Mucilage of gum arabic - - - - -	½ do.
Water - - - - - - -	1½ do.

When the paper is dry, it is washed over once with a solution containing 1 dram of nitrate of silver in 1 ounce of distilled water. The paper is allowed to dry in the dark, and it is fit for use. It can be preserved in a portfolio, and employed at any time in the camera obscura, exposing it to the light from 2 to 8 minutes, according to its vivacity. When the paper is taken out of the camera, no trace of a picture can be seen. To produce this effect, mix 1 dram of a saturated solution of sulphate of iron, with 2 or 3 drams of mucilage of gum arabic, and brush over the paper evenly with this mixture. In a few seconds the latent images are seen to develop themselves, producing a negative photographic picture. The excess of the iron solution is to be washed off with a sponge whenever the best effect appears. The drawing is then to be soaked a short time in water, and is fixed by washing over with ammonia, or preferably with hyposulphite of soda; taking care to wash out the excess of salt. From the pictures thus produced, any number of others, corrected in light and shadow, may be produced by using like succinated papers, in the common way of transfer in sunshine.—*Athenæum.*

PICKLES are various kinds of vegetables and fruits preserved in vinegar. The substances are first well cleaned with water, then steeped for some time in brine, and afterward transferred to bottles, which are filled up with good vinegar. Certain fruits, like walnuts, require to be pickled with scalding-hot vinegar; others, as red cabbage, with cold vinegar; but onions, to preserve their whiteness, with distilled vinegar. Wood vinegar is never used by the principal pickle-manufacturers, but the best malt or white-wine vinegar, No. 22 or 24. Kitchener says, that by parboiling the pickles in brine, they will be ready in half the time of what they require when done cold. Cabbage, however, cauliflowers, and such articles, would thereby become flabby, and lose that crispness which many people relish. When removed from the brine, they should be cooled, drained, and even dried, before being put into the vinegar. To assist the preservation of pickles, a portion of salt is often added, and likewise, to give flavor, various spices, such as long pepper, black pepper, white pepper, allspice, ginger, cloves, mace, garlic, mustard, horseradish, shallots, capsicum. When the spices are bruised, they are most efficacious, but they are apt to render the pickle turbid and discolored. The flavoring ingredients of Indian pickle are Curry powder mixed with a large proportion of mustard and garlic. Green peaches are said to make the best imitation of the Indian mango.

I have examined the apparatus in the great fish-sauce, pickle, and preserved-fruit establishment of Messrs. Crosse and Blackwell, Soho square, and found it arranged on the principles most conducive to economy, cleanliness, and salubrity; no material employed there is ever allowed to come into contact with copper. A powerful steam-boiler is placed in one corner of the ground floor of the factory, from which a steam-pipe issues, and is laid horizontally along the wall about 4 feet above the floor. Under this pipe a range of casks is placed, into the side of each of which a branch steam-pipe, furnished with a stop-cock, is inserted, while the mouth of the cask is exactly closed with a pan of salt-glazed earthenware, capable of resisting the action of every acid, and incapable of communicating any taint to its contents. These casks form, by their non-conducting quality as to heat, the best kind of steam-jackets. In these pans the vinegars with their compounds are heated, and the fish and other sauces are prepared. The waste steam at the farthest extremity of the pipe is conducted into a reservoir of clean water, so as to furnish a constant supply of hot water for washing bottles and utensils.

The confectionary and ham-smoking compartments are placed in a separate fireproof chamber on the same floor.

The floor above is occupied along the sides with a range of large rectangular cast iron cisterns, furnished with a series of steam-pipes, laid gridironwise along their bottoms, which pipes are covered with a perforated wooden shelf. These cisterns being filled up to a certain height above the shelf with water, the bottles full of green gooseberries, apricots, cherries, &c., to be preserved, are set upon the shelf, and the steam being then admitted into the gridiron pipes, the superjacent water gets gradually heated to the boiling point; the air in the bottles round the fruit is thus partly expelled by expansion, and partly disoxygenated by absorption of the green vegetable matter. In this state the bottles are tightly corked, and being subsequently sealed, preserve the fruit fresh for a very long period.

The sauces, pastes, and potted meats, prepared in the above-described apparatus, can seldom be rivalled and probably not surpassed in the kitchens of the most fastidious *gastronomes.*

PITCOAL, ANALYSIS OF. The greater part of the analyses of coals hitherto published have been confined to the proportions of carbon, hydrogen, and oxygen, to the neglect of the sulphur, which exists in many coals to a degree unwholesome for their domestic use, pernicious for the smelting of iron, and detrimental to the production of gas; since the sulphuretted hydrogen produced requires so much washing and purification as at the same time to impoverish the light, by condensing much of the olefiant gas, its most luminiferous constituent. In the numerous reports upon the composition of coals which I have been professionally called upon to make, I have always sought to determine the proportion of sulphur, which may be done readily to one part in a thousand; as also that of combustible gaseous matter, of coke, and of incombustible ashes.

The following coals have been found to be of excellent quality, as containing very little sulphur, seldom much above 1 per cent., and little incombustible matter—hence well adapted as fuel, whether for steam-navigation, for iron-smelting, for household consumption, or for gas, according to their relative proportions of carbon and hydrogen; a relative excess of carbon constituting a coal best adapted for furnaces of various kinds, while a relative excess of hydrogen forms the best coal for the common grates and gas-works.

1. *Mr. Powell's Duffry, or Steam Coal.*—Specific gravity, 1·32; ashes, per cent., 2·6; gaseous products in a luted crucible, 14; brilliant coke, 86; not more than 1 per cent. of sulphur; while many of the Newcastle coals contain from 4 to 6, and others which I have examined from 8 to 10 of the same noxious constituent; and which is a less powerful calorific constituent than hydrogen and carbon.

2. *The Blackley Hurst Coal of Lancashire.*—Specific gravity, 1·26; ashes, per cent., 1·2; combustible gases, 41·5; coke, 58·5; sulphur, 1. Another specimen had a specific gravity of 1·244; 2 per cent. of ashes; 38·5 of combustible gases; 1 of sulphur. This is a very good coal for gas and for domestic use.

3. *The Varley Rock Vein Coal,* near Pontypool; shipped by Mr. John Vipond.—Specific gravity, 1·296; ashes (whitish) 5 per cent.; 32 of combustible gases; 68 of coke. Sulphur, from 2 to 3 per cent. A good household coal.

4. *The Llangennech Coal* has a well-established reputation for the production of steam, and is much employed by the British government for steam navigation, as well as at Meux's, and others of the great breweries in London. It affords a very intense heat, with little or no smoke; and sufficiently diffusive for extending along the flues of the boilers; whereas the anthracite coal, containing very little hydrogen, yields, in common circumstances, a heat too much concentrated under the bottom of the boilers, and acting too little upon their sides. Specific gravity, 1·337; intermediate between that of the Newcastle and the anthracite. Ashes per cent., from 3 to 3·5; combustible gases, 17; coke, 83; sulphur, only *one half* per cent. It is therefore a pure and very powerful fuel.

I have examined many coals with my calorimeter; of which some account is given under FUEL.

PLATING. See ELECTROTYPE.

PLATINUM MOHR. This interesting preparation, which so rapidly oxidizes alcohol into acetic acid, &c., by what has been called in chemistry the catalytic or contact action, is most easily prepared by the following process of M. Bœttger: The insoluble powder of potash-chlorure or ammonia-chlorure of platinum, is to be moistened with sulphuric acid (oil of vitriol), and a bit of zinc is to be laid *in* the mixture. The platinum becomes reduced into a black powder, which is to be washed first with muriatic acid, and then with water. The fineness of this powder depends upon that of the saline powders employed to make it; so that if these be previously finely ground, the platinum-mohr will be also very fine, and proportionally powerful as a chemical agent.

POTTER'S OVEN. A patent was obtained in August, 1842, by Mr. W. Ridgway, for the following construction of oven, in which the flames from the fireplaces 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 fireplaces are built in the two sides of the oven opposite to the partition wall; from which fireplaces narrow flues rise in the inner face of the wall, and distribute the flame in a sheet equally over the whole of its surface. The other portion of the heat is conveyed by many parallel or diverging horizontal flues, under and across the floor or hearth of the oven, to the middle or partition wall; over the surface of which the flame which ascends from the numerous flues in immediate contact with the wall is equally distributed. This sheet of ascending flame strikes the shoulder of the arch, and is reverberated from the seggars beneath, till it meets the flame reverberated from the opposite side of the arch, and both escape at the top of the oven. The same construction is also applied to the opposite chamber. In *figs.* 116, 117, *a,* represents the

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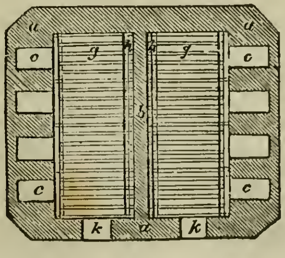

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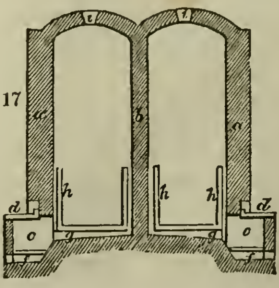


square walls or body of the oven; *b*, the partition wall; *c*, the fireplaces or furnaces with their iron boilers; *d*, the mouths of the furnaces for introducing the fuel; *f*, the ash-pits; *g*, the horizontal flues under the hearth of the oven; *h*, the vertical flues; *i*, the vents in the top of the arches; and *k*, the entrances to the chambers of the ovens.

*PRUSSIAN BLUE. The following process deserves peculiar notice, as the first in which this interesting compound has been made to any extent, independently of animal matter. Mr. Lewis Thompson, of the Old Barge House, Lambeth, received a well-merited medal from the Society of Arts for this invention. He justly observes, 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 favorable circumstances upon a mixture of carbon and potash. He has found the following prescription 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 an hour to a full red heat in an open fire, with occasional stirring of the mixture. During this process, little jets of purple flame will be observed to rise from the surface of the materials. When these cease, the crucible must be removed and allowed to cool. The mass is to be lixiviated; the lixivium, which is a solution of ferrocyanide of potassium, with excess of potash, is to be treated in the usual way, and the black matter set aside for a fresh operation with a fresh dose of pearlash. Mr. Thompson states that 1 pound of pearlash, containing 45 per cent. of alkali, yielded 1,355 grains of pure Prussian blue, or ferrocyanide of iron; or about 3 ounces avoird.

PRUSSIATE OF POTASH. Leuch's Polytechnic Zeitung, June, 1837. Manufacture of Kalium Eisen Cyanure, by Hofflmayr and Prükner.—The potash must be free from sulphate, for each atom of sulphur destroys an atom of the Eisencyankalium. A very strong heat is advantageous. The addition of from 1 to 3 $^0/_0$ of saltpetre is useful, when the mass is too long of fusing. A reverberatory furnace (flammofen) is recommended; but the flame must not beat too much upon the materials, for fear of oxygenating them. When the smoky red flame ceases, it is useful to throw in from time to time small portions of uncarbonized 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 carbonized, but left somewhat brown-colored, provided they be readily pulverized. Of uncarbonized 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; 2, 100 parts of horns or hoofs; from 33 to 35 potash; 2 to 4 iron; 3, 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 carbonized 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 parts more 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.

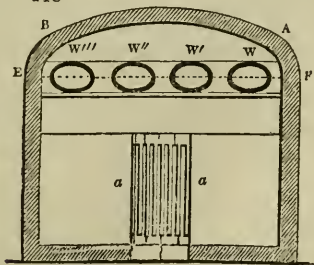
A patent for a singular process and apparatus, for making this compound, was obtained by a foreigner not named, by Mr. Berry, patent agent, in January, 1840. The prescription is as follows:—

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.

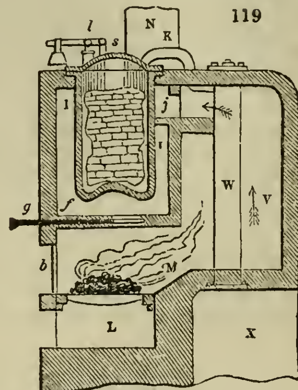
In *fig*. 118, A, B, C, D, is a horizontal section of a furnace constructed to receive four elliptical iron pipes. The furnace is arched in the part A, C, B, in order to reverberate the heat, and drive it back on the pipes W, W′, W″, W‴. These pipes are placed on the plane E, F, of the ellipsoid; *a 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*. 119, 120, 121.

This pot or retort is placed in a separate compartment, as seen in *fig*. 119, which is a vertical section taken through *fig.* 121, at the line G, H. K, is a connecting tube from the retort and the elliptical pipes W.

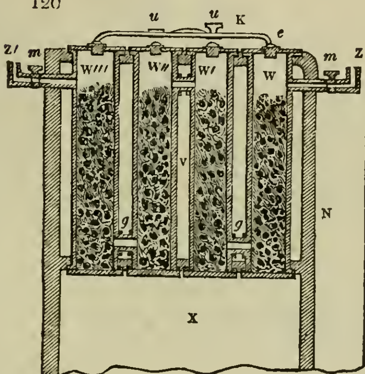
118



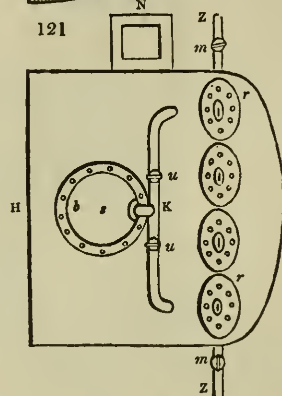
119



120



121



In the section, *fig.* 119, the shape of the tube K, will be better seen; also its cocks *u*, and likewise its connexion with the pipes W. *l*, is a safety valve; *s*, the cover of the pot or retort; L, is the ash-pit; and *b*, the door of the furnace; X, is an open space, roofed over, or a kind of shed, close to the furnace, and under it the pipes are emptied.

The arrows indicate the direction of the current of heat. This current traverses the intervals left between the pipes, and ascends behind them, passing through the aperture *j*, in the brickwork, which is provided with a valve or damper, for closing it, as required. The heat passes through this aperture, and strikes against the sides of the pot when the valve is open. Another valve *f*, *g*, must also be open to expose the pot or retort to the direct action of the fire. The smoke escapes by a lateral passage into a chimney 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.

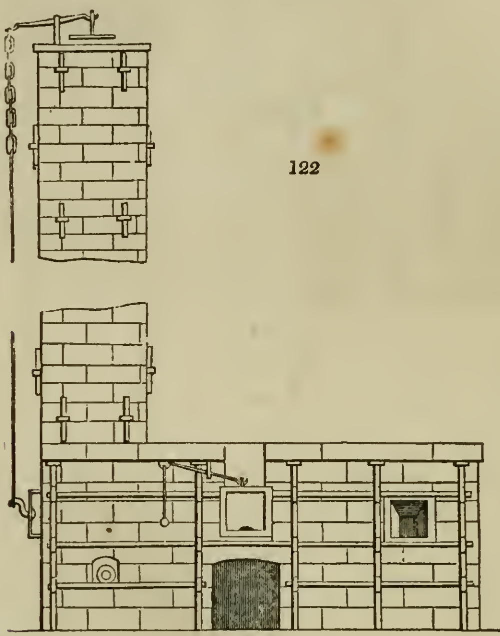
In *fig.* 120 is shown an inclined plane M (also represented in *fig*, 119) and the junction-tubes which connect the four pipes with their gas-burners Z, Z, and the cocks *m*, *m′*. *r*, *r*, are covers, closing the pipes, and having holes formed in them; these holes are shut by the stoppers *e*.

Whether the pipes are placed in the vertical or horizontal position, it is always proper to be able to change the direction of the current of gas; this is easily done by closing, during one hour (if the operation is to last two hours) the cocks *u*, *m′*, and opening those *u′ m*; then the gas passes through *u′*, into the branch K, and entering W‴, passes through *q*, into W″, through *p*, into W′, and through *o*, and W, and finally escapes by the burner z. During the following or other hour, the cocks *u′ m*, must be closed; the cocks *u*, *m′* being opened, the current then goes from *u*, into 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 labor 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 among the substances contained in the pipes. It is for this purpose that apertures are formed, so as to be easily opened and closed.

The patentee remarks, that although this operation is only described with reference to potash, for obtaining prussiate of potash, it is evident, that the same process is applicable to soda; and when the above mentioned ingredients are employed, soda being substituted for potash, the result will be prussiate of soda.—*Newton's Journal*, C. S. xxi. 96.

PUDDLING OF IRON. This is the usual process employed in Great Britain for converting cast iron into bar or malleable iron—a crude into a more or less pure metal. The following plan of a puddling furnace has been deemed economical, especially with respect to fuel, as two furnaces are joined side by side together, and the workmen operate at doors on the opposite sides. *Fig.* 122 represents this twin furnace



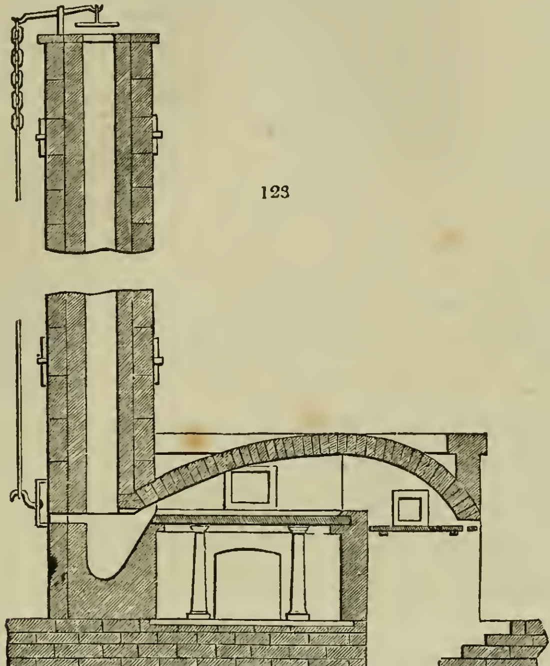
122

in a side elevation; *fig.* 123 in section, according to the line E F, in *fig.* 124, which exhibits a plan of the furnace. The various parts are so clearly shown in form and construction as to require no explanation. The total length outside is 14¾ feet; width, 12¾ feet: from which the dimensions of the other parts may be measured.

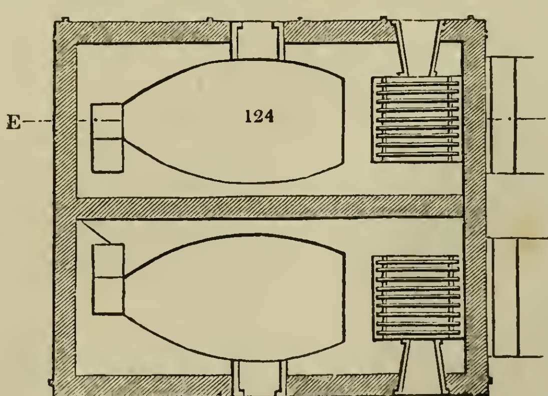
Iron is puddled either from cast pigs, or from the plates of the refinery (finery) furnace. In several iron-works a mixture of these two crude metals is employed. In the refining process, the waste at the excellent establishment of Mr. Jessop, at Codner Park, is from 2½ to 2¾ cwt. per ton; on which process the wages are 1*s*. per ton; and the coke ½ ton, worth 6*s*.; so that the total cost of refining per ton is 15*s*., when pig-iron is worth 3*l*. 10*s*.

The puddling is accompanied with a loss of weight of 1½ cwt. per ton; it costs in wages, for puddling refinery plates, 6*s*. 6*d*., and for pigs, 8*s*.; in which 18 cwt. of coal are consumed; value, 5*s*. per ton.

Shingling (condensing the bloom by the heavy hammer) costs, in wages, 1*s*. 9*d*. per ton; and rough-rolling, 1*s*. 2*d*. Cutting and weighing these bars cost 9*d*. for wages, including their delivery to the mill furnace, where they are reheated and welded together. The mill furnace heating costs 1*s*. 6*d*. in wages, and consumes in fuel 12 cwt. of coals, at 5*s*. per ton. The rolling and straightening cost 5*s*. 6*d*.; cropping the ends, weighing, and stocking in the warehouse, 1*s*. for wages. Wear and tear of power, 5*s*. Laborers for clearing out the ashes, &c., 1*s*. 6*d*. per ton.


123

In Wales 4 tons of pig-iron afford upon an average only 3 tons of bars. From the above data a calculation may easily be made of the total expense of converting crude into cast iron at the respective iron works.



124

A great economy in the conversion of the cast into wrought metal seems about to be effected in our iron works, by the application of a current of voltaic electricity to the crude iron in a state of fusion, whether on the hearth of the blast furnace, on the fused pigs in the sand, or on the metal immediately on its being run from the finery furnace; the voltaic force of from 50 to 100 pairs of a powerful Smee's battery being previously arranged to act upon the whole train of the metal. This process, for which

Mr. Arthur Wall has recently obtained a patent, is founded upon the well-established fact, that when a compound is subjected to an electrical current, its negative and positive elements are detached from one another. Crude iron contains more or less carbon, sulphur, phosphorus, arsenic, oxygen, and silicon—bodies all electro-negative in relation to iron, which is electro-positive. When the impure iron, as it flows from the blast furnaces, is subjected during its cooling and consolidation to a powerful stream of voltaic electricity, the chemical affinities by which its various heterogeneous components are firmly associated, are immediately subverted, whereby, in the case of crude iron, the sulphur, phosphorus, &c., which destroy or impair its tenacity and malleability, become readily separable in the act of puddling. On this principle, I would explain the extraordinary effect of Mr. Wall's patent electric process, as performed in my presence in the excellent iron-works of Mr. Jessop, at Codner Park, Derbyshire, where the electrised forge pigs discharged those noxious elements so copiously in the puddling furnace, as to become after a single reheating, without piling or fagoting, brilliant bars of the finest fibrous metal. The bars so made have been subjected, under my inspection, to the severest proofs by skilful London blacksmiths, and they have been found to bear piercing, hammering, bending, and twisting, as well as the best iron in the market. I have also analyzed the said iron with the utmost minuteness of chemical research, and have ascertained it to be nearly pure metal, containing neither sulphur nor phosphorus, and merely an inappreciable trace of arsenic. I can therefore conscientiously recommend Mr. Wall's patent process to iron-masters as one of the greatest, easiest, and most economical improvements, which that important art has ever received.

The pecuniary advantage of this process, in respect of saving of labor and waste of material, has been estimated by competent judges at from one pound to two pounds sterling per ton.

The effect of electrising iron is displayed in a singular manner by the conversion into steel of a soft rod, exposed in contact with coke, for a few hours, to a moderate red heat; a result which I have witnessed and can fully attest.

PURPLE OF CASSIUS is best made according to the French Pharmacopœia, by dissolving 10 parts of acid chloride of gold in 2,000 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 1,000 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.

R.

REFINING OF SILVER. In this process, as effected by sulphuric acid, the arrangements are so complete, that a two thousandth part, or even less, of gold is extracted free of charge to the bullion merchant, and the whole silver returned or accounted for. By mistake a one thousandth was stated in the article REFINING OF SILVER in the Dictionary.

RESINS. An ingenious memoir upon the resins of dammar, copal, and animé, has lately been published by M. Guibourt, an eminent French *pharmacien*, from which the following extracts may be found interesting.

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 colorless, 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 smelting and kindling at a candle-flame, and running down in drops, while amber burns and swells up without flowing; 2dly, this hard copal or animé, when blown out and still hot, exhales a smell like balsam copaiva or capivi; while amber exhales an unpleasant bituminous odor; 3dly, when moistened by alcohol of 85 per cent., copal becomes sticky, and shows after drying a glazed opaque surface, while amber is not affected by alcohol; 4thly, the copal affords no succenic acid, as amber does, on distillation.

When the pulverized copal is digested in cold alcohol of 0·830, it leaves a considerable residuum, at first pulverulent, but which swells afterward, and forms a slightly coherent mass. When this powder is treated with boiling alcohol, it assumes the consistence of a thick gluten, like crumbs of bread, but which does not stick to the fingers. Thus treated, it affords,

Resin soluble in cold alcohol	31·42
Resin dissolved in boiling alcohol	4·00
Resin insoluble in both	65·71
	100·83

The small excess is due to the adhesion of some of the menstruum to the resins.

Ether, boiling hot, dissolves 39·17 per cent. of copal.

Essence (spirits) of turpentine does not dissolve any of the copal, but it penetrates and combines with it at a heat of 212° Fahr.

The property of swelling, becoming viscid and elastic, which Berzelius assigns to copal, belongs not to it, but to the American resin of courbaril, or the occidental animé; and the property of dissolving entirely in ether belongs to the aromatic *dammar*, a friable and tender resin.

2. Resin of courbaril of Rio Janeiro, the English gum-animé, and the semi-hard copal of the French. It is characterized by forming, in alcohol, a bulky, tenacious, elastic mass. It occurs in rounded tears, has a very pale, glassy aspect, transparent within, covered with a thin white powder, which becomes glutinous with alcohol. Another variety is soft, and dissolves, for the most part, in alcohol; and a third resembles the oriental copal so much as to indicate that they may both be produced from the same tree. 100 parts of the oriental and the occidental animé yield respectively the following residua:—

	With alcohol.	With ether.	With essence.
Oriental - - -	65·71	60·83	111
Occidental - - -	43·53	27·50	75·76

The hard and soft copals possess the remarkable property in common of becoming soluble in alcohol, after being oxygenated in the air.

3. *Dammar puti, or dammar batu.*—This resin, soft at first, becomes eventually like amber, and as hard. It is little soluble in alcohol and ether, but more so in essence of turpentine.

4. *Aromatic dammar.*—This resin occurs in large orbicular masses. It is pretty soluble in alcohol. Only small samples have hitherto been obtained. Of 100 parts, 3 are insoluble in alcohol, none in ether, and 93 in essence of turpentine. M. Guibourt thinks that this resin comes from the Molucca islands. Its ready solubility in alcohol, and great hardness, render it valuable for varnish-making.

5. *Austral dammar.*—This resin is the product of the *Dammara australis*, one of the highest trees in New Zealand, where it is called *Kaurè* or *Kouri*. It resembles elemi in some measure. It flows from the trunk and branches in the form of a resinous juice called *vare*, and gum-*cowdee* by the English settlers. The natives chew it continually, and with the soot obtained from its combustion they make the indelible black tatoo figures upon their faces. It comes home in lumps of considerable size. It possesses a certain toughness, which makes it difficult to break or to pulverize. It takes fire at a candle-flame, and continues to burn by itself. It melts in water, heated below the boiling point. Alcohol boiled with it, leaves 43·3 per cent. of insoluble matter; ether leaves 36·66; and essence of turpentine 80 per cent. This resin, in fact, resembles very closely the resin of courbaril.

6. *Slightly aromatic dammar* leaves, after alcohol, 37 per cent.; after ether, 17 per cent.; and after essence, 87 per cent.

7. *Tender and friable dammar selan.*—This resin occurs in considerable quantity in commerce (at Paris). It is in round or oblong tears, vitreous, nearly colorless and transparent within, dull whitish on the surface. It exhales an agreeable odor of olibanum, or mastic, when it is heated. It crackles with the heat of the hand like roll-sulphur. It becomes fluid in boiling water, but brittle when cooled again. It sparkles and burns at the flame of a candle; but this being the effect of a volatile oil, the combustion soon ceases.

Resin soluble in cold alcohol - - - -	75·28
Resin insoluble in boiling alcohol - - - -	20·86

It dissolves readily and completely in cold essence of turpentine, and forms a good varnish. M. Guibourt refers the origin of this resin to the *Dammara selanica* of Rumphius. Of the preceding resins, 100 parts have left respectively.

	Alcohol of 0.830.	Insoluble in Ether.	Essence.
Hard copal, or animé - -	65·71	60·83	111
Tender copal - - -	43·53	27·50	75·76
Dammar puti - - - -	—	—	—
Dammar aromatic - -	3.0	—	93
Dammar austral - - -	43·33	36·66	80
Dammar slightly aromatic -	37·00	17·00	87
Dammar friable - - -	20·86	2·00	—

RETORTS OF CLAY are now extensively used in gas-making, and they are well manufactured at Newcastle. See the article GAS.

S.

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 1,000 parts of a liquid by volume above the weight of a like volume of distilled water; so that if the specific gravity be 1,045, 1,070, 1,090, &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 1,000 is the standard in the first case, and 360 in the second.

The saccharometer now used by the Excise, and by the trade, is that constructed by Mr. R. B. Bate, well known for the accuracy of his philosophical and mathematical instruments. The tables published by him for ascertaining the values 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 downward from the first to 30; these divisions, which are laid down in an original manner, observe a diminishing progression according to true principles; therefore each division correctly indicates the one thousandth part of the specific gravity of water; and further, by the alteration made in the bulk of the saccharometer at every change of poise, each of the same divisions continues to indicate correctly the said one thousandth part throughout."

In my own practice, I prefer to take specific gravities of all liquids whatever with a glass globe containing 500 or 1,000 grains of distilled water at 60° Fahr., when it is closed with a capillary-bored glass stopper; and with the gravity so taken, I look into a table constructed to show the quantity per cent. of sugar, malt, extract, or of any other solid, proportional to the density of the solution. By bringing the liquid in the gravity-bottle to the standard temperature, no correction on this account is needed. Mr. Bate's elaborate table contains all these equations correctly for solutions of sugar of every successive specific gravity. When employed in such researches by the Molasses Committee of the House of Commons in the year 1830, I found that the specific gravities of solutions of the concrete extract of malt differed somewhat from those of solutions of sugar, as given by Mr. Bate. (*See page* 100 *of Dictionary.*)

The following table shows the quantities of sugar contained in syrups of the annexed specific gravities. It was the result of experiments carefully made:—

Experimental spec. gravity. of solution at 60° F.	Sugar in 100· by weight.	Experimental spec. gravity. of solution, at 60° F.	Sugar in 100· by weight.
1·3260	66·666	1·1045	25·000
1·2310	50·000	1·0905	21·740
1·1777	40·000	1·0820	20·000
1·4400	33·333	1·0635	16·666
1·1340	31·250	1·0500	12·500
1·1250	29·412	1·0395	10·000
1·1110	26·316		

N. B. The column in the opposite table, marked *Solid extract by weight*, is Mr. Bate's; it may be compared with this short table, and also with the table of malt infusions in page 100 of the Dictionary.

If the decimal part of the number denoting the specific gravity of syrup be multiplied by 26, the product will denote very nearly the quantity of sugar per gallon in pounds weight, at the given specific gravity.*

* This rule was annexed to an extensive table, representing the quantities of sugar per gallon corresponding to the specific gravities of the syrups constructed by the author, for the Excise, in subserviency to the Beet-roo bil

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
1·004	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
1·043	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 LAMP. During a visit which I paid to Newcastle some time ago, I took pains to learn the opinion of the best judges of coal mining, upon the merits of the patent invention of Upton and Roberts, described in the Dictionary, and I found from the concurring testimony of that very able engineer, Mr. Buddle, since lost to his friends and the world, and of Mr. Sopwith, well known for the geological study of the coal formation, that the said lamp could not be safely used on account of its glass case, which, being most liable to break, would be apt to cut or rupture the meshes of the wire gauze within it, and thus to lay the flame open for explosions. It is not therefore in use.

SAGO. See Pepper in this Supplement.

SAL AMMONIAC. A patent was obtained in 1840, for improvements in the manufacture of this article, by Mr. H. Waterton. Two modes of operating are described; the first consists in making a saturated solution of common salt in water, and mixing with it a quantity of finely pulverized carbonate of ammonia, about equal in weight to the salt contained in the solution. The mixture is agitated in a close vessel for six or eight hours, and as much carbonic acid gas is infused therein as it will absorb (but the introduction of the gas is not absolutely necessary, although the patentee prefers it); the liquid is then separated from the solid matter, by filtration and pressure. The solid matter is chiefly bi-carbonate of soda, and the liquid holds in solution muriate and carbonate of ammonia, and common salt, and sometimes a small portion of the bi-carbonate of soda.

The liquid is now placed in a distilling vessel, and the carbonate of ammonia being distilled over into a suitable receiver, a solution of muriate of ammonia and common salt remains in the still. This solution is evaporated, by heat, to such a consistency as will cause the separation of the common salt, by crystallization, and the salt, thus crystallized, is evaporated from the liquid by any convenient method. The liquid is then evaporated until it attains the proper specific gravity for crystallizing, and it is transferred into suitable utensils for that purpose. The crystals, produced by these means, are nearly pure muriate of ammonia, and, when pressed and dried, may be brought to market without further preparation, or they may be sublimed into cake sal ammoniac.

The other mode of manufacturing sal ammoniac consists in taking a quantity of liquid, containing ammonia, either in the caustic state, or combined with carbonic, hydrosulphuric, or hydrocyanic acid (such as gas ammoniacal liquor, or bone ammoniacal liquor), and rectifying it, by distillation, until the distilled portion contains from twenty to twenty-five per cent. of carbonate of ammonia. If the liquid contains any other acids than those above mentioned, a sufficient quantity of lime is used in the distillation to decompose the ammoniacal salt.

The distilled liquid being now mixed with as large a quantity of powdered common salt as it will dissolve, is agitated for several hours, and as much carbonic acid gas is infused into it as it will absorb. The remainder of the operation is the same as before described in the first method of manufacturing sal ammoniac.—*Newton's Journal*, C. S. xxii. 35.

SEMOULE. The name given in France, and used in this country, to denote the large hard grains of wheat flour retained in the bolting machine after the fine flour has been passed through its meshes. The best sémoule is obtained from the wheat of the southern parts of Europe. With the sémoule, the fine white Parisian bread called *gruau* is baked. Skilfnl millers contrive to produce a great proportion sémoule from the large-grained wheat of Naples and Odessa.

SILK. Several pieces of silk were put into my hands, for analysis, on the 18th of February, after I had, on the preceding 12th of the month, visited the St. Katharine's Dock warehouses, in New street, Bishopsgate street, for the purpose of inspecting a large package of the Corahs, per Colonist. I was convinced, by this inspection, that, notwithstanding the apparent pains bestowed upon the tin plate and teakwood packing-cases, certain fissures existed in them, through which the atmospheric air had found access, and had caused iron-mould spots upon the gunny wrapper, from the rusting or oxidizement of the tinned iron.

I commenced my course of analysis upon some of the pieces which were most damaged, as I thought they were most likely to lead me to an exact appreciation of the cause of the mischief; and I pursued the following general train of research :—

1. The piece of silk, measuring from 6 to 7 yards, was freely exposed to the air, then weighed, afterward dried near a fire, and weighed again, in order to determine its hygrometric property, or its quality of becoming damp by absorbing atmospheric vapor. Many of the pieces absorbed, in this way, from one tenth to one eighth of their whole weight; that is, from 1 oz to 1½ oz. upon 13 oz. This fact is very instructive, and shows that the goods had been dressed in the loom, or imbued subsequently, with some very deliquescent pasty matter.

2. I next subjected the piece to the action of distilled water, at a boiling tempera-

ture, till the whole glutinous matter was extracted; five pints of water were employed for this purpose, the fifth being used in rinsing out the residuum. The liquid wrung out from the silk was evaporated first over the fire, but toward the end over a steam bath, till it became a dry extract; which in the damaged pieces was black, like extract of liquorice, but in the sound pieces was brown. In all cases the extract so obtained absorbed moisture with great avidity. The extract was weighed in its driest state, and the weight noted, which showed the addition made, by the dressing to the weight of the silk. The piece of silk was occasionally weighed in its cleansed state, when dry, as a check upon the preceding experiment.

3. The dry extract was now subjected to a regular chemical analysis, which was modified according to circumstances, as follows: 100 parts of it were carefully ignited in a platinum capsule; during which a considerable flame and fetid smoke were disengaged. The ashes or incombustible residuum were examined by the action of distilled water, filtration, as also by that of acids, and other chemical tests, whereby the constituents of these ashes were ascertained. In the course of the incineration or calcination of the extract from the several samples, I never observed any sparkling or scintillation; whence I inferred that no nitre had been used in the dressing of the goods, as some persons suggested.

4. Having, in the course of boiling some of the extract from two of the damaged pieces in a little distilled water, felt a urinous odor, I was induced to institute the following minute course of researches, in order to discover whether the urine of man had been introduced into the dressing paste of the silk webs. I digested a certain portion of the said extract in alcohol, 60 per cent. over proof, which is incapable of dissolving the rice water, or other starchy matter, which might be properly applied to the silk in the loom. The alcohol, however, especially when aided by a moderate heat, readily dissolves urea, a substance of a peculiar nature, which is the characteristic constituent of human urine. The alcohol took a yellow tint, and being, after subsidence of the sediment, decanted clear off into a glass retort, and exposed to the gentle heat of a water bath, it distilled over clear into the receiver, and left a residuum in the retort, which possessed the properties of urea. This substance was solid when cold, but melted at a heat of 220° F.; and at a heat of about 245° it decomposed with the production of water and carbonate of ammonia—the well-known products of urea at that temperature. The exhalation of ammonia was very sensible to the smell, and was made peculiarly manifest by its browning yellow turmeric paper, exposed in a moist state to the fumes, as they issued from the orifice of the glass tube, in which the decomposition was usually effected. I thus obtained perfect evidence that urine had been employed in India in preparing the paste with which a great many of the pieces had been dressed. It is known to every experienced chemist, that one of the most fermentative or putrefactive compositions which can be made, results from the mixture of human urine with starchy or gummy matter, such as rice water; a substance which, by the test of iodine water, these Corahs also contained, as I showed to the gentlemen present, at my visit to the Bonding Warehouse.

5. On incinerating the extract of the Corahs, I obtained, in the residuum, a notable quantity of free alkali; which, by the test of chloride of platinum, proved to be potassa. But, as the extract itself was neutral to the tests of litmus and turmeric paper, I was consequently led to infer that the said extract contained some vegetable acid, probably produced by the fermentation of the weaver's dressing, in the hot climate of Hindostan. I, accordingly, examined the nature of this acid, by distilling a portion of the extract along with some very dilute sulphuric acid, and obtained in the receiver a notable quantity of the volatilized acid condensed. This acid might be the acetic (vinegar), the result of fermentation, or it might be the formic or acid of ants, the result of the action of sulphuric acid upon starchy matter. To decide this point, I saturated the said distilled acid with magnesia, and obtained on evaporation the characteristic gummy mass of acetate of magnesia, soluble in alcohol, but none of the crystals of formiate of magnesia, insoluble in alcohol. From the quantity of alkali (potassa) which I obtained from the incineration of the extract of one piece of the damaged silk, and which amounted to six grains at least, I was convinced that wood ashes had been added, in India, to the mixture of sour rice water and urine, which would therefore constitute a compound remarkably hygrometric, and well qualified to keep the warp of the web damp, even in that arid atmosphere, during the time that the Tanty or weaver was working upon it. The acetate of potassa, present in the said Corahs, is one of the most deliquescent salts known to the chemist: and, when mixed with fermented urine, forms a most active hygrometric dressing—one, likewise, which will readily generate mildew upon woven goods, with the aid of heat and the smallest portion of atmospheric oxygen. By the above-mentioned fermentative action, the carbon, which is one of the chemical constituents of the rice or starchy matter, had been eliminated, so as to occa-

sion the dark stains upon the silk, and the blackness of the extract taken out of it by distilled water.

6. That the dressing applied to the webs is not simply a decoction of rice, becomes very manifest, by comparing the incinerated residuum of rice with the incinerated residuum of the extract of the said Corahs. I find that 100 grains of rice, incinerated in a platinum capsule, leave only about one fifth of a grain, or 1 in 500 of incombustible matter, which is chiefly silicious sand; whereas, when 100 grains of an average extract of several of these Corahs were similarly incinerated, they left fully 17 parts of incombustible matter. This consisted chiefly of alumina or earth of clay, with silica, potassa, and a little common or culinary salt. (Has the clay been added, as is done in Manchester, to give apparent substance to the thin silk web?)

From the above elaborate course of experiments, which occupied me almost constantly during a period of four weeks, I was fully warranted to conclude that the damage of the said goods had been occasioned by the vile dressing which had been put into them in India; which, as I have said, under the influence of heat and air, had caused them to become more or less mildewed, in proportion to their original dampness when packed at Calcutta, and to the accidental ingress of atmospheric air into the cases during the voyage from Calcutta to London.

The following is the list of Corahs which I chemically examined:—

1 and 2, per Colonist, from Calcutta, 2 pieces, sound.—These two pieces had been dressed with a sweet viscid matter, like jaggery or goor (molassy sugar), mixed with the rice water. This extract contained no urine, but emitted a smell of caramel or burned sugar, when ignited. It amounted to 270 grains in the one, and 370 in the other.

3, ditto, 1 piece, mildewed, 1st degree.—This piece had been dressed like No. 5, and contained no trace of urine. It afforded 400 grains of a most deliquescent sweetish glutinous matter.

4, ditto, 1 piece, mildewed, 1st degree, as No. 3.

5, ditto, 1 piece, mildewed, 3d degree.—This piece contained no trace of urine, but it afforded 210 grains of a light brown extract, being rice water, mixed with something like jaggery.

6, ditto, 1 piece, 3d degree, mildewed.—This piece afforded evidence of urine in it, by test of carbonate of ammonia. The extract amounted to 320 grains.

8, ditto, 2 pieces, damaged in the 3d degree.—The total weight of one of these pieces, after exposure to air, was 4,610 grains, and it lost 440 grains by drying. The total weight of the other was 4,950 grains, and it lost 320 grains by drying. The weight of extract was, in one piece, 210 grains; and both pieces contained abundant traces of urine, as well as of potash. These constituents, along with the rice water, accounted sufficiently for the great damage of these two pieces by mildew.

10, ditto, 2 pieces, sound.—These contained no urea. Each afforded from 300 to 500 grains of a light brown vegetable extract.

12, ditto, 2 pieces.—The extract in the one amounted to 222 grains, and in the other to 330. Both contained urea, and had, therefore, been imbued with urine.

14, ditto, 2 pieces, mildewed, 3d degree.—There was no urea in the extracts from these two pieces; but they afforded, the one 300 grains of extract, and the other 750. But this extract was a saccharine molassy matter, impossible to dry over a steam heat. The same quantity as the last, if dried by stronger means, would have weighed probably 600 grains. Its extraordinary deliquescence kept the pieces very moist, and thereby caused the mildewing of them. With the saccharine matter, four per cent. of culinary salt was mixed in one of these extracts.

16, ditto, 2 pieces, 3d degree of mildew.—The extract, about 200 grains, contained abundant evidence of urea, and, consequently of urine.

18, ditto, 2 pieces, sound.—Both these contained some traces of urea; but the one yielded only 102 grains of extract, and the other 370 grains. They must have been well screened from the air to have resisted the action of the urine.

20, ditto, 2 pieces, damaged, 1st degree.—No urea. The extract of the one was 320 grains; of the other piece 380; and it had a light brown color, being a saccharine mucilage.

22, ditto, 2 pieces, 3d degree mildew.—200 grains of extract in the one, and 210 in the other: they contained urea.

24, 2 pieces, 3d degree of mildew.—310 grains of extract in the one, and 180 grains in the other. Both were impregnated with urea, and consequently with urine.

Having in the preceding report demonstrated, by the clearest processes of chemical research, that the above mildewed Corahs had been damaged by the fermentative decomposition of the dressing paste with which they had been so abundantly impregnated, I would recommend the importers of such goods to cause the whole of the dressing to be washed out of them, and the pieces to be thoroughly dried, before being packed up.

I believe that clean silk may be kept and transported, even in the most humid atmosphere, without undergoing any change, if it be not imbued with fermentative paste.

I examined eight other pieces of a different mark, imported by another mercantile house, per Colonist, and they afforded results similar to the above.

SILVER, *Extraction of from Lead; Pattinson's process.*—The desilverizing apparatus of Locke, Blackett, and Co., consists of seven crystallizing pots, and one smaller pot for receiving the desilvered lead. They are all made of cast iron, and arranged in a straight line.

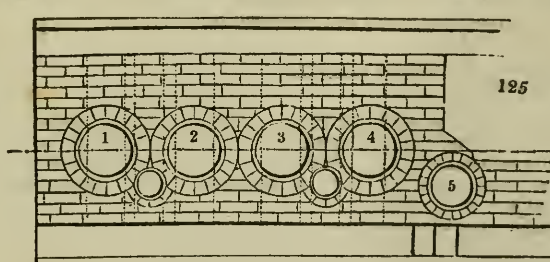
The lead in each pot varies in its contents of silver.

	oz.	oz.
The first containing 85 cwts. lead, at about 60 oz. of silver, or 1 544ths per ton		255
Is divided into 55 cwts. crystals carried to second pot, at 35 oz. per ton -	96	
18 cwts. do. to be put in first pot again, at 64 oz. per ton	57	
and 12 cwts. rich lead to be cupelled, at 170 oz. per ton - -	102	
	——	255
The second pot containing 90 cwts. lead, at about 35 oz. silver per ton -		157
Is divided into 60 cwts. crystals carried to third pot, at 20 oz. per ton -	60	
and 30 cwts. lead put into first pot, at 65 oz. per ton - -	97	
	——	157
The third pot containing 90 cwts. of lead, at about 20 oz. per ton - -		90
Is divided into 55 cwts. crystals carried to fourth pot, at 10 oz. per ton -	27	
and 25 cwts. lead put into second pot, at 36 oz. per ton - -	63	
	——	90
The fourth pot containing 80 cwts. lead, at about 10 oz. per ton - -		40
Is divided into 55 cwts. crystals, carried to fifth pot, at $5\frac{1}{2}$ oz. per ton -	15	
and 25 cwts. lead put into third pot, at 20 oz. per ton - -	25	
	——	40
The fifth pot containing 80 cwts. lead, at about $5\frac{1}{2}$ oz. silver per ton - -		22
Is divided into 55 cwts. crystals, put into sixth pot, at 3 oz. per ton - -	$8\frac{1}{4}$	
and 25 cwts. lead, put into fourth pot, at 11 oz. per ton - -	$13\frac{3}{4}$	
	——	22
The sixth pot containing 80 cwts. lead, at about 3 oz. per ton - - -		12
Is divided into 55 cwts. crystals, carried to seventh pot, at $1\frac{1}{2}$ oz. per ton -	$4\frac{1}{2}$	
and 25 cwts. lead, put into fifth pot, at 6 oz. per ton - - -	$7\frac{1}{2}$	
	——	12
The seventh pot containing 55 cwts. lead, at about $1\frac{1}{2}$ oz. per ton - -		4
Is divided into 25 cwts. crystals, carried to small pot, at $1\frac{1}{2}$ oz. per ton -	$\frac{1}{2}$	
and 30 cwts. lead, put into sixth pot, at $2\frac{1}{2}$ oz. per ton - -	$3\frac{1}{2}$	
	——	4

The above 25 cwts. of crystals are melted and cast into pigs and sent to the market.

In operating upon lead containing about 10 oz. per ton, the fourth pot is filled with it; if it should contain 20 oz., or thereabouts, it is put into the third pot; and so of any other.

Fig. 125 represents the arrangement of the iron pots or caldrons, in their order.



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The desilvering apparatus represented in *fig.* 125 is composed of five caldrons of cast iron, each heated by its own fire, besides two smaller pots, similarly heated. The caldrons rest by their upper flange and surface upon bricks properly formed and arranged. Their shape is not hemispherical; their mouth is 40 inches in length, but only 26 inches in width. Over the door of the fireplace, the mouth stands 8 feet 4 inches above the ground or bottom of the ash-pit, of which space, 18 inches intervene between the grate and the brim. The grate is 2 feet long and 8¾ inches wide. All the caldrons have the same elliptic form, with a bottom like the small end of an egg. The fifth alone is smaller, but this one serves merely to melt the lead which has been stripped of its silver, in order to be cast into salmons or blocks.

The charge consists of 64 or 65 salmons, each weighing from 120 to 140 lbs. When they are well melted, the fire is removed from the grate, as well as the small film of litharge from the surface of the metal; and one or two salmons are added to accelerate the cooling, or sometimes, instead, a little soapy water is sprinkled into the caldron, whereby a crust of lead is formed, which being pushed down into the mass, melts with ebullition. This is repeated till the whole becomes sufficiently cool, that is, when crystals begin to form. The lead concreted round the sides being now detached, the whole is stirred with an iron bar, by a motion in a vertical plane, and varying its posture in this plane. During this operation, intended to establish a uniform temperature throughout the mass, a second workman heats in the smaller pot adjoining to No. 1 a large skimmer at the end of a long wooden handle, and next proceeds to fish out the crystals, taking care to let them drain off for a few seconds all the liquid lead among them, and then turns out the crystals slowly into the next caldron, No. 2; the second workman meanwhile adds the metal solidified round the sides, and stirs all together to equalise the temperature. These two-fold operations occupy about fifty minutes; by which time, there remains in the caldron about 16 salmons. The workman now lifts out the crystals, as before, with the drainer, and throws them upon the ground in two heaps. His assistant takes them up a little while afterward, and puts them away to make room for fresh crystals, which the first workman continues to throw down. This process goes on till only 8 salmons remain in the caldron, a point ascertained by gauging the height to the bath. The fire being at this time removed from cauldron No. 2 into the grate of No. 1, the 8 salmons of lead enriched with silver, which remain at the bottom of the caldron, are run out into movable moulds; and the 8 salmons which were thrown upon the ground are put into it; the full charge being then made up with salmons of the same richness as those previously used.

While this mass is melting in No. 1 the process just finished in it is repeated in No. 2. About three fourths of the metallic mass is next separated in the state of crystals, which are transferred to No. 3, and also one eighth of crystals thrown on the ground, after pouring the remaining one eighth at the bottom of caldron No. 2 not into moulds, but into No. 1.

A like process is performed in caldrons 3 and 4; and the poor lead taken out of 4 is transferred to 5 to be melted, and run into salmons, which are submitted afresh to the preceding series of crystallizations, provided the lead still contains a sufficient proportion of silver.

The following Table will place the results of the above successive operations in a clear light:—

		Silver in 1 Ton of Lead.
Original lead	- - - - - -	0·001153
1. Rich crystals	- - - - - -	0·003324
2. Poor ditto	- - - - - -	0·000933
—Rich ditto	proceeding from the treatment of the preceding No. 2 poor crystals	0·0020802
3. Poor ditto		0·0007021
4. Rich	proceeding from the treatment of No. 3 poor crystals	0·001399
—Poor		0·0004569
—Rich	as above from No. 4	0·0008135
(Lead) poor		0·0001128

We thus see, that four crystallizations, repeated upon the original lead from the smelting furnace, of the above richness, will afford a lead ten times poorer. With a lead originally containing only 0·0002248 in silver, three crystallizations would suffice to make it ten times poorer. In general, the poorer the lead, within certain limits, the better adapted is it to this process.

SILVERING. See Electrotype.

SLIDES. The name given by the Cornish miners to clay veins of more modern formation.

SMELTING IRON FURNACES, commonly called BLAST FURNACES. Several of these furnaces, as mounted near Glasgow, deserve to be made known, on account of the economy of their construction, the advantage of their form, and the amount of their performance.

Fig. 126 represents one of the smallest of these, which measures from the line at the bottom to the top 48 feet, from which all the other dimensions may be estimated. It produces a soft cast iron for casting into moulds and for melting in the cupola. *Figs*. 127 and 128 represent a much larger furnace, being from the top, to the line A, B, C, D, 60 feet high. A few have been built still larger. This furnace has a double case, each of which consists of fire-bricks. This case is enclosed by common bricks, and these by a wall of stone masonry. The successive rows of bricks are laid stair-wise, having the

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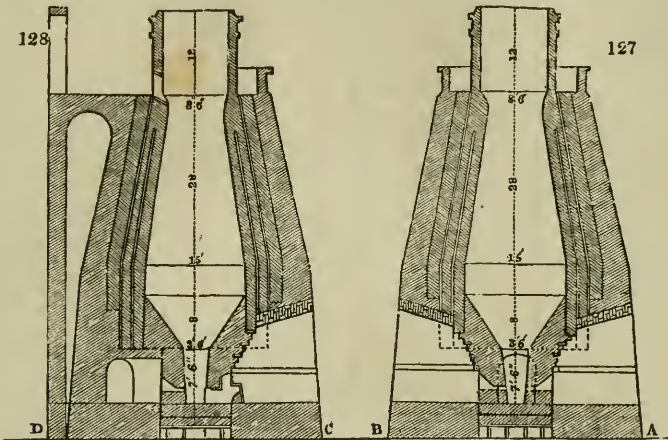

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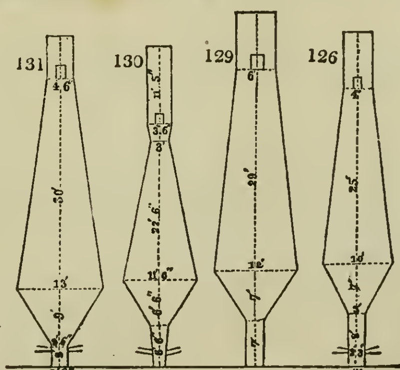
angular retreat filled up with fire-clay. *Fig.* 131 is a modern furnace of very large dimensions, as the numbers upon it show.

131 130 129 126



William Jessop, Esq., proprietor of the great iron works of Butterley and Codner Park in Derbyshire, has invented a very elegant and effective apparatus for feeding his blast furnaces with fuel, *mine* (calcined ironstone), and limestone in due proportions, and equally distributed round the inside of the furnace. *Figs.* 132, 133, represent this feed-apparatus. *Fig.* 132, shows at A, an outline of the furnace, and at B, the line of entrance into its throat. C, is the feed mechanism. It consists of a long balance lever barrow, D, E; D, being an iron cylinder, open at top and bottom, 4 feet in diameter and $2\frac{1}{2}$ feet in height, in the inside of which a hollow cone of iron is suspended, with its apex uppermost, so that while the base of the cone is kept above the level of the bottom of the cylinder it shuts it; but on the cone being lowered below that level, it allows the charge of materials resting all round on the slant surface of the cone to fall down equally round the side of the cylinder into the furnace. In *fig.* 133 the barrow lever, D, E, is seen in profile or vertical section; *a*, is the fulcrum wheel, upon which the lever is in equilibrio when 9 cwt. of coals are put into the cylinder; then a weight is hung on, near the end, E, of the lever, as an equipoise either to 9 or 12 cwt. of mine, according to circumstances; and next, a weight to balance one third of that weight of limestone. These weights of materials being introduced into the cylinder, while the barrow rests upon a level with the line E D, it is then rolled forward into its place, as shown in the figure, upon the wheels, *b*, *b*, upon a platform sustained on the top of an inverted cylinder within the cast-iron column, into which cylinder air is admitted (through a valve opened by the workman) from the furnace blast, the air passing up the

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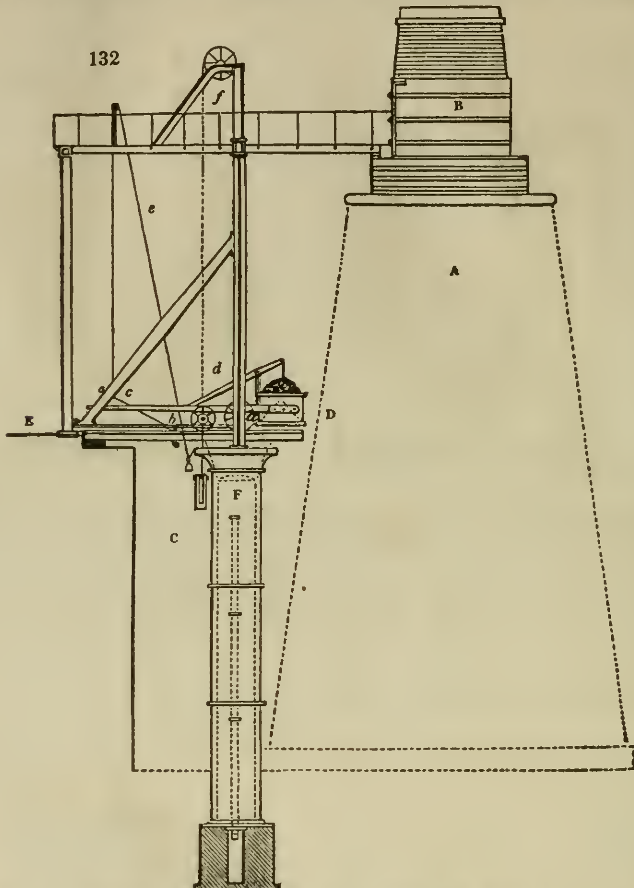
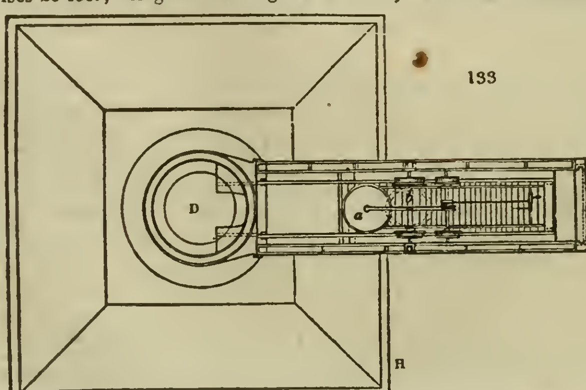


tube seen in the axis of F. The inverted air-cylinder is 3½ feet in diameter, 36 feet long, and rises 25 feet; being made air-tight with water, it ascends in its columnar case,



133

which is 4 feet in diameter, without friction. The space, G H, *fig.* 133, is 36 feet square.

The iron cone, which serves as a valve to the charging-drum or cylinder, is raised and lowered by means of a chain passing round a worm-wheel, which is turned round by an endless screw, acted upon by the long rod at *c*, which the workman can move by hand at pleasure, thereby lowering or raising the end of the short lever, *d*, to which the valve cone is suspended. The cord by which the workman opens or shuts the air piston-valve is seen at *e*, *f*. I have viewed with much pleasure the precise and easy movements of this feed-apparatus, at an excellent blast furnace in Codner Park iron works.

SMOKE PREVENTION. Among the fifty several inventions which have been patented for effecting this purpose, with regard to steam-boiler and other large furnaces, very few are sufficiently economical or effective. The first person who investigated this subject in a truly philosophical manner was Mr. Charles Wye Williams, managing director of the Dublin and Liverpool Steam Navigation company, and he also has had the merit of constructing many furnaces both for marine and land steam-engines, which thoroughly prevent the production of smoke, with increased energy of combustion, and a more or less considerable saving of fuel, according to the care of the stoker. The specific invention, for which he obtained a patent in 1840, consists in the introduction of a proper quantity of atmospheric air to the bridges and flame-beds of the furnaces, through a great number of small orifices, connected with a common pipe or canal, whose area can be increased or diminished, according as the circumstances of complete combustion may require, by means of an external valve. The operation of air thus entering in small jets into the half-burned hydro-carburetted gases over the fires, and in the first flue, is their perfect oxygenation, the development of all the heat which that can produce, and the entire prevention of smoke. One of the many ingenious methods in which Mr. Williams has carried out the principle of what he justly calls his Argand furnace, is represented in *fig.* 134, where *a* is the ash-pit of a steam boiler furnace; *b*, is the

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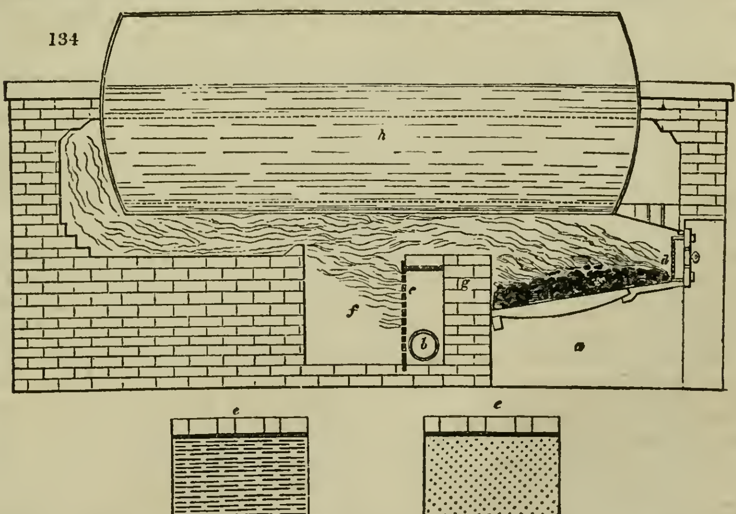

mouth of a tube which admits the external air into the chamber or iron box of distribution, *c*, placed immediately beyond the fire-bridge, *g*, and before the diffusion or mixing chamber, *f*. The front of the box is preforated either with round or oblong orifices, as shown in the two small figures *e*, *e* beneath *fig.* 134; *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 fireplace, are constructed of perforated fire-tiles, enclosed in common brickwork, with an intermediate space, into which the air may be admitted in regulated quantity through a moveable valve in the door. I have seen a fireplace of this latter construction performing admirably, without smoke, with an economy of one seventh of the coals formerly consumed in producing a like amount of steam from an ordinary furnace; *h* is the steam boiler.

Very ample evidence was presented last 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 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, that when the fire was left to burn in the usual way, and with the production of the usual volumes of smoke. It is to be hoped, that a law will be enacted in the next session of parliament for the suppression, or at least abatement, of this nuisance, which so greatly disfigures and pollutes many parts of London, as well as all our manufacturing towns, while it acts injuriously on animal and vegetable life. Much praise is due to Mr. Williams for his indefatigable and disinterested labors in this difficult enterprise, and for his forbearance under much unmerited obloquy from narrow-minded prejudice and indocile ignorance.

SOAP. Several contrivances upon this subject have bustled over the patent stage within these few years; such as Mr. Dunn's for making soap rapidly at a temperature of 310° Fahr. under high steam pressure, by which many credulous shareholders were gulled into a belief that they would realize by this joint-stock project 200,000*l.* per annum. The soap so made was merely swelled in size and weight, by being surcharged with water, so that in a few weeks, the bars of it shrunk, rent, and twisted into mere skeletons; and being in this plight, returned to the company by their customers, caused that large soap bubble to burst.

Mr. Sheridan's silica soap had a somewhat longer career, but is now also nearly consigned to oblivion. Causticity and abrasiveness were the chief characteristics, resulting from the mixture of a strong solution of silicate of soda, or liquor of flints, with soap made in the common way.

The invention for which Dr. Normandy obtained a patent merits a better fate. When yellow soap is made with the cheaper kinds of fat, it will hardly acquire a sufficient degree of firmness or hardness to satisfy the thrifty washerwoman. It melts away too rapidly in the hot water; a defect which may be well remedied by the introduction into the soap of a little fused sulphate of soda; and the salt concreting gives the soap a desirable hardness, while it improves its color, and renders it a more economical article for the washing-tub. In a trial recently before the court of common pleas, it was proved that the soap made according to Dr. Normandy's patent was worth fully 2*l.* a ton more than the original soap, without the sulphate of soda.

Mr. Dunn has recently obtained a patent for accelerating the process of soap-making; he promotes the combination of the alkali, fat, and water, by pumping streams of atmospheric air through the saponaceous materials, while exposed to the usual heat in the pan. This scheme is said to effect its purpose, and to save much time.

SODA. On the 30th of June, 1838, Messrs. Dyar and Hemmings obtained a patent for manufacturing soda by the decomposition of sea salt with sesqui-carbonate or bicarbonate of ammonia. Equal parts of the chloride of sodium and sesqui-carbonate are prescribed, being very nearly the equivalent decomposing proportions, and the ammonia salt is recommended to be added in powder to a saturated solution of the sea salt, and the mixture to be stirred and then set aside till the mutual action and decomposition be effected. Having been employed to examine this process for a gentleman who wished to adopt it upon a manufacturing scale, I obtained the following results: On making the prescribed mixture in the cold, brisk effervescence takes place, because the quantity of carbonic acid combined with the ammonia is greater than the resulting soda can readily absorb, even to form its bicarbonate, and this extrication of gas carries off with it more or less ammonia, amounting, in carefully conducted experiments, to no less than 27 per cent. of the sesqui-carbonate employed; though the magma deposited from the mixture was drained in vessels nearly close, and though the ammonia which adhered to it, as well as that in the drained mother liquors, was recovered by distillation in vessels connected with a Woulfe's apparatus. Moreover, the utmost amount of soda-ash (not pure carbonate) which was obtained, was only 37·5 for 100 of sea salt used, whereas 90 of carbonate should result from 100 of the sea salt, with the above equivalent dose of sesqui-carbonate of ammonia. This latter salt contains about one half more carbonic acid than is required by the soda to become a carbonate. A good illustration of the loss of ammonia in a similar case is afforded by the decomposition of chloride of calcium in solution, by adding to it the equivalent dose of pulverized ammonia carbonate; viz., 56 of the former and 59 of the latter. The rapid extrication of the carbonic acid on making this mixture, causes such a waste of ammonia, that more of the sesqui-carbonate must be afterward introduced, to complete the decomposition of the chloride; the stronger the solution of the chloride the greater is the loss of ammonia.

In one of my experiments where were employed 3500 grains=half a pound avoirdupois, of each ingredient, the following were the products :—

	Grains.
1. Ammonia recovered by distillation from the drained magma, equivalent in sesqui-carbonate to - - - - - - -	257
2. Ammonia as carbonate, from the remaining liquid, sucked into a vacuous apparatus and distilled - - - - - -	1509
3. Additional ammonia as carbonate, obtained from the cold mother liquors, by distillation with quicklime, and out of the sal ammoniac formed - - - - - - - - - -	775
	2541
Sesqui carbonate employed - - - - - - - -	3500
Loss - - - - - - -	959

or 27·4 per cent.

The product from this experiment in dry soda ash was only 1500 grains, which were

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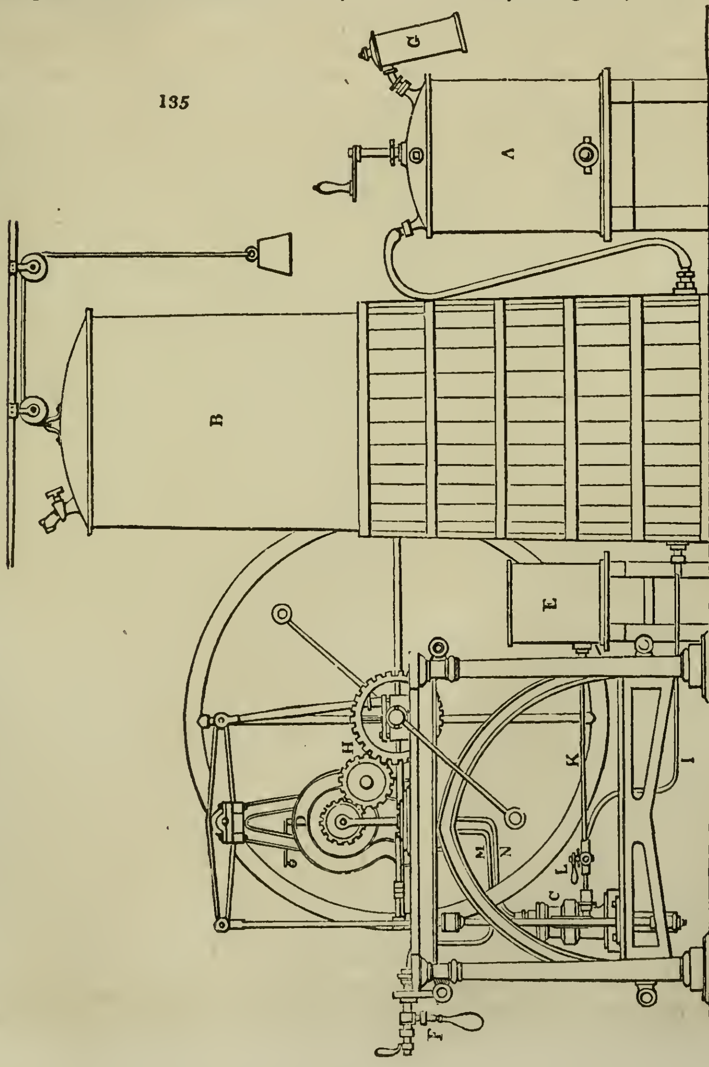

found to contain only 1,312 of pure carbonate, or 87·5 per cent. of the whole. Here is a deficiency of soda carbonate, upon the quantity of the chloride used, of no less than 58½ per cent., for only 1,312 grains are obtained instead of 3,150.

Subsequently a method occured to me, whereby this process, elegant in a scientific point of view, might possibly be executed with advantage upon the commercial scale; but it would require a very peculiar apparatus, though not nearly so costly as what was erected by Mr. Cooper under the direction of the patentees at Battersea, and in Brussels.

SODA-WATER. At page 21 of vol. x. of the conjoined series of Newton's Journal, the patent apparatus of Mr. F. C. Bakewell, of Hampstead, for making soda-water, is well described with illustrative figures. The patent was obtained in March, 1832, but how far it has been introduced into practice I have not heard. Its arrangement discovers ingenuity, but it seems less likely to prove durable than the patent apparatus of Mr. Tyler, which *fig.* 135 in the preceding page represents according to his latest specification. A, is the gas generator, where the chalk and sulphuric acid are mixed; B, the gasometer; C, the soda-water pump, for forcing in the gas; D, the condenser; E, the solution (of soda) pan; F, the bottling cork; G, the acid bottle, at the right hand shoulder of A; H, the wheels, for working the agitator in the condenser; I, the pipe, for conveying the gas to the pump; K, pipe for conveying the solution to the pump; L, cocks for regulating the admission of the gas into the solution; M, drawing-off pipe leading to the bottling cork; N, the forcing pipe from the pump to the condenser.

The vessel in which the soda-water is condensed is lined with silver in order to resist corrosion.

SOLDERING OF LEAD, *and other metals*, 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. He effects this purpose, by directing a jet of burning hydrogen gas, from a small movable beak, upon the two surfaces or edges to be soldered together. Metals thus joined are much less apt to crack asunder at the line of union, by differences of temperature, flexure, &c., than when the common soldering processes are employed. The fusing together the edges of lead sheets, for making sulphuric acid chambers, has been long practised in this country, but it was performed by pouring some of the melted metal along the line of junction, and afterward removing its excess by means of a plumber's soldering iron. The method of M. Richemont is a great improvement upon that old practice. It is much quicker and more convenient.

SPINNING. The greatest improvement hitherto made in forming textile fabrics, since the era of Arkwright, is due to Mr. G. Bodmer, of Manchester. By his patent inventions the several organs of a spinning factory are united in one self-acting and self-supplying body—a system most truly *automatic*. His most comprehensive patent was obtained in 1824, and was prolonged by the Judicial Committee of the Privy Council, for 7 years after the period of 14 years was expired. It contained the first development of a plan by which fibres of cotton, flax, &c., were lapped and unlapped through all the operations of cleaning and blowing, carding, drawing, roving, and spinning; in the latter, however, only as far as the operation of feeding is concerned. The lapping from the blower was then not new, but the lapping directly and in connexion with the carding engines was his invention, and was brought by him into operation at St. Blaize in the Black Forest, several years before he took out his patent

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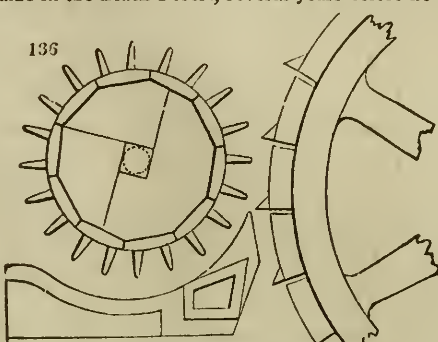

Patent of 1835.

in England. The method applied through all the following operations was then new. Mr. Dyer's and several other patents granted subsequently were decided and acknowledged infringements. The patent of 1824 was the beginning; the result of which was the several patents for improvements in 1835, 1837, 1838, and 1842, of Mr. Bodmer.

By a machine generally called a Devil or Opener ("Wolf," in German), which consists of a feeding-plate set with teeth and a roller covered with spikes (see *fig.* 136), 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.* 137, without teeth, and over this plate the cotton is delivered to the operation of the common beaters, from which it is received

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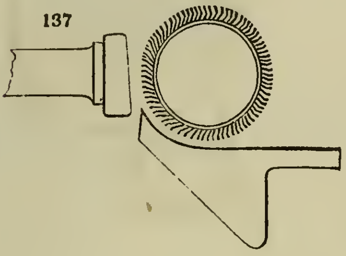

Patent of 1835.

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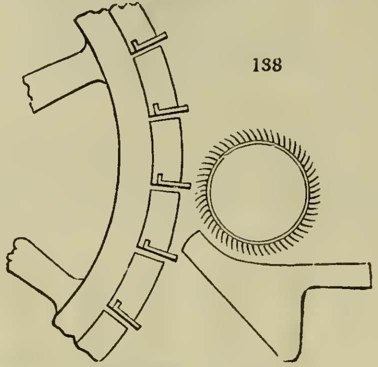

Patents of 1824 *and* 1835.

into a narrow compartment of $4\frac{1}{2}$ or 5 inches broad, and wound, by means of his lap-machines, upon rollers in beautifully level and well-cleaned laps. Eight of these narrow laps are then placed behind a second blower, of a similar construction to the first. Instead of the common beater, however, a drum with toothed straight edges is used (see *fig.* 138), 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.—His patent of 1824 showed a mode of coupling a number of carding engines, the product of which was delivered upon an endless belt or a trough, and at the end of this trough was wound upon a roller. This arrangement wants no description, as it is generally known. I have seen it in use on the Continent.

When a set of cards work together, any interruption or stoppage of a single carding engine causes a defect in the produce of the whole lap. Interruption 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.* 139), 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.* 140, and 141, give an idea of the clearer: the mechanism within the clearer,

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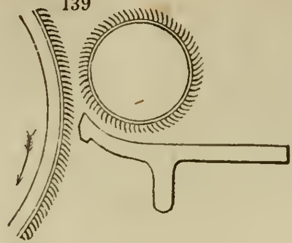

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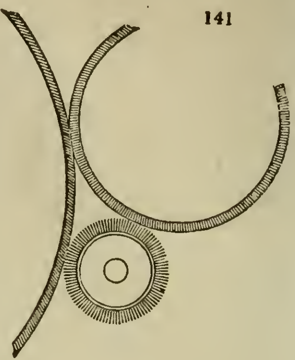

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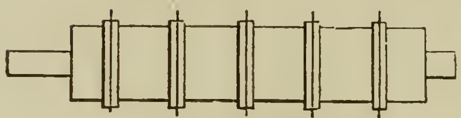

Patents of 1838 *and* 1842.

and by which the brushes, *a*, are caused to travel, is simple and solid. The main cylinders for the carding engines are made of cast iron, the two sets of arms and rim 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.* 142 and 143.) The twist is given by tubes in two directions, so that it remains in it (see *fig.* 143), 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 can not be formed under pressure. Coiling in cotton can not be claimed, as it was done in the first system of cotton spinning.

Coil Frame.—The bobbins (*fig.* 142), 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.* 144), 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 calender rollers, A, and cause the rovings to be laid down in a spiral line closely one by one, and as the rollers, A, work at a regular

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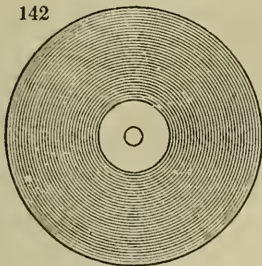

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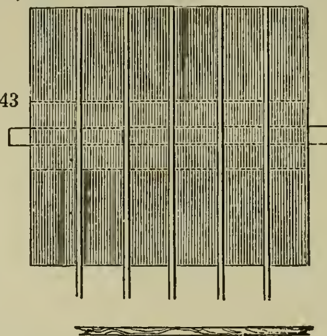

Patents of 1835, 1838, *and* 1842,

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

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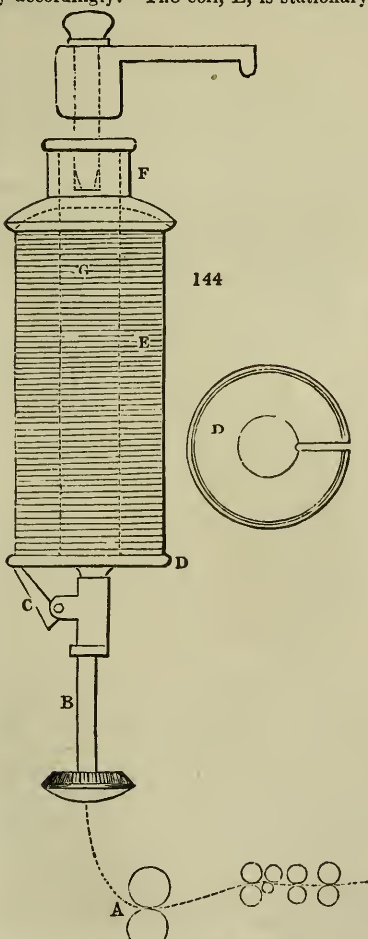

Patents of 1838 *and* 1842.

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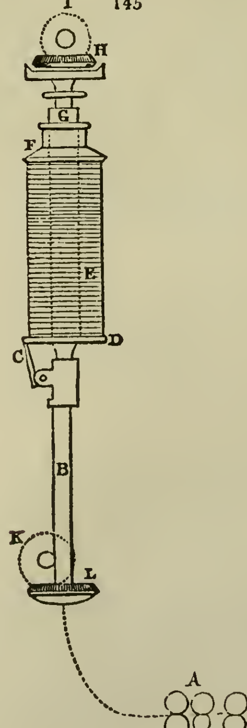

Patents of 1838 *and* 1842.

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 $4\frac{1}{2}$ lbs. of cotton. Mr. Bodmer has several modes of forming these coils, but one only is shown here. These coils are placed behind the twist coil frames in half cans or partly open ones or troughs, or behind a winding machine, where they are wound upon rollers side by side, like the lap or bobbin shown in the drawing frame, and placed behind the twist coil frame in this state.

Twist Coil Frame.—This frame forms rovings into coils similar to those above explained, with this difference, that the rovings are fine, say, from 1 to 10 hanks per pound, and regularly twisted: their diameter varies from $2\frac{1}{2}$ to 5 inches. The same machine produces 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.* 145.) 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 speeds 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, *a* (see *fig.* 146), on each machine, for the purpose of

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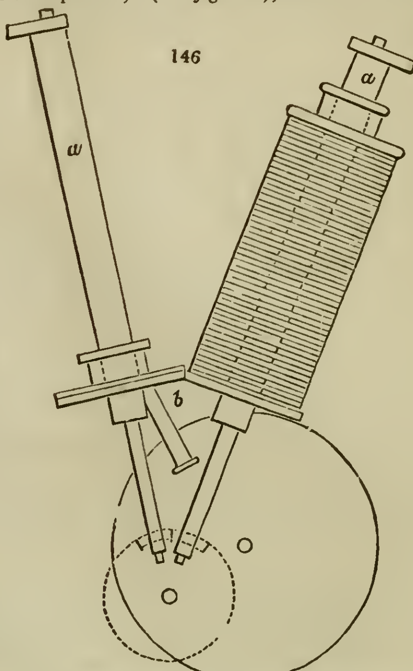
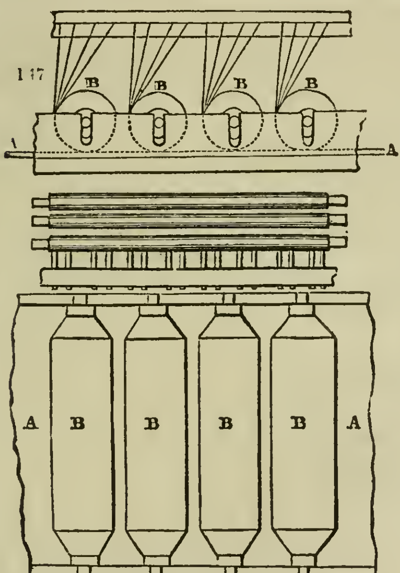


Patents of 1842

doffing without stopping the drawing frame or 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.

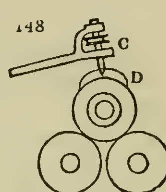
Mr. B. forms coils in various ways, also in cans; but this description is sufficient to show the application of this mode of winding up bands or rovings. Several of the above-described machines are adopted with equal success to wool and flax. In his patents of 1835, 1837, and 1838, he shows several modes of applying his system to cotton and other machinery. He winds directly from the carding engines the slivers separately upon long bobbins, and he gives them twist in two directions, for the purpose of uniting the fibres to some extent, so that they not only come off the bobbins without sticking to one another, but also that they may draw smoother. He also showed a machine, by which several rovings, say 4 or more, are put upon the same bobbin with conical ends; these bobbins are placed behind the mules or throstles, and are unwound by a belt or strap running parallel with the fluted rollers of the spinning machine, as seen in *fig.* 147. The belt or band, A, is worked in a similar way to that described in his former patent, and the bobbins, B, rest upon and revolve upon their surface, exactly according to the speed of the belt. It is quite evident that the whole set of rovings must be unwound exactly at the same speed, and that no stretching can take place. He can put real and reversed twist in these rovings as well as false twist only. The most important feature in the roving machine is a metal plate, in which a slot is formed through which the rovings pass; this slot is seen in *figs.* 148, 149, and 150. The cotton, when coming from

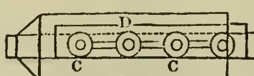
147



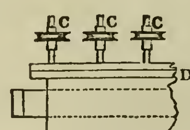
Patent of 1835.

148





149



150

151

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.* 151, 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.* 151. 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.

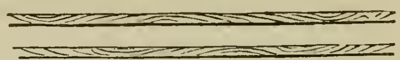
Rovings wound upon bobbins by means of tubes revolving in one direction, are certainly not so fit for spinning as rovings into which a small degree of twist is put. The tube by which a twist is put in on one side and taken out at the other, curls or ruffles the cotton, and causes it to spread out as it passes between the rollers, while rovings with a little permanent twist in them are held together in the process of drawing, and thus produce smooth yarn. To remedy the evil above described, when untwisted rovings are used, he causes the spouts or guides, through which the rovings pass into or between the drawing rollers, to revolve slowly first in one, and then in the other direction, and thus puts a certain quantity of twist into the rovings while they are being prepared for spinning. Two modes of performing this operation are clearly described in his patent of 1835.

There is a little defect in the working of the rovings with reversed twist when too much or too little twist is put in them, or when the winding machine is not kept in good order. This defect proceeds from the change in the twist of the roving seen at A, *fig.* 152; in this place the twist is not like that at B, and it would, in some parts of the

152

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.* 153: in this case the reversing place of one roving meets the twisted place of the other, and the fault is completely rectified.

153



The preceding description given 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.* 154; *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

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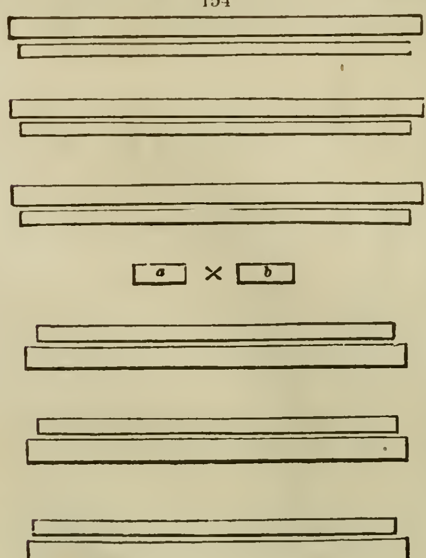
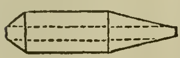


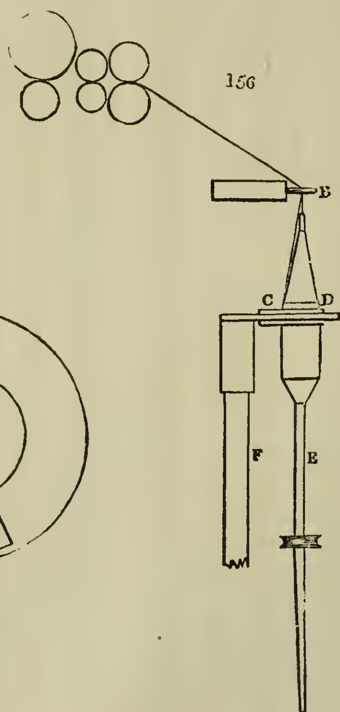
as the creels behind the mules are not wanted in his system, this impediment to the sight of the girl would be removed. He schemed these machines for the purpose of altering, at a trifling expense, the common mules into self-actors; they are equally good for any numbers of yarn.

Bastard Frame.—In his patent of 1838 and 1842, we find the description of a very simple bastard frame, namely, a throstle with mule spindles, forming cops, as seen in *fig.* 155, and wound so hard that they can be handled about without any danger of spoiling them; in the same dimensions they contain one third more yarn than the best cops of self-actors. The machine is extremely simple; but owing to some circumstances in the construction of the winders and plates, he has not been able to spin advantageously upon large machines above No. 20's. He has spun on it No. 56, and most beautiful yarn. The quantity this machinery produces is nearly one third more than the best self-actor, on an equal number of spindles, and the yarn and cops are much superior. Of course there is a copping motion connected with the machine: the winding, however, is continuous, as well

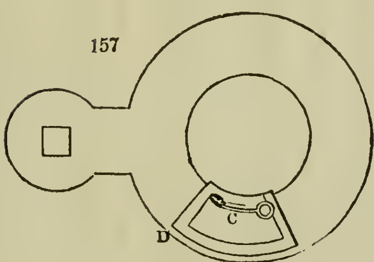
155



156



157



Patents of 1838, *and* 1842.

as the twisting, and *figs.* 156 and 157, 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.

SPIRITS. Correspondence between Specific Gravity and per Cents. over Proof at 60° F.

Specific Gravity.	Per Cent. Over Proof.	Specific Gravity.	Per Cent. Over Proof.	Specific Gravity.	Per Cent. Over Proof.	Specific Gravity.	Per Cent. Over Proof.
0·8856	67·0	·8455	51·7	·8748	33·4	·9056	11·4
·8160	66·8	·8459	51·5	·8751	33·2	·9060	11·1
·8163	66·6	·8462	51·3	·8755	32·9	·9064	10·8
·8167	66·5	·8465	51·1	·8758	32·7	·9067	10·6
·8170	66·3	·8469	50·9	·8762	32·4	·9071	10·3
·8174	66·1	·8472	50·7	·8765	32·2	·9075	10·0
·8178	65·6	·8476	50·5	·8769	32·0	·9079	9·7
·8181	65·8	·8480	50·3	·8772	31·7	·9082	9·4
·8185	65·6	·8482	50·1	·8776	31·5	·9085	9·2
·8188	65·5	·8486	49·9	·8779	31·2	·9089	8·9
·8192	65·3	·8490	49·7	·8783	31·0	·9093	8·6
·8196	65·1	·8493	49·5	·8786	30·8	·9097	8·3
·8199	65·0	·8496	49·3	·8790	30·5	·9000	8·0
·8203	64·8	·8499	49·1	·8793	30·3	·9104	7·7
·8206	64·7	·8503	48·9	·8797	30·0	·9107	7·4
·8210	64·5	·8506	48·7	·8800	29·8	·9111	7·1
·8214	64·3	·8510	48·5	·8804	29·5	·9115	6·8
·8218	64·1	·8513	48·3	·8807	29·3	·9118	6·5
·8221	64·0	·8516	48·0	·8811	29·0	·9122	6·2
·8224	63·8	·8520	47·8	·8814	28·8	·9126	5·9
·8227	63·6	·8523	47·6	·8818	28·5	·9130	5·6
·8231	63·4	·8527	47·4	·8822	28·3	·9134	5·3
·8234	63·2	·8530	47·2	·8825	28·0	·9137	5·0
·8238	63.1	·8533	47·0	·8829	27·8	·9141	4·8
·8242	62·9	·8537	46·8	·8832	27·5	·9145	4·5
·8245	62·7	·8540	46·6	·8836	27·3	·9148	4·2
·8249	62·5	·8543	46·4	·8840	27·0	·9152	3·9
·8252	62·3	·8547	46·2	·8843	26·8	·9156	3·6
·8256	62·2	·8550	46·0	·8847	26·5	·9159	3·3
·8259	62·0	·8553	45·8	·8850	26·3	·9163	3·0
·8263	61·8	·8556	45·6	·8854	26·0	·9167	2·7
·8266	61·6	·8560	45·4	·8858	25·8	·9170	2·4
·8270	61·4	·8563	45·2	·8861	25·5	·9174	2·1
·8273	61·3	·8566	45·0	·8865	25·3	·9178	1·9
·8277	61·1	·8570	44·8	·8869	25·0	·9182	1·6
·8280	60·9	·8573	44·6	·8872	24·8	·9185	1·3
·8284	60·7	·8577	44·4	·8876	24·5	·9189	1·0
·8287	60·5	·8581	44·2	·8879	24·3	·9192	0·7
·8291	60·4	·8583	43·9	·8883	24·0	·9196	0·3
·8294	60·2	·8587	43·7	·8886	23·8	·9200	Proof.
·8298	60·0	·8590	43·5	·8890	23·5	Under	Proof.
·8301	59·8	·8594	43·3	·8894	23·2	·9204	0·3
·8305	59·6	·8597	43·1	·8897	23·0	·9207	0·6
·8308	59·5	·8601	42·8	·8901	22·7	·9210	0·9
·8312	59·3	·8604	42·6	·8901	22·5	·9214	1·3
·8315	59·1	·8608	42·4	·8908	22·2	·9218	1·6
·8319	58·9	·8611	42·2	·8912	21·9	·9222	1·9
·8322	58·7	·8615	42·0	·8915	21·7	·9226	2·2
·8326	58·6	·8618	41·7	·8919	21·4	9229	2·5
·8329	58·4	·8622	41·5	·8922	21·2	·9233	2·8
·8333	58·2	·8625	41·3	·8926	20·9	·9237	3·1
·8336	58·0	·8629	41·1	·8930	20·6	·9241	3·4
·8340	57·8	·8632	40·9	·8933	20·4	·9244	3·7
·8344	57·7	·8636	40·6	·8937	20·1	·9248	4·0
·8347	57·5	·8639	40·4	·8940	19·9	·9252	4·4
·8351	57·3	·8643	40·2	·8944	19·6	·9255	4·7
·8354	57·1	·8646	40·0	·8948	19·3	·9259	5·0
·8358	56·9	·8650	39·8	·8951	19·1	·9263	5·3
·8362	56·8	·8653	39·5	·8955	18·8	·9267	5·7
·8365	56·6	·8657	39·3	·8959	18·6	·9270	6·0
·8369	56·4	·8660	39·1	·8962	18·3	·9274	6·4
·8372	56·2	·8664	38·9	·8966	18·0	·9278	6·7
·8376	56·0	·8667	38·7	·8970	17·7	·9282	7·0
·8379	55·9	·8671	38·4	·8974	17·5	·9286	7·3
·8383	55·7	·8674	38·2	·8977	17·2	·9291	7·7
·8386	55·5	·8678	38·0	·8981	16·9	·9295	8·0
·8390	55·3	·8681	37·8	·8985	16·6	·9299	8·3
·8393	55·1	·8685	37·6	·8989	16·4	·9302	8·6
·8396	55·0	·8688	37·3	·8992	16·1	·9306	9·0
·8400	54·8	·8692	37·1	·8996	15·9	·9310	9·3
·8403	54·6	·8695	36·9	·9000	15·6	·9314	9·7
·8407	54·4	·8699	36·7	·9004	15·3	·9318	10·0
·8410	54·2	·8702	36·4	·9008	15·0	·9322	10·3
·8413	54·1	·8706	36·2	·9011	14·8	·9326	10·7
·8417	53·9	·8709	35·9	·9015	14·5	·9329	11·0
·8420	53·7	·8713	35·7	·9019	14·2	·9332	11·4
·8424	53·5	·8716	35·5	·9023	13·9	·9337	11·7
·8427	53·3	·8720	35·2	·9026	13·6	·9341	12·1
·8431	53·1	·8723	35·0	·9030	13·4	·9345	12·4
·8434	52·9	·8727	34·7	·9034	13·1	·9349	12·8
·8438	52·7	·8730	34·5	·9038	12·8	·9353	13·1
·8441	52·5	·8734	34·3	·9041	12·5	·9357	13·5
·8445	52·3	·8737	34·1	·9045	12·2	·9360	13·9
·8448	52·1	·8741	33·8	·9049	12·0	·9364	14·2
·8452	51·9	·8744	33·6	·9052	11·7	·9368	14·6

Table—*continued*.

Specific Gravity.	Per Cent. Under Prf.	Specific Gravity.	Per Cent. Under Prf.	Specific Gravity.	Per Cent. Under Prf.	Specific Gravity.	Per Cent. Under Prf.
·9372	14·9	·9530	31·0	·9685	52·2	·9846	79·2
·9376	15·3	·9534	31·4	·9689	52·9	·9850	79·8
·9380	15·7	·9539	31·1	·9693	53·3	·9854	80·4
·9384	16·0	·9542	32·3	·9697	54·2	·9858	81·1
·9388	16·4	·9546	32·8	·9701	54·8	·9862	81·7
·9392	16·7	·9550	33·2	·9705	55·5	·9866	82·3
·9396	17·1	·9553	33·7	·9709	56·2	·9870	82·9
·9399	17·5	·9557	34·2	·9713	56·9	·9874	83·5
·9403	17·8	·9561	34·6	·9718	57·6	·9878	84·0
·9407	18·2	·9565	35·1	·9722	58·3	·9882	84·6
·9411	18·5	·9569	35·6	·9726	59·0	·9886	85·2
·9415	18·9	·9573	36·1	·9730	59·7	·9890	85·8
·9419	19·3	·9577	36·6	·9734	60·4	·9894	86·3
·9422	19·7	·9580	37·1	·9738	61·1	·9898	86·9
·9426	20·0	·9584	37·6	·9742	61·8	·9902	87·4
·9430	20·4	·9588	38·1	·9746	62·5	·9906	88·0
·9434	20·8	·9592	38·6	·9750	63·2	·9910	88·5
·9437	21·2	·9596	39·1	·9754	63·9	·9914	89·1
·9441	21·6	·9599	39·6	·9758	64·6	·9918	89·6
·9445	21·9	·9603	40·1	·9762	65·3	·9922	90.2
·9448	22·2	·9607	40·6	·9766	66·0	·9926	90·7
·9452	22·7	·9611	41·1	·9770	66·7	·9930	91·2
·9456	23·1	·9615	41·7	·9774	67·4	·9934	91·7
·9460	23·5	·9619	42·2	·9778	68·0	·9938	92·3
·9464	23·9	·9623	42·8	·9782	68·7	·9942	92·8
·9468	24·3	·9627	43·3	·9786	69·4	·9946	93·3
·9472	24·7	·9631	43·9	·9790	70·1	·9950	93·8
·9476	25·1	·9635	44·4	·9794	70·8	·9954	94·3
·9480	25·5	·9638	45·0	·9798	71·4	·9958	94·9
·9484	25·9	·9642	45·5	·9802	72·1	·9962	95·4
·9488	26·3	·9646	46·1	·9806	72·8	·9966	95·9
·9492	26·7	·9650	46·7	·9810	73·5	·9970	96.4
·9496	27·1	·9654	47·3	·9814	74·1	·9974	96·8
·9499	27·5	·9657	47·9	·9816	74·8	·9978	97·3
·9503	28·0	·9661	48·5	·9822	75·4	·9982	97·7
·9507	28·4	·9665	49·1	·9826	76·1	·9986	98·2
·9511	28·8	·9669	49·7	·9830	76·7	·9990	98·7
·9515	29·2	·9674	50·3	·9834	77·3	·9993	99·1
·9519	29·7	·9677	51·0	·9838	78·0	·9997	91.6
·9522	30·1	·9681	51·6	·9842	78·6	1·0000	100·0
·9526	30·6						

STAINED GLASS. The blues of vitrified colors are all obtained from the oxide of cobalt. Cobalt ore (sulphuret) being well roasted at a dull red heat, to dissipate all the sulphur and arsenic, is dissolved in somewhat dilute nitric acid, and after the addition of much water to the saturated solution, the oxide is precipitated by carbonate of soda, then washed upon a filter, and dried. The powder is to be mixed with thrice its weight of saltpetre; the mixture is to be deflagrated in a crucible, by applying a red hot cinder to it, then exposed to the heat of ignition, washed, and dried. Three parts of this oxide are to be mixed with a flux, consisting of white sand, borax, nitre, and a little chalk, subjected to fusion for an hour, and then ground down into an enamel powder for use. Blues of any shade or intensity may be obtained from the above, by mixing it with more or less flux.

The beautiful greenish yellow, of which color 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 flints; 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 afterward reduced to a fine powder.

Violet. One part of calcined black oxide of manganese, one of zaffre, ten parts of white glass pounded, and one of red lead, mixed, fused, and ground. Or gold purple (Cassius's purple precipitate) with chlorsilver previously fused, with ten times its weight of a flux, consisting of ground quartz, borax, and red lead, all melted together; or, solution of tin being dropped into a large quantity of water, solution of nitrate of silver may be first added, and then solution of gold in *aqua regia*, in proper proportions. The precipitate to be mixed with flux and fused.

STARCH. In January, 1839, M. Pierre Isidore Verduer obtained a patent for making starch, the chief object of which was to obtain the gluten of the wheat in a pure state, as a suitable ingredient in making bread, biscuits, &c. He works wheat flour into dough by a machine, kneads it, washes out the starch by streams of cold water, a process long known to the chemist, and purifies the starch by fermentation of the superjacent water. I can see nothing new in his specification.

Mr. Jones's patent, of date April, 1840, is based upon the purification of the starch of rice and other farinaceous matters, by means of caustic alkali. He macerates 100 lbs. of ground rice in 100 gallons of a solution composed of 200 grains of caustic soda or potash to a gallon of water, stirs it gradually, till the whole be well mixed; after 24 hours, draws off the superjacent liquid solution of gluten in alkali, treats the starchy deposite with a fresh quantity of weak caustic ley, and thus repeatedly, till the starch becomes white and pure. The rice before being ground is steeped for sometime in a like caustic ley, drained, dried, and sent to the mill.

Starch is made from wheat flour in a like way. The gluten may be recovered for use, by saturating the alkaline solution with sulphuric acid, washing and drying the precipitate.

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. James Colman, by his patent invention of December, 1841, makes starch from ground maize or Indian corn, by the agency either of the ordinary process of steeping and fermenting, or of caustic or carbonated alkaline leys. He also proposes to employ dilute muriatic acid to purify the starchy matter from gluten, &c.—*See Newton's Journal, C. S.* xix. 246; xx. 184, 188; and xxi. 173.

The manufacture of potato flour (*fecule*) or starch in France and Holland has been economized to such a degree that they supply this country with it, at the rate of 8*s*. or 10*s*. a hundredweight. *Fig.* 158 represents in section the powerful and ingenious

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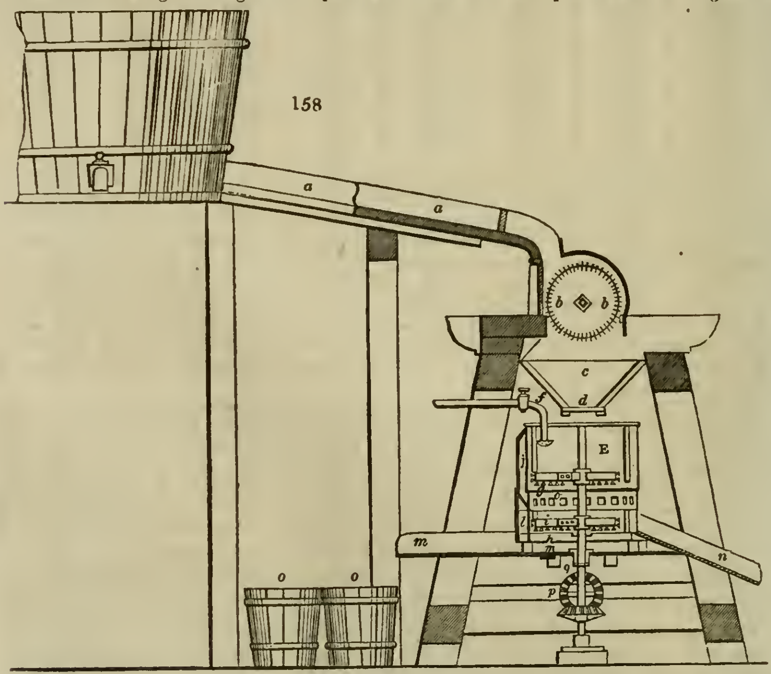

mechanical grater, or rasp (*râpe*), now used in France: *a a*, is the canal, or spout, along which the previously well-washed potatoes descend; *b b*, is the grater, composed of a wooden cylinder, on whose round surface circular saw rings of steel, with short sharp teeth, are planted pretty close together. 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 in a minute, and it will convert into pulp from 14 to 15 hectolitres (about 300 imperial gallons) of potatoes in an hour. Potatoes contain from 15 to 22 per cent. of dry fecula. The pulp, after leaving the rasp, passes directly into the apparatus for the preparation of the starch. *c 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 consist also of wire-cloth; it is collected into a wooden spout, *m*, and is thence conducted into the tubes *o o*, to be deposited and washed. *p*, is a metre-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*.

STEARINE. *Fig.* 159, is a view of both the exterior and interior of the saponi-

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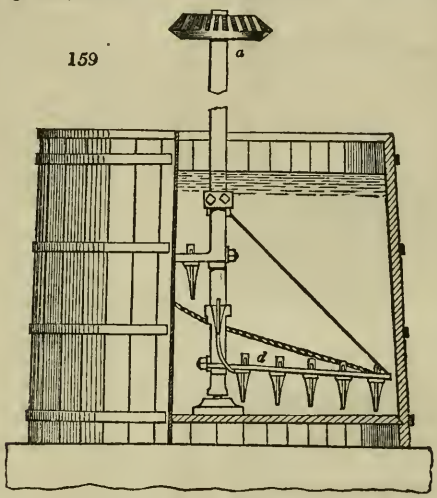

fying tun of a stearine factory; where the constituents of the tallow are combined with quicklime, by the intervention of water and steam: *a*, is the upright shaft of iron, turned by the bevel wheel above, in gear with another bevel wheel on the moving shaft, not shown in this figure. This upright shaft bears several arms *d*, furnished with large teeth. The tun is bound with strong hoops of iron, and its contents are heated by means of a spiral tube laid on the bottom, perforated with numerous holes, and connected by a pipe with a high-pressure steam-boiler.

Fig. 160, represents a longitudinal section of the horizontal hydraulic press for depriving stearic acid, as also spermaceti, of all their fluid oily impurities. *a*, is the

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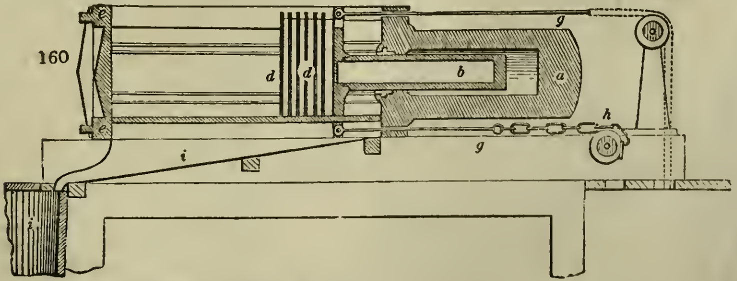

cylinder of the press; *b*, the ram or piston: *i, i, i, i*, hair and flannel bags enclosing the impure cakes to be exposed to pressure; *d, d, d, d*, iron plates previously heated, and placed between every two cakes to facilitate the discharge of their oily matter; *e, e*, solid iron end of the press, made to resist great pressure; it is strongly bolted to the cylinder *a*, so as to resist the force of the ram; *g*, *g*, iron rods, for bringing back the ram *b*, into its place after the pressure is over, by means of counter weights suspended to a chain, which passes over the pulleys *h*, *h* ; *i*, *i*, a spout and a sheet-iron pan for receiving the oily fluid.

STEEL. One of the greatest improvements which this valuable modification of iron has ever received is due to Mr. Josiah M. Heath, who, after many elaborate and costly researches, upon both the small and the great scale, discovered that by the introduction of a small portion, 1 per cent., and even less, of carburet of manganese into the melting-pot along with the usual broken bars of blistered steel, a cast steel was obtained, after fusion, of a quality very superior to what the bar steel would have yielded without the manganese, and moreover possessed of the new and peculiar property of being weldable either to itself or to wrought iron. He also found that a common bar-steel, made from an inferior mark or quality of Swedish or Russian iron, would, when so treated, produce an excellent cast coal. One immediate consequence of this discovery has been the reduction of the price of good steel in the Sheffield market by from 30 to 40 per cent., and likewise the manufacture of table-knives of cast steel with iron tangs welded to them; whereas, till Mr. Heath's invention, table-knives were necessarily made of shear steel, with unseemly wavy lines in them, because *cast* steel could not be welded to the tangs. Mr. Heath obtained a patent for this and other kindred meritorious inventions on the 5th of April, 1839; but, strange and melancholy to say, he has never derived any thing from his acknowledged improvement but vexation and loss, in consequence of a numerous body of Sheffield steel manufacturers having banded together to pirate his patent, and to baffle him in our complex law courts. I hope, however, that eventually justice will have its own, and the ridiculously unfounded pretences of the pirates to the prior use of carburet of manganese will be set finally at rest. It is supposed that fifty persons at least are embarked in this pilfering conspiracy.

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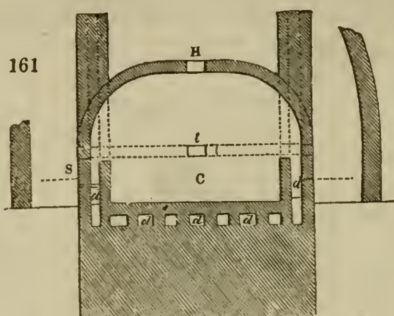

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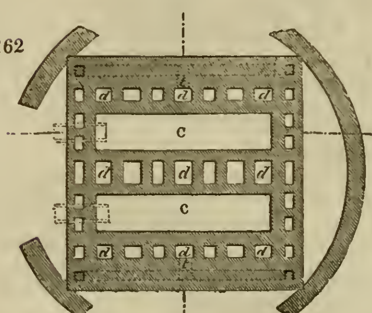

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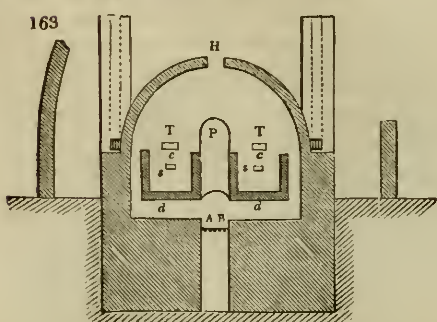

The furnace of cementation in which bar-iron is converted into bar or blistered steel is represented in *figs.* 161, 162, 163. It is rectangular and covered in by a groined or *cloister* arch: it contains two cementing chests, or sarcophaguses, C, C, made either of fire-stone or fire-bricks: each is $2\frac{1}{2}$ feet wide, 3 feet deep, and 12 long; the one being placed on the one side, and the other on the other of the grate, A B, which occupies the whole length of the furnace, and is from 13 to 14 feet long. The grate is 14 inches broad, and rests from 10 to 12 inches below the inferior plane or bottom level of the chests; the height of the top of the arch above the chests is $5\frac{1}{2}$ feet; the bottom of the chests is nearly on a level with the ground, so that the bars do not need to be lifted high in charging the furnace. The flame rises between the two chests, passes also below and round them through horizontal and vertical flues, *d*, and issues from the furnace by an opening, H, in the top of the vault, and by orifices, *t*, which communicate with the chimneys placed in the angles. The whole is placed within a large cone of bricks, 25 or 30 feet high, and open at top; this cone increases the draught, makes it more regular, and carries off the smoke away from the establishment. The furnace has three doors; two, T (*fig.* 162), above the chests, serve to admit and to remove the bars; they are about 7 or 8 inches square; in each of them a piece of sheet-iron is put, folded back on its edges; upon which the bars are made to slide, so as to save the wall. A workman enters by the middle door, P, to arrange the bars; the trial bars are taken out from time to time by the apertures, S (*fig.* 161), left in the sides of the chests. The bars are laid in strata, along with wood charcoal in powder, in the said chests; they are about 3 inches broad, and one third of an inch thick; they must not be placed too near each other, lest they should get welded together; the last or uppermost layer is covered with a stratum of loamy matter from 4 to 5 inches thick. The furnace must be gradually heated, not reaching its maximum temperature before 8 or 9 days, and the cooling lasts 5 or 6 days; the whole operation 18 or 20 days, and sometimes more, according to the quality of the steel to be cemented. About 13 tons of coals are consumed in this period. It is of consequence that the refrigeration be slow, to favor the crystallization of the metal. The grain of the steel varies with the rate of cooling, the largest and whitest grain denoting the most fusible steel.

STILL. The continuous system of distillation has been carried in France to a great pitch of perfection, by the ingenuity chiefly of M. Cellier Blumenthal, and M. Ch. Derosne. *Fig.* 164 is a general view of their apparatus; A and B are boilers or alembics encased in brickwork, and receiving directly the action of the flame playing beneath them; in the copper, A, the *vinasse*, or spent wine, is finally exhausted of all its alcohol. C, is the column of distillation; D, the column of rectification; E, the wine-heating condenser; F, the refrigerator; G, a vessel supplying *vinasse* to the cooler F, and feeding itself at the same time by means of a ball stop-cock placed in the vessel H; H, reservoir of vinasse; I, tube of communication conducting the alcoholic vapors of the rectifying column, D, up into the flat worm of the wine-heater, E; *a*, stop-cock of discharge of the alembic, A; when the operation goes on, the spent *vinasse* runs off continually by this stop-cock; *b*, a glass tube to show the height of the liquor in A; *c*, a safety-valve; *d*, a stop-cock for passing the vinasse from the alembic, B, into the bottom of the alembic, A; *e*, a tube to lead the alcoholic vapors, generated in A, into the bottom of B, which vapors, in passing through the liquor in B, heat it, and are partially condensed; *f*, glass tube to mark the level of the liquor in B; *g*, and *g*, level indicators; *h*, pipe conducting the vinasse from the lower part of the wine-heater, E, upon the uppermost of the series of horizontal discs, mounted within the column of distillation: *i*, a stop-cock for emptying the wine-heater at the end of an operation; *l*, *l*, two tubes fitted to the wine-heater, E, of which the first descends into the last compartment of the rectifier, whence it rises

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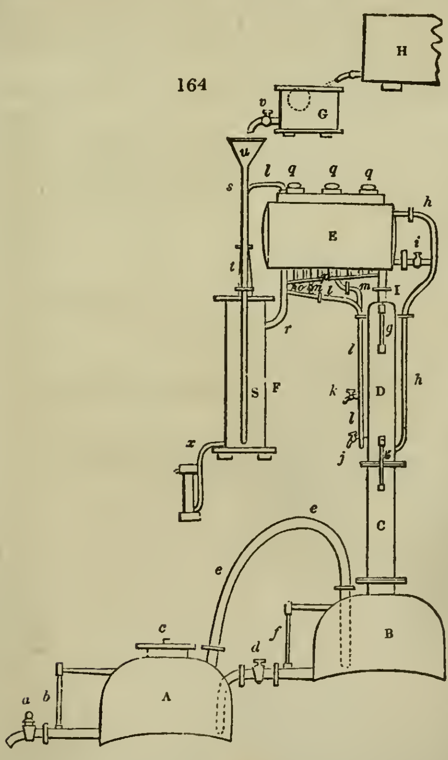

to the fifth; and the second tube descends to the third compartment, whence it rises above the second. At the curvature of each of these two tubes a stop-cock, *l*, and *k*, is placed on them, for drawing at pleasure a sample of the liquor returned to the rectifier; *m*, *n*, and *o*, are tubes communicating on one side with the slanting tube, *p*, and on the other with the tube *l*. These three communications serve to furnish a spirit of greater or less strength. Thus if it be wished to obtain a very strong spirit, the alcoholic vapors which condense in the worm enclosed in E, are all to be led back into the rectifier, D, to effect which purpose, it is requisite merely to open the stop-cocks, *n* and *o*; again, weaker spirits may be had by closing the stop-cock, *o*, and still weaker by closing the stop-cock *n*; for in this case, the alcoholic vapors condensed in the worm within E, will flow off into the worm within the upright cooler F, and will get mixed with the richer vapors condensed in this refrigeratory. The interior of the columns C, contains a series of movable concave scale pans (like those of balances), with spaces between, each alternate pan having the convex side turned reversely of the preceding one, for the purpose of prolonging the cascade descent of the vinasse through C, and exposing it more to the heating action of the ascending vapors; the edges of these pans are, moreover, furnished with projecting spiculæ of copper wires, to lead off the liquor from their surfaces in a fine shower. The interior of the rectifier column, D, is mounted with a series of shelves, or floors, the passage from one compartment to that above it being through a short tube, bent at right angles, and open at either end; *p*, *p*, *p*, is a general tube, for receiving the vapors condensed in each of the turns of the large serpentine within E. The axis of this worm is horizontal; *q*, *q* *q*, peep-holes in the top of the wine-heater; *r*, a tube to conduct the alcoholic vapors not condensed in the worm of E, and also, if desired, those which have been condensed there, into the worm of the refrigeratory, F; *s*, a tube to bring the vinasse from the reservoir, G, into the lower part of the cooler, F; *t*, a tube to lead the vinasse from the upper part of the cooler, F, into the upper part of the wine-heater, E; *u*, a funnel; *v*, a stop-cock to feed the tube, *t*, with vinasse; *x*, a tube of outlet for the spirits produced; it ends, as shown in the figure, in a test tube containing an hydrometer.

The still of Laugier is represented by a general view in *fig.* 165: A and B are alembics

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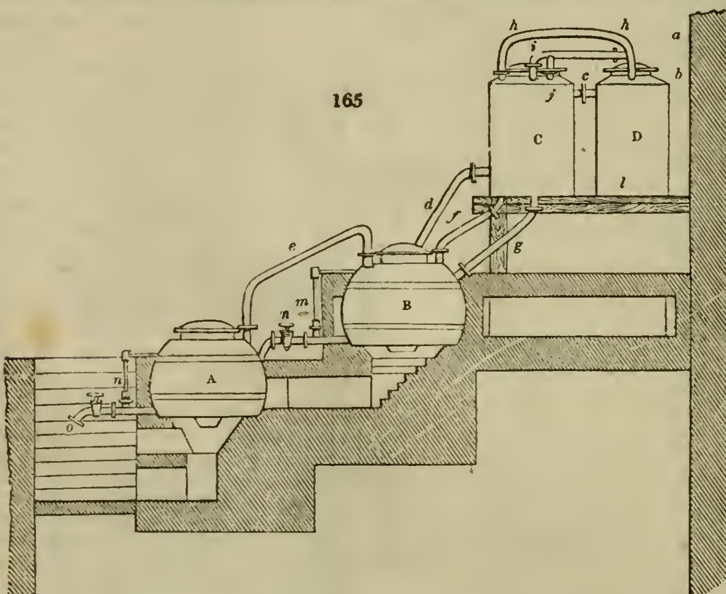

exposed to the direct action of the fire, and serve a like purpose to those of *fig.* 164; C, is a cylinder containing the rectifier, and serving as a wine-heater; D, is the condensing cylinder; *a*, a stop-cock communicating with the wine tun; *b*, a plunger-tube, furnished with a funnel, through which wine runs constantly into the condenser, D; *c*, an overflow pipe of D, between C and D, communicating by a tube, dipping in the cylinder, C; *d*, a plunger equilibrium tube, supplying the alembics with hot wine; *e*, a tube leading the vapors of the first alembic, A, into the second one, B, into which it dips;

f, a tube conducting the vapors of alcohol from the alembic, B, into the circles of the rectifier; *g*, a tube bringing back into the alembic, B, the vapors condensed in the circles of the rectifier; *h*, a tube conducting the vapors not condensed into the worm of the condenser; *i*, a tube serving for the expulsion of the air when the wine comes into the vessel, *c*; it communicates with the tube, *h*, so as not to lose alcohol. *j*, is a prolongation of the tube D, communicating with the tube *h*, so that it may be in contact with the external air; *l*, a stop-cock through which the alcohol condensed runs off into the serpentine; *m*, levels, indicating the height of the liquor in the alembics, A and B; *n*, tube with a stop-cock, for feeding the alembic A; *o*, discharge stop-cock of the spent vinasse (wash).

A description of the operation of the first still will render that of the second intelligible.

The alembic A, being filled three fourths with vinasse, and B having only 4 or 5 inches of vinasse over its bottom, the liquor in A is made to boil, and the stop-cock, *r*, being at the same time opened, some of the wine to be distilled is allowed to fall into the funnel, *u*; this cold liquor runs to the bottom of the cooler, F, fills it, passes into the wine-heater by the tube *l*, spreads into a perforated conduit along the top of E, thence trickles down into this vessel till it fills it to the level of the tube *h*, by which it is conducted into the column, C, and, flowing down through all its compartments, it falls at last into the second alembic, B.

During this progress, the liquor of A having begun to boil, the alcoholic vapor passes, by means of the tube *e*, *e*, into the second alembic, B, which, being heated by those vapors, and by the products of combustion issuing from the fireplace under the first alembic, is also soon made to boil. The vapor which it produces is disengaged into the column of distillation C, meets there the wine which trickles through all its compartments, transfers to it a portion of its heat, and deprives it of alcohol, goes into the column D, where it is alcoholized afresh, then enters into the worm within the wine-heater E, glides through all its windings, gets stripped in part of the aqueous vapors which accompanied the alcohol, and which return first by the tube *p*, *p*, then by *l*, *l*, into the column of rectification; afterward the spirituous vapor passes into the worm enclosed in the cooler F, to issue finally condensed and deprived of all the water wished to be taken from it, by the tube *x*, into the gauge receiver.

When the indicator *f*, of the alembic B, shows it to be nearly full, the stop-cock *a* of the alembic A is opened, and the vinasse is allowed to run out entirely exhausted of spirit; but as soon as there are only seven inches of liquor above the discharge pipe the cock *a* is shut, and *d* is opened to run off seven inches of liquor from B.

It appears, therefore, that in reference to the discharge, the operation is not quite continuous; but this slight interruption is a real improvement introduced by M. Derosne into the working of M. Blumenthal's apparatus. It is impossible for any distiller, however expert, to exhaust entirely the liquor of the last alembic, if the discharge be not stopped for a short time. The above distilling apparatus requires from two to three hours to put it in full action. From 10 to 15 per cent. of spirit of $\frac{3}{6}$ are obtained from the average of French wine! and 600 litres of such spirit are run off with 150 kilogrammes of coals; or about two old English quarts of spirit for each pound of coals.

STONES, for building, and bricks, may be proved as to their power of resisting the action of frost, by the following method, first practised by M. Brard, and afterward by MM. Vicat, Billaudel, and Coarad, engineers of the bridges and highways in France. The operation of water in congealing within the pores of a stone may be imitated by the action of a salt, which can increase in bulk by a cause easily produced; such as efflorescence or crystallization, for example. Sulphate of soda or Glauber's salt answers the purpose perfectly, and it should be applied as follows:—

Average samples of the stones in their sound state, free from shakes, should be sawed into pieces 2 or 3 inches cube, and numbered with China ink or a graving tool. A large quantity of Glauber's salt should be dissolved in hot water, and the solution should be left to cool. The clear saturated solution being heated to the boiling point in a saucepan, the several pieces of stone are to be suspended by a thread in the liquid for exactly one half-hour. They are then removed and hung up each by itself over a vessel containing some of the above cold saturated solution. In the course of 24 hours, if the air be not very damp or cold, a white efflorescence will appear upon the stones. Each piece must be then immersed in the liquor in the subjacent vessel, so as to cause the crystals to disappear, be once more hung up, and dipped again whenever the dry efflorescence forms. The temperature of the apartment should be kept as uniform as possible during the progress of the trials. According to their tendency to exfoliate by frost, the several stones will show, even in the course of the first day, alterations on the edges and angles of the cubes; and in 5 days after efflorescence begins, the result 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.

STREAM-WORKS. The name given by the Cornish miners to alluvial deposites of tin ore, usually worked in the open air.

STRINGS. The name given by the Cornish miners to the small filamentous ramifications of a metallic vein.

SUGAR. The recent researches of the eminent French chemist, M. Casaseca, upon cane-juice at Havana, in Cuba, have demonstrated clearly the enormous loss which sugar-planters suffer by the imperfection of their manufacturing processes. His results confirm those previously obtained by M. Peligot in Paris, and show that cane-juice evaporated in vacuo at the atmospheric temperature, yields, in 100 parts:—

Crystalline white sugar	20·94
Water	78·80
Mineral substances	0·14
Organic matter, different from sugar	0·12
	100·00

The cane from which the above was drawn is called *canade la tierra* in Cuba. The juice of the Otaheite cane is identical with the preceding. But the proportions of ligneous fibres in the two canes are very different; that of *la tierra* containing, according to M. Casaseca, 16·4 per cent., while that of Otaheite contains only 10. Other canes, however, differ in this respect considerably from these two varieties. The average quantity of grained sugar obtained from cane-juice in our colonial plantations is probably not more than one third of the quantity of crystalline sugar in the juice which they boil.

The following analysis of cane-juice, performed by a French chemist, was given me by Mr. Forstall of New Orleans. In 10 English gallons, of 231 cubic inches each, of juice marking 8½° Baumé, there are 5¾ ounces English of salts, which consist of—

Sulphate of potash	17·840 grammes = 15·44 grains each.
Phosphate of potash	16·028
Chlorure of potassium	8·355
Acetate of potash	63·750
Acetate of lime	36·010
Gelatinous silica	15·270
	157·253 = 5·57 ounces avoirdupois.

To the large proportion of deliquescent saline matter, of which one half, he says, remains in the sugar, the analyst ascribes very properly the deliquescence and deterioration of the sugar when kept for some time or transported. It was probably the juice of the cane grown in the rich alluvial soil of Louisiana, and therefore more abundant in saline matter than the average soil of our West India islands. The Demerara cane-juice has perhaps the above saline constitution, as it suffers much loss of weight by drainage in the home voyage.

SUGAR OF POTATOES, GRAPES, or STARCH. About two years ago a sample of sweet mucilaginous liquid was sent to me for analysis, by the honorable the commissioner of customs. It was part of a quanity imported in casks at Hull, from Rotterdam. It was called by the importers, "Vegetable Juice." I found it to be imperfectly saccharified starch or fecula; and, on my reporting it as such, it was admitted at a moderate rate of duty.

Three months since I received a sample of a similar liquid from the importer at Hull, with a request that I would examine it chemically. He informed me that an importation just made by him, of 30 casks of it, had been detained by orders of the excise, till the sugar duty of 25*s*. per cwt. of solid matter it contained was paid upon it. It was of specific gravity 1·362, and contained 80 per cent. of ill-saccharified fecula.

In the interval between the first importation and the second, an act of parliament had been obtained for placing every kind of sugar, from whatever material it was formed, under the provisions of the "Beet-root Sugar Bill." As the saccharometer tables, subservient to the levying of the excise duties, under this act, were constructed by me, at the request of the president of the board of trade, I well knew that 50 per cent. of the syrup of the beet-root was deducted as a waste product, because beet-root molasses is too crude an article for the use of man. Well saccharified starch paste, however, constitutes a syrup, poor indeed in sweetness when compared with cane syrup, or that of the beet-root; but then it does not spontaneously blacken into molasses, by evaporation, as solutions of ordinary sugar never fail to do when they are concentrated, even with great care. Hence the residuary syrups of saccharified fecula may be all worked up into a tolerably white granular mass, which, being crushed, is used by greedy grocers to mix with their dark-brown bastard sugars, to improve their color.

It is only within two years that sugar has been in this country manufactured from potato starch to any extent, though it has been long an object of commercial enterprise in France, Belgium, and Holland, where the large coarse potatoes are used for this purpose. The raw material must be very cheap there, as well as the labor; for potato flour or starch, for conversion into sugar, has been imported from the continent into this country in large quantities, and sold in London at the low price of 10*s.* per cwt.

The process usually followed by the potato-sugar makers, is to mix 100 gallons of boiling water with every 112 lbs. of the fecula, and 2 lbs. of the strongest sulphuric acid. This mixture is boiled about 12 hours in a large vat, made of white deal, having pipes laid along its bottom, which are connected with a high pressure steam-boiler. After being thus saccharified, the acid liquid is neutralized with chalk, filtered, and then evaporated to the density of about 1·300, at the boiling temperature, or exactly 1·342, when cooled to 60°. When syrup of this density is left in repose for some days. it concretes altogether into crystalline tufts, and forms an apparently dry solid, of specific gravity 1·39. When this is exposed to the heat of 220°, it fuses into a liquid nearly as thin as water; on cooling to 150°, it takes the consistence of honey, and at 100° F. it has that of a viscid varnish. It must be left a considerable time at rest before it recovers its granular state. When heated to 270°, it boils briskly, gives off one tenth of its weight of water, and concretes, on cooling, into a bright yellow, brittle, but very deliquescent mass, like barley sugar. If the syrup be concentrated to a much greater density than 1·340, as to 1·362, or if it be left faintly acidulous, in either case it will not granulate, but will remain either a viscid magma or become a concrete mass, which may indeed be pulverized, though it is so deliquescent as to be unfit for the adulteration of raw sugar. The Hull juice is in this predicament, and is therefore, in my opinion, hardly amenable to the new sugar law, as it can not by any means be worked up into even the semblance of sugar.

Good Muscovado sugar, from Jamaica, fuses only when heated to 280°, but it turns immediately dark brown, from the disengagement of some of its carbon, at that temperature, and becomes, in fact, the substances called "caramel" by the French, which is used for coloring brandies, white wines, and liqueurs.

Thus we see that starch or grape-sugar is well distinguished from cane-sugar, by its fusibility, at a moderate heat, and its inalterability at a pretty high heat. Its sweetening power is only two fifths of that of ordinary sugar. A good criterion of incompletely formed starch-sugar is, its resisting the action of sulphuric acid, while perfectly saccharified starch or cane-sugar is readily decomposed by it. If, to a strong solution of imperfectly saccharified grape-sugar, nearly boiling hot, one drop of strong sulphuric acid be let fall, no perceptible change will ensue, but if the acid be dropped into solutions of either of the other two sugars, black carbonaceous particles will make their appearance.

The article which was lately detained by the Excise, for the high duties, at Hull, is not affected by sulphuric acid, like the solutions of cane-sugar, and of the well-made potato-sugar of London; and for this reason I gave my opinion in favor of admitting the so-called vegetable juice at a moderate rate of duty.

I submitted the solid matter, obtained by evaporating the Hull juice, to ultimate analysis, by peroxide of copper, in a combustion tube, with all the requisite precautions, and obtained, in one experiment, 37 per cent. of carbon; and in another 38 per cent., when the substance had been dried in an air bath, heated to 275°. The difference to 100, is hydrogen and oxygen, in the proportion to form water. Now this is nearly the constitution of starch. Cane-sugar contains about 5 per cent. more carbon, whereby it readily evolves this black element, by the action of heat or sulphuric acid.

An ingenious memoir, by Mr. Trommer, upon the distinguishing criteria of gum, dextrine, grape-sugar, and cane-sugar, has been published in the 39th volume of the "Annalen der Chemie und Pharmacie." I have repeated his experiments, and find them to give correct results, when modified in a certain way. His general plan is to expose the hydrate of copper to the action of solutions of the above-mentioned vegetable products. He first renders the solution alkaline, then adds solution of sulphate of copper to it, and either heats the mixture or leaves it for some time in the cold. By pursuing his directions, I encountered contradictory results; but, by the following method, I have secured uniform success, in applying the criteria, and have even arrived at a method of determining, by a direct test, the quantity of sugar in diabetic urine.

I dissolve a weighed portion of sulphate of copper in a measured quantity of water, and make the solution *faintly* alkaline, as tested with turmeric paper, by the addition of potash ley, in the cold; for if the mixture be hot, a portion of the disengaged green hydrate of copper is converted into black oxide. This mixture being always agitated before applying it, forms the test liquor. If a few drops of it be introduced into a solution of gum, no change ensues on the hydrate of copper, even at a boiling heat, which shows that a gummate of copper is formed, which resists decomposition: but the cupreous mixture, without the gum, is rapidly blackened at the boiling temperature. I do not find that the gummate is redissolved by an excess of water, as Trommer affirms.

Starch and tragacants comport like gum, in which respect I agree with Trommer. Starch, however, possesses already a perfect criterion, in iodine water. Mr. Trommer says, that solution of dextrine affords a deep glue-colored liquid, without a trace of precipitate; and that when his mixture is heated to 85° C., it deposites red grains of protoxide of copper, soluble in muriatic acid. I think these phenomena are dependant, in some measure, upon the degree of alkaline excess in the mixture. I find, the solution of dextrine, treated in my way, hardly changes in the cold; but when heated slightly, it becomes green, and by brisk boiling an olive tint is produced. It thus betrays its tendency of transition into sugar.

Solution of cane-sugar, similarly treated, undergoes no change in the cold at the end of two days; and very little change of color even at a boiling heat, if not too concentrated. Cane-sugar, treated by Trommer in his way, becomes of a deep blue; it can be boiled by potash in excess, without any separation of orange-red oxide of copper.

Starch or grape-sugar has a marvellous power of reducing the green hydrate of copper to the orange oxide. I find, however, that it will not act upon the pure blue hydrate, even when recently precipitated; it needs the addition, in every case, of a small portion of alkali. Yet ammonia does not seem to serve the purpose; for, in using the ammonia-sulphate of copper, in solution, I obtained unsatisfactory results with the above vegetable products.

The black oxide of copper is not affected by being boiled in solution of starch-sugar.

"If solution of grape-sugar," says Trommer, "and potash, be treated with a solution of sulphate of copper, till the separated hydrate is redissolved, a precipitate of red oxide will soon take place, at common temperatures, but it immediately forms, if the mixture is heated. A liquid containing $\frac{1}{100\,000}$ of grape-sugar, even one millionth part," says he, "gives a perceptible tinge (orange), if the light is let fall upon it." To obtain such a minute result, very great nicety must be used in the dose of alkali, which I have found it extremely difficult to hit. With my regulated alkaline mixture, however, I never fail of discovering an exceedingly small proportion of starch-sugar, even when mixed with Muscovado sugar; and thus an excellent method is afforded of detecting the frauds of the grocers.

I find that manna deoxidizes the green hydrate of copper slowly when heated, but not nearly to the same extent as grape-sugar, which reduces it rapidly to the orange oxide.

If an excess of the hydrate of copper test be used, there will be a deposite of green hydrate at the bottom of the vessel, under the orange oxide.

To apply these researches to the sugar of diabetic urine: This should first be boiled briskly to decompose the urea, and to dissipate its elements in the form of ammonia, as well as to concentrate the saccharine matter, whereby the test becomes more efficacious. Then add to the boiling urine, in a few drops at a time, the cupreous mixture, containing a known quantity of sulphate of copper, till the whole assumes a greenish tint, and continue the heat until the color becomes bright orange. Should it remain green, it is a proof that more hydrate of copper has been introduced than has been equivalent to the deoxidizing power of the starch-sugar. I have found that one grain of sulphate of copper in solution, supersaturated very slightly with potash, is decomposed with the production of orange protoxide, by about 3 grains of potato-sugar; or, more exactly, 30 parts of the said sulphate, in the state of an alkaline hydrate of copper, pass altogether into the state of orange oxide, by means of 100 parts of granular starch-sugar. Thus, for every 3 grains of sulphate so changed, 10 grains of sugar may be estimated to exist in diabetic urine.

Acetate of copper may be used in the above experiments, but it is not so good as the sulphate. The chloride of copper does not answer.

Specific gravity is also an important criterion, applied to sugars; that of the cane and beet-root is 1·577; that of starch-sugar, in crystalline tufts, is 1·39, or perhaps 1·40, as it varies a little with its state of dryness. At 1·342, syrup of the cane contains 70 per cent. of sugar; at the same density, syrup of starch-sugar contains 75½ per cent. of concrete matter, dried at 260° F., and therefore freed from the 10 per cent. of water which it contains in the granular state. Thus, another distinction is obtained between the two sugars, in the relative densities of their solutions, at like saccharine contents per cent.

SULPHATE OF AMMONIA. This salt, now so extensively used in preparing artificial manures and imitations of guano, for farmers, is made of great purity, and at an economical rate, by the patent process of Mr. Croll, described under the article GAS. A mixture of 10 per cent. of this sulphate with 20 of bone-dust, some gypsum, and farmyard manure, will form a very fertilizing compost, applicable to a great variety of soils.

SULPHURIC ACID. A valuable improvement of the process for manufacturing this fundamental chemical agent has been lately 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 Desornes, and to encounter there a stream of sulphuric acid of specific gravity 1·750. The nitrous acid gas, which is in a well-regulated chamber always slightly redundant, is perfectly absorbed by the said sulphuric acid; which, thus impregnated, is made to trickle down through another cascade, up through which passes a current of sulphurous acid, from the combustion of sulphur in a little adjoining chamber. The condensed nitrous acid gas is thereby immediately transformed into nitrous gas (deutoxide of azote) which is transmitted from this second cascade into the large vitriol chamber, and there exercises its well-known reaction upon its aeriform contents. The economy thus effected in the sulphuric acid manufacture is such that for 100 parts of sulphur 3 of nitrate of soda will suffice, instead of 9 or 10 as usually consumed.

Upon the formation of sulphated nitrous gas ($N\,O^2$, 3 $S\,O^3$, 2 $H\,O$), and its combination with oil of vitriol, the manufacture of hydrated sulphuric acid is founded. Either sulphur is burned in mixture with about one ninth of saltpetre; whence along with sulphurous acid gas, nitrous oxide gas is disengaged, while sulphate of potash remains; thus $K\,O, N\,O^5 + S = S\,O^3 + N\,O^2, K\,O$. 2. Or, nitric acid in the fluid or vaporous form may be present in the lead-chamber, into which the sulphurous acid gas passes, in consequence of placing in the flames of the sulphur a pan, charged with a mixture of sulphuric acid and nitre or nitrate of soda. This nitric acid being decomposed by a portion of the sulphurous acid, there will result sulphuric acid and nitrous gas. By the mutual reaction of the sulphurous and nitric acids, sulphuric acid and nitrous gas will be produced: $N\,O^5 + 3\;S\,O = N\,O^2 + 3\;S\,O^3$. 3. Or, by heating sugar or starch with nitric acid, the mixture of nitrous gas and nitrous acid vapor which results, may be thrown into the chamber among the sulphurous acid. In any one of these three cases, sulphurous acid gas, nitrous acid vapors (proceeding from the mixture of nitrous oxide and atmospherical oxygen) and steam are mingled together; whence arises the crystalline compound of sulphated nitrous oxide with sulphuric acid, which compound subsides in white clouds to the bottom of the chamber, and dissolves in the dilute oil of vitriol placed there, into sulphuric acid, with disengagement of nitrous gas. This gas now forms, with the remaining atmospherical oxygen, nitrous acid vapors once more, which condense a fresh portion of sulphurous acid gas into the above crystalline compound; and thus in perpetual alternation.

Sulphurous acid gas does not act upon nitrous gas, not even upon the nitrous acid vapor produced by the admission of oxygen, if water be absent; but the moment that a little steam is admitted, the crystalline compound is condensed. The presence of much sulphuric acid favors the formation of the sulphated nitrous gas. These crystals are decomposed by tepid water with disengagement of nitrous gas, which seizes the oxygen present and becomes nitrous acid (hyponitric of many chemists).

T.

TEA. This well-known plant has recently acquired peculiar interest among men of science, both in a chemical and physiological point of view. In its composition it approaches by the quantity of azote it contains to animalized matter, and it seems thereby qualified, according to Liebig, to exercise an extraordinary action on some of the functions of animals, especially the secretion of bile. The chemical principle characteristic of tea, coffee, and cocoa-beans, is one and the same when equally purified, from whichever of these substances it is extracted; and is called indifferently either theine or caffeine. Mulder takes it from tea, by treating the evaporated extract by hot water, with calcined magnesia, filtering the mixture, evaporating to dryness the liquor which passes through, and digesting the residuum in ether. This solution being distilled, the ether passes over, and the theine remains in the retort. This principle is extracted in the same way from ground raw coffee and from *guarana*, a preparation of the seeds of *paullinia*, highly valued by the Brazilians. Theine, when pure, crystallizes in fine glossy needles, like white silk, which lose, at the heat of boiling water, 8 per cent. of their weight, constituting its two atoms of water of crystallization. These needles are bitter tasted. They melt at 350° F., and sublime at 543° without decomposing. The crystals dried at 250° dissolve in 98 parts of cold water, 97 of alcohol, and 194 parts of ether. In their ordinary state, they are but little more soluble in these menstrua. Theine is a feeble base, and is precipitable by tannin alone from its solution.

Mr. Stenhouse prepares theine by precipitating a decoction of tea with solution of acetate of lead, evaporating the filtered liquor to a dry extract, and exposing this extract to a subliming heat in a shallow iron pan, whose mouth is covered flatly with porous paper luted round the edges, as a filter to the vapor, and surmounted with a cap of compact paper, as a receiver to the crystals. In this way he obtained, at a maximum, only 1·37 from 100·00 of tea. But M. Peligot, from the quantity of azote amounting to about 6 per cent., which he found in the tea leaves, being led to believe that much more theine existed in them than had hitherto been obtained, adopted the following improved process of extraction. To the hot infusion of tea, subacetate of lead and then ammonia were added; through the filtered liquor a current of sulphureted hydrogen was passed to throw down all the lead, and the clear liquid being evaporated at a gentle heat afforded, on cooling, an abundant crop of crystals. By re-evaporation of the mother liquor, more crystals were procured, amounting altogether to from 5 to 6 out of 100 of tea.

The composition of theine may be represented by the chemical formula, C^8, H^5, N^2, O^2; whence it appears to contain no less than 29 per cent. of nitrogen or azote.

Peligot found, on an average, in 100 parts of—

	Parts soluble in boiling Water.
Dried black teas	43·2
—— green teas	47·1
Black teas, as sold	38·4
Green teas, ditto	43·1

Tea, by Mulder's general analysis, has a very complex constitution; 100 parts contain—

	Green.	Black.
Essential oil (to which the flavor is due)	0·79	0·60
Chlorophyle (leaf-green matter)	2·22	1·84
Wax	0·28	
Resin	2·22	3·64
Gum	8·56	7·28
Tannin	17·80	12·88
Theine	0·43*	0·46
Extractive matter	22·80	19·88
Do. dark-colored	—	1·48
Colorable matter separable by muriatic acid	23·60	19·12
Albumine	3·00	2.80
Vegetable fibre	17·08	28·32
Ashes	5·56	5·24

Since the proportion of azote in theine and caffeine is so much greater than even in any animal compound, urea and uric acid excepted, and since so many different nations have been, as it were, instinctively led to the extensive use of tea, coffee, and chocolate or cocoa, as articles of food and enlivening beverage, which agree in no feature or property, but in the possession of one peculiar chemical principle, we must conclude that the constitution of these vegetable products is no random freak of nature, but that it has been ordained by Divine Wisdom for performing beneficial effects on the human race. Hitherto, indeed, medicine, a conjectural art, exercised too much by men superficially skilled in the science of nature, and the slaves or abettors of baseless hypotheses, has laid tea and coffee generally under its ban, equally infallible with the multitude, as that of the pope in the olden time, and has denounced their use, as causing a variety of nervous and other *nosological* maladies. But chemistry, advancing with her unquenchable torch into the darkest domains of nature, has now unveiled the mystery, and displayed those elemental transformations of the organic functions in the human body, to which tea and coffee contribute a salutary and powerful aid.

Liebig, in his admirable researches into the kingdoms of life, has been led to infer that the bile is one of the products resulting from the decomposition of the animal tissues, and that our animal food may be resolved by the action of oxygen, so amply applied to the lungs in respiration, into bile and urea, the characteristic constituent of urine.

When the consumption of tissue in man is small, as among mankind in the artificial state of life, with little exercise and consequently languid digestion, assimilation, and decomposition, the constant use of substances rich in azotized compounds, closely analogous to the chief principle of the bile, must assist powerfully in the production of this secretion, so essential to the healthy action of the bowels and other organs. Liebig has fully proved that the bile is not an excrementitious fluid, merely to be rejected, as

* This constituent is obviously much underrated.

a prejudicial inmate of the system, but that it deserves, after secretion, some important purpose in the animal economy, being, in particular, subservient to respiration.

I shall conclude these remarks, perhaps more appropriate to a work on chemistry than to the present, by stating the relation between *theine* and the animal product *taurine*, the characteristic constituent of bile.

One atom of theine - =	C_8, N_2, H_5, O_2	}	Two atoms of taurine.
Nine atoms of water - =	H_9, O_9	}	$= C_8, N_2, H_{14}, O_{20}$.
Nine atoms of oxygen - =	O_9	}	

The letters C, N, H, O, denote carbon, nitrogen or azote, hydrogen, and oxygen; and the figures attached to each, the number of atoms; one atom of carbon being 6, one of azote 14, one of hydrogen 1, and one of oxygen 8; from which the composition of the bodies, theine and taurine, may be easily computed for 100 parts. Now, supposing one tenth of the bile to consist of solid matter, and this solid matter to be choleic acid (resolvable into taurine but different from it), which contains 3·87 of nitrogen, then 2·8 grains of theine would afford to 480 grains of bile (supposed solid, or 4,800 grains in its ordinary state) all the nitrogen required for the constitution of *taurine*, its peculiar cyrstalline principle.

It may be remarked here, however, with regard to tea and coffee, that while they agree in the main feature, they differ in some others, and especially in the large proportion of tannin in the former, and its non-existence, according to my experiments, in the latter, notwithstanding the statement of its presence, in many chemical works. Hence, tea may act injuriously in persons of *Cretian* habits,* while coffee has no constipating power, however much it may cause excitement and heat under certain idiosyncrasies.

A pure, agreeable, and convenient concentrated preparation of tea and coffee has been recently made the subject of an ingenious patent by Mr. Staite, which I can recommend as being made from the best articles in the market, by a perfectly wholesome apparatus and process. The patentee has printed a little explanatory pamphlet on the object of his improvement, from which the following extracts are taken :—

"The quantity of tea grown and consumed in China can not be ascertained, but the consumption of Europe and America may be taken as follows :—

Russia - - - -	6,500,000 lbs.
United States of America -	8,000,000
France - - - -	2,000,000
Holland - - -	2,800,000
Other countries - -	2,000,000
Great Britain - - -	50,000,000
	71,300,000 lbs. or 31,830 tons.

"The number of tea-dealers in the year 1839 was, in England, 82,794; in Scotland, 13,611; and in Ireland, 12,744; making a total of 109,179. It is presumed that in consequence of the increased population their number at present must exceed 120,000.

"The observations of Liebig afford a satisfactory explanation of the cause of the great partiality of the poor not only for tea, but for tea of an expensive and superior kind. He says, 'We shall never certainly be able to discover how men were first led to the use of the hot infusion of the leaves of a certain shrub (tea), or of a decoction of certain roasted seeds (coffee). Some cause there must be, which will explain how the practice has become a necessary of life to all nations. But it is still more remarkable, that the beneficial effects of both plants on the health must be ascribed to one and the same substance (*thêine* 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 *thêine* 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.

* Titus, chap. i., v. 12.

One of his experiments on the nutritious qualities of tea, as compared with those of soup, was decidedly in favor of the former.

"Coffee is grown in Brazil, Cuba, Hayti, Java, British West Indies, Dutch Guiana, states of South America, French West India colonies, Porto Rico, Sumatra, Ceylon, Bourbon, Manilla, and Mocha. Brazil produces the largest quantity, 72,000,000 pounds weight; and the other states and colonies according to the order in which they are enumerated, down to Mocha, which produces the least, or 1,000,000 pounds; making a total of 346,000,000 pounds, equal to the consumption of the enormous quantity of 2,900 tons weekly, or 150,800 tons per annum.

"From the official returns, the quantities of coffee exported in one year from the different places of production were 154,550 tons:—

	TONS.		TONS.
To France - - -	29,650	Denmark - - -	1,400
U. S. of America - -	46,070	Spain - - - -	1,000
Trieste - - -	9,000	Prussia - - - -	930
Hamburg - - -	20,620	Naples and Sicily - -	640
Antwerp - - -	10,000	Venice - - - -	320
Amsterdam - - -	8,530	Fiume - - - -	170
Bremen - - -	4,500	Great Britain (average of 10 y'rs)	18,250
St. Petersburg - - -	2,000		
Norway and Sweden - -	1,470		154,550

"Every reflecting man will admit, that articles of such vast consumption as tea and coffee (amounting together to more than 185,000 tons annually), forming the chief liquid food of a whole nation, must exercise a great influence upon the health of the people, and that any discovery which tends to the purification of these alimentary drinks, rendering them more wholesome, without rendering them less agreeable, is a great boon conferred upon society.

"The inventor and manufacturers of the 'Pure Concentrated Fluid Essence of Tea and Coffee,' hope that the convenient and portable form in which they are enabled to offer them to the public (in 'Rand's Patent Collapsible Tubes,' made of pure tin, whereby all the usual trouble and inconvenience of making tea and coffee are avoided), affords rational grounds (in addition to more important considerations) for anticipating an extensive sale."

TOBACCO. This important subject of our national revenue has been, during the last session of parliament, very fully investigated in reference to the smuggling and adulteration carried to an enormous extent, and hitherto but little checked by all the efforts of the officers of the customs and excise. Mr. Joseph Hume, M.P., who moved the appointment of the committee of the house of commons, and of which he was chairman, proposed a reduction of duty from 3*s.* 2*d.* a pound to 1*s.*, as the only effectual remedy against these joint evils; but he was counteracted by Mr. Goulbourn, chancellor of the exchequer, and a majority of the members of the committee, on the score that the state of the national finances did not permit such a defalcation of income as that reduction would occasion. It would appear, from a great mass of evidence, that much more tobacco is introduced illicitly than what duty is paid upon, and that very great adulterations are practised. The following statement shows the temptations:—

Virginia leaf costs in bond	$3\frac{1}{2}d.$ per lib.,	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	"
Havana 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.		Per English Pound.
Austria—leaf tobacco - - - - -	3*d.*	Other German states - - - -	$\frac{1}{2}d.$
Belgium ditto - - - - - -	$\frac{1}{4}d.$	Hamburgh $\frac{3}{8}$ per cent. ad valorem.	
Bremen ditto, $\frac{1}{2}$ per cent. ad valorem.		Holland 2 per cent. ad valorem.	
Denmark leaves and stems - - -	$\frac{1}{4}d.$	Ditto, cigars - - - - - -	2*d.*
Prussia, Saxony, Bavaria, Brunswick, Wurtemberg, Frankfort on the Maine. — Zoll-Verein States	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 Dutchies of Parma and Lucca, and the Grand Dutchy 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.

In the years 1841, 1842, and 1843, the average revenue in this country on tobacco, at 3*s.* 2*d.* per lb., was 3,635,105*l.*

The greater part of the committee's report is occupied with the examination of witnesses as to the extent, modes, facilities, and chief localities of the illicit trade. It exhibits a great body of very curious and useful information, and demonstrates, beyond a doubt, that no measure short of a reduction of the duty to 1*s.* per lb. can put a stop to it.

The portion of the report most interesting to the readers of the present work will probably be found to be the scientific evidence as to the means of detecting adulteration.

The society of tobacco manufacturers in London, desirous of ascertaining how far chemistry could detect adulteration in tobacco, mixed four samples with different materials. No. 1 contained 5 per cent. of refined sugar; No. 2 10 per cent. of extraneous matter, viz., sugar and common salt; No. 3 15 per cent. of extraneous matter, the one half of it sugar, and the other half a certain powder used by the trade; No. 4 15 per cent. also, consisting of about 3 parts sugar, and 1 part *terra japonica* (catechu). These four samples were placed in the hands of Mr. A. Garden, chemist, of Oxford street, for analysis, who made the following report upon their composition:—

"The leaves of the tobacco-plant, in addition to the vegetable principles of which they are chiefly composed, are known to contain a considerable number of saline and earthy substances, and which no doubt ought to be regarded as legitimate constituents of the plant. The proportion which these saline substances bear to the whole vegetable mass, is, it is true, but small, yet it becomes a question how far the presence of these salts, in quantities somewhat larger than those in which they are generally found to exist, can fairly be referred to a process of adulteration. The five samples of tobacco sent to me for examination do not appear to differ very widely from one another. After the removal of all the vegetable matter, they have, on an average, yielded 14 per cent. of solid substances, consisting of soluble and insoluble saline and earthy compounds, the principal of which are as follows: sulphate and phosphate of lime, carbonate of potash, muriate of ammonia and soda, sulphate of iron, malate of lime, and siliceous earth. The specimens marked 1, 2, and 4,* are exceedingly similar; that marked genuine contains about 2 per cent. less than the others, and the specimen No. 4 (3 as stated above) is remarkable for having yielded a proportion of oxide of iron, which would almost lead to the supposition that sulphate of iron had been introduced. The other samples, it is true, also afforded evidence of the presence of iron, but in such minute quantity as might easily be accounted for by the contact of iron vessels or instruments, in the transports or manipulations to which the articles may have been exposed.

"A. Garden."

Mr. Rogers, chairman of the Tobaconist's Society, who superintended the adulteration, states that no iron or copperas was put into any of them; that Mr. Garden had them some time under process, having received them in May or June, and having made his report on the 26th of August, 1843. "The manufacturers, in consequence of that report, came to the conclusion that the analyzation was not satisfactory, and could not be done, so far as that process was concerned."

Mr. Joseph Hume, M. P., under instructions from the committee, requested two chemists, Mr. Heathfield and Mr. Edward Solly, Jun., each to prepare six samples in the presence of two members of the committee. That was done, and the samples were sent to the Excise Board, and during ten or twelve days were carefully analyzed by the three chemists employed by the board to detect adulteration. The evidence of these three gentlemen, viz., Professor Graham, Mr. Richard, and Mr. George Phillips, will explain the course they took to carry on the analysis; and the following are the results:—

* 6 in the original, but altered by me to 4, as denoting the fourth of the adulterated samples. The fifth was genuine tobacco.

Particulars of Six Samples of Tobacco, prepared as above, in the presence of Sir Charles Douglas, M. P., and Mr. Ewart, M. P., Members of the Committee.

No. I., marked X.

9 lbs. 8 oz. of tobacco, with 1 lib. 8 oz. of garden rhubarb-leaves, about 16 per cent., or 12½ per cent. in 100 parts.

No. II., marked K.

9 lbs. 6 oz. of tobacco, with 1 lib. foxglove leaves. About 10 per cent. added, or 9·52 in 100 parts.

No. III., marked N.

11 lbs. 11 oz. tobacco, mixed with 8 oz. brown paper, soaked in decoction of sarsaparilla. 10½ oz. syrup of sugar, combining solid sugar, 7 or 8 dwts.; 1 oz. of saltpetre, and ½ oz. of alum; in all, 18½ oz. About 8 per cent. added, or 7·54 in 100 parts.

No. IV., marked F.

11 lbs. 14 oz. of tobacco, mixed with chickory root, dried and powdered, Irish moss glutenized, carbonate of potash, sulphate of potash, carbonate of magnesia, and carbonate of lime, about 9 oz., or about 5¼ per cent., or 4 in 100 parts.

No. V., marked O.

13 lbs. 9 oz. of tobacco, mixed with 12 ox. of ground tobacco stalks.

No. VI. marked R.

11 libs. 4 oz. No adulteration.

Report of the Analysis of the first Series of Six Samples by Messrs. Richard Phillips, Graham, and George Phillips, 7th June, 1844.

No. I., marked X.

Adulterated with the leaves of garden rhubarb; the amount of the adulteration is estimated at 3.3 per cent.

No. II., marked K.

Adulterated by a green leaf, not tobacco, which appears to belong to a plant of the same natural family, probably the potato; the amount of the adulteration estimated at 3·9 per cent.

No. III., marked N.

Adulterated with brown paper or millboard. and also with sugar; the amount of the first adulteration is estimated at 6 per cent., of the second 1½ or two per cent.

No. IV., marked F.

Adulterated with a vegetable matter, not tobacco, the nature of which we are not agreed upon. The amount of this adulteration is estimated at 1·2 per cent. There is reason to suspect the addition to this tobacco of both sand and sugar, in small quantity.

No. V., marked O.

Adulterated with sand and sugar; the amount of the first adulteration is estimated at 2 per cent.; of the second at 3 per cent.

No. VI., marked R.

Genuine, but with a proportion of sand usually high.

Particulars of Six Samples of Tobacco, mixed and sealed up at Mr. Rogers's, 392 Oxford street, in the presence of Sir Charles Douglas and Mr. Ewart, by Edward Solly, Jun., Esq.

No. I., marked C.

Adulterated with sugar of milk	5
Terra japonica	1
Nitrate of potash	1
Alum	1
Total per cent.	8

No. II., marked L.

Adulterated with refined sugar	3
Terra japonica	1
Carbonate of potash	1
Common salt	1
Total per cent.	6

No. III., marked Q.

Adulterated with refined sugar	2
Crude nitrate of ammonia	4
Common salt	1
Muriate of potash	0·5
Nitrate of potash	0·5
Alum	1.0
Total per cent.	9

No. IV., marked P.

Adulterated with sugar of milk	5
Refined sugar	3
Common salt	1
Carbonate of potash	1
Total per cent.	10

No. V., marked B.

Not adulterated at all.

No. VI., marked M

Not adulterated at all.

Second Series of Six Samples, signed Rogers and Son, marked as under, analyzed by Messrs. Richard and George Phillips, and Thomas Graham.

No. I., marked C.

Adulterated with sugar, the adulteration estimated at 1 per cent.

No. II., marked L.

Adulterated with sugar, the adulteration estimated at 3 per cent.

No. III., marked Q.

Adulterated with sugar, the adulteration estimated at 2 per cent.

No. IV., marked P.

Adulterated with sugar, the adulteration estimated at 4 per cent.

No. V., marked B.

Genuine; grains of sugar were, however, found in it and picked out, but the quantity so small, that we allow their introduction to be accidental.

No. VI., marked M.

Adulterated with loaf-bread, which has been cut up in the same manner as the tobacco; the amount of this adulteration was not estimated, but is small; the sample contains also a little sugar.

It appears from the preceding statement, that the chemists made no attempt at a true chemical analysis, but contented themselves with a physical examination of the appearances, and with the single process of fermentation to detect sugar, by the production of alcohol; and yet they declare the presence of sugar in the tobacco which contained none; as in samples F, O, and B. They did not search for saline matter, such as nitrate of potash, alum, common salt, nitrate of ammonia, muriate of potash, or carbonate of potash, and in fact do not seem to have made any analytical research for any such foreign bodies; so that if the sugar had been left out (as a skilful adulterator would have done), and if the foxglove-leaves had been well browned by tobacco-juice, none of the adulterations would have been detected.

Mr. R. Phillips says, in his examination before the committee "generally speaking we did not employ chemical tests," but it was principally by mechanical analysis and examination of the plant that they judged. When asked if he could obtain alcohol from sugar of milk, Mr. R. Phillips replies, "I think not." Question 7,555.

"7,597. *Chairman.*—Will you [Mr. R. Phillips] look at your report, letter C, adulterated with sugar estimated at 1 per cent.? I asked you the question, whether you could discover the adulteration, if made with sugar of milk; and your answer was, 'No, I believe not, for I think it would not ferment.'

"7,598. That specimen was mixed with 5 per cent. of sugar of milk, and 3 per cent. of other articles, earthy matters, making altogether 8 per cent.; your report is, 'adulterated with sugar, estimated at 1 per cent.;' how do you reconcile your detecting sugar there, when you said that you could not detect sugar of milk?—I said that I spoke from the best of my recollection, and that is my recollection."

"7,632. Letter O, you [Mr. R. Phillips] report as being 'adulterated with sand and sugar; the amount of the first estimated at 2, and the second at 3 per cent.,' therefore that is reported as adulterated to the extent of 5 per cent.?—Yes.

"7,633. That specimen is stated to be '13 pounds 9 ounces of tobacco mixed with 12 ounces of ground stalk;' what should you say to that? Are you perfectly satisfied that the sugar in this specimen was foreign matter?—I have no doubt of it; and with respect to the increased quantity of sand, that might come in with the increased quantity of stalks, which always contain a larger quantity than leaf-tobacco."

"7,637. But are you the least shaken in your opinion as to this analysis, by its being stated to you, that that which was presented to you was tobacco mixed with 12 ounces of stalk?—*Not the least, neither with respect to sugar nor sand; confirmed with respect to sand, and not shaken with regard to sugar.*"

"7,640. Here is an addition of *eight* per cent. of stalk; do you imagine that that would give *two* per cent. of sand upon the whole amount?—It seems a large amount, but I can not account for it in any other way; it would increase it, but I can not say to what amount."

"7,645. Taking the specimen letter Q, on which you were before examined, in which you have stated, 'adulteration at 2 per cent.;' if informed that eight per cent. of muriate of potash, and other soluble matters were mixed, do you not consider that tobacco might be adulterated by those matters, which you could not discover as adulterations, to the extent of 5 or 6 per cent., without the possibility of detection?—I think they might, with such matter us that, without the possibility of detection."

Mr. R. Phillips says, in answer to question 7,673, that he never saw nicotine, and "never saw anybody that saw it." Now he has seen me often, and I have a specimen of pure nicotine, which I showed to the committee in my examination, and which I shall be happy to show him at any time.

"Mr. George Phillips called in and examined.

"7,767. What situation do you hold in the excise?—That of an examiner.

"7,768. What are the duties of an examiner?—They are various, but I have been employed chemically.

"7,769. How long have you been in that situation?—About two years."

"7,773. Have you been educated as a chemist?—No, I am self-educated."

"7,775. Have you examined all those specimens which have been suspected to be adulterated tobacco?—Yes, I have examined the whole of them.

"7,776. And you were employed at Gainsborough, Liverpool, and Manchester, in those different seizures and trials which took place?—Yes, I was present at the whole of them.

"7,777. You were also associated with Mr. Richard Phillips and Professor Graham, in making inquiries into the 12 samples submitted to you?—Yes."

"7,780. What time did you take in making these experiments?—I think we were about 12 days.

"7,781. In examining the 12 specimens?—Yes.

"7,782. Did you sign the report?—Yes."

His process of examination consists in drying the tobacco thoroughly by a heat of from 176° to 182°, in then weighing out 100 grains of it, in digesting that weight in 2½ pints of water of the above temperature, stirring the mixture with a glass rod, leaving it to infuse for 50 minutes, and then separating the liquid from the insoluble matter by a fine strainer or filter. The insoluble part is gently pressed, dried at the above heat, and weighed. In this way Mr. Phillips found, that—

	Ligneous.	Extractive.
Virginia hand, the entire leaf and stem gave	46	54
Virginia stripped, the stem being taken out	49	51
Do. do.	47	53
Kentucky hand	50	50
Do. do.	55·8	44·2
Do. stripped	54·8	45·2
Do. do.	53·3	46·7
Maryland, not stripped	56·9	43·1
Do. do.	57·7	42·3
Mean of Virginia hand experiments	46	54
Do. do. stripped do.	48	52
Do. Kentucky hand	52·9	47·1
Do. do. stripped	54·05	49·95
Do. do. do.	57·3	42·7

After experimenting upon between 500 and 600 different samples, he has never found any to exceed the highest of the above, which is 54; though he calls it, in his subsequent examination, 55 of extract.

	Ligneous.	Extractive
Porto-Rico tobacco-leaf gave	70	30
Colombia do.	61·5	38·5
Do. do.	60·8	39·2
Virginia stalks	48·5	51·5
Kentucky do.	64·1	35·9
Do. do.	66·4	33·6
Turkey	46·8	53·2

"7,865. Do you know to what natural family tobacco belongs?—Mr. G. Phillips. I am not a botanist."

"7,867. Take the foxglove, for instance?—I can not say whether it belongs to the same family. I know it has not the same character; it is essentially different in character."

Yet the sample marked K, which contained foxglove, maladroitly introduced in the green state, and thus easily distinguishable by the least experienced eye from tobacco, was pronounced by the three chemists to be "adulterated by a green leaf, not tobacco, which appears to belong to a plant of the same natural family, possibly the potato." Digitalis belongs to the family Scrophulariæ, not the Solaneæ, like tobacco.

By selecting such tobaccoes from the above tables as abound in ligneous matter, imbuing them with a quantity of some cheap vegetable extracts not fermentable into alcohol, drying and pressing them properly, it would be easy to adulterate tobaccoes to the amount of 10 or more per cent., and set at defiance this scheme of Mr. G. Phillips. The manufacturer has, of course, a stock of Virginia tobacco at hand, capable of yielding a like proportion of extract, to cover his deception, which he puts into their hands, *pour leur donner le change.*

"7,869. What is the power of microscope you employ?—About 60,000."

Does Mr. G. Phillips mean to say that the linear magnifying power of his microscope is 60,000? There is no such instrument in existence. If he means the area is enlarged by his microscope 60,000 times, he ought to have said so, and the linear power in that case would be about 245 times.

"7,877. In what manner do you obtain saline matter from the tobacco?—I first ascertained the amount of ashes: I took 100 grains of Virginia leaf; I burned it to a red heat, not sufficiently high to drive off anything beyond the carbonaceous matter; those 100 grains of Virginia leaf produced 10·5 of ashes, and it contained 1·3 of sand or silica. The next experiment upon the same leaf gave ashes 11·2, and precisely the same amount of sand as the other, 1·3. The next was upon stalk alone, 100 grains of the same tobacco-stalk; it gave ashes 16·5, and ·4 of sand. The next, stalk and leaf, was upon 62 grains, which gave ashes 8·2, and ·5 of sand (13·2 and 0·8 per cent.) Now we come to the Kentucky: 100 grains of the Kentucky leaf gave ashes 19·5, sand 1·4; ditto 18·4 and 1·4; 47 grains of stalk and leaf gave ashes 9·5, and sand ·8 (20 and 1·7 per cent.); 100 grains of stalk gave 20·4 and ·9. Another experiment gave the same." Here we have nearly double the proportion of sand from leaf that there is from stalks.

Let us compare these experiments of Mr. G. Phillips with the unlucky counter-statement of Mr. R. Phillips. The former actually finds in the one set of stalks only 4 10ths of 1 per ct. of sand, and 1 and 3 10ths, or upward of three times as much, in the leaf; while, in the other set, he finds about one half of sand in the stalks of what was in the leaf. Now Mr. R. Phillips defers to Mr. G. P. as his standard authority on this point. Thus—

"Question 7,580. You [Mr. R. Phillips] are not able to state the exact amount of those saline matters which exist in the different kinds of tobacco?—No, I have never tried."

"7,582. You have not, up to this time, made that experiment in the various inquiries you have made?—No, I have not. I have not thought it necessary.

"7,583. You state that the earthy matter found" (in the ashes) "is silica; do you mean sand?—Yes.

"7,584. What is the greatest or the smallest quantity you have found in the genuine tobacco?—I have not got the proportion; I *perhaps* could find it, but I have it not with me.

"7,585. You do not know the *minimum* or the *maximum?*—No, but I believe that can be stated by Mr. George Phillips very accurately."

"7,633.———.—[Answer of Mr. R. Phillips.] With respect to the increased quantity of sand, that might come in with the increased quantity of stalks, *which always contain a larger quantity than leaf-tobacco.*

"7,634. Would the proportion of sand be accounted for, in your opinion, by the introduction of 12 oz. of stalks?—I think it would."

Why did not the two Messrs. Phillips compare notes beforehand?

"7,878. Besides silica, what did you [Mr. G. Phillips] find?—Number 36, which produced 19·5; gave carbonate of lime 7·3 grains, silica 1·4, carbonate of potash, and a trace of iron, 9·7 grains;* that is, it showed the presence of iron, but there was no appreciable quantity. The object of separating it into lime and potash was, that if there had been an introduction of 5 per cent. of potash, I should have had an increased amount of extractive matter" (soluble, he should say), "and an increased amount of ashes; in genuine tobacco, where the extractive proportion is high, the ashes are low."†

"7,885. Are there any other articles found, besides the silica, and carbonate of lime, and potash?—Not by my mode: both lime and potash exist in tobacco, in various quantities, malate and nitrate, and so on; but the amount of each has never been found by any one."‡

"7,918.———.—*Ans.* The only two kinds of tobacco manufactured worth speaking of, are Virginia and Kentucky, and they come in strips principally. Now the tobacco-manufacturer might endeavor to defeat us in this way; suppose we endeavor to tie him down, he might mix his tobacco not in the proportion that we expect."

The excise, though it has no power to tie the manufacturers *down* so hard and fast that they may not use any duty-paid tobacco which they please, yet it is too apt to give rise to a spirit of evasion. When a low-priced Kentucky, poor in extract, is laid down, it may be easily enriched with 10 per cent. of some vegetable extract to bring it up to Mr. G. Phillips's standard Virginia pitch of 55.

"7,924. Have you subjected the extract to the process of combustion, in order to ascertain its amount of saline matter?—Not the extract; I make a point of preserving part, in order to experiment upon."

Yet he immediately afterward declares he makes no experiments upon it.

"7,928. What do the ashes of C consist of?—We did not try that beyond the sand.

"7,929. You have got the ashes 16 by combustion?—Yes, we suspected this sample to contain sugar, and also tried for sand."

"7,934. Could you not find alum?—Yes, but it would be impossible to try for the various salts that might be put in tobacco; you might be experimenting for years on one sample."

Relatively to Mr. R. Phillips's explanation of the *rationale* of the production of sand, question 7,961 to Mr G. Phillips affords a flat contradiction. "Could the introduction of 12 ounces of ground stalk into 13 pounds 9 ounces of tobacco, give an adulteration of 3 per cent. of sand?—*It is perfectly* impossible; the stalk contains less sand than the leaf."

"8,032. In any of those 12 specimens that you examined, were you able to distin-

* An extraordinary quantity.
† How easy to give this character to tobacco by adding extractive matter from different plants!
‡ What a rash assertion! He missed a uniform and main constituent, the phosphate of lime.

guish any vegetable mixture besides the tobacco ?—We readily distinguished in K, the mixture of foxglove and rhubarb."

There was no rhubarb in K; the foxglove was unluckily conspicuous by its light green color, and easily picked out. Answer to question 7,858: "So also as regards the rhubarb, the rhubarb is very full of massy strong hairs, which are something like bodkins rather round; they are larger at the end; in fact, where the points of the hairs of tobacco are small, the rhubarb swell out and increase and cross each other in various directions, while those of the tobacco are flattened at the top."

Has the foxglove the same massy hairs as the rhubarb ?

With regard to the production of alcohol from the samples of adulterated tobacco, Mr. E. Solly, in his examination before the committee, makes the following observations in answers to questions 8,350, 8,352: "Then you do not consider the mode by which saccharine matter is said to be detected at present to be a good and sufficient test ?—I should receive it with very great caution."

"8,352.—*Ans.* I believe that tobacco contains substances that may give rise to the formation of spirit; therefore I think it possible, until the contrary has been proved. that spirit may be formed from fermenting pure tobacco."

Seven samples of tobacco, mixed under the superintendence of the committee, as above described, were sent to me on the 18th of June last, for analysis, marked B B, C C, F F, M M, O O, Q Q, X X, which I now presume were of like composition to the parcels marked B, C, F, M, O, Q, X, in those sent to the excise. As I operate always alone in my laboratory, I required naturally a considerable time to perform the several sets of experiments which I deemed requisite *in trying* to detect adulterations in so heterogeneous a compound as tobacco. In my first examination before the committee, on the 15th of July, I stated that my first line of research had been to determine the proportion of azote in each of the above specimens, and compare it with that in genuine tobacco, with the view of ascertaining into which of the parcels non-azotized plants, such as rhubarb and other indigenous leaves, might have been introduced. For this purpose, I took a weighed portion of each tobacco, dried it thoroughly by a gentle steam heat, and found thereby how much moisture it contained.—*See second table below.*

	Ammonia.		Azote. in 100 grains.
B B when dry, afforded, by ignition with hydrate of soda and quicklime, in an appropriate apparatus	2·55	=	2·1
C C afforded	2·49	=	1·89
F F "	2·38	=	1·96
M M "	3·06	=	2·52
O O "	2·72	=	2·24
Q Q "	3·6	=	2·97
X X "	2·72	=	2·24
Virginia (genuine)	2·6	=	2·14

I was now convinced that no good purpose could be served by this process of analysis, since it appeared that the differences in the proportions of azote resulting from the different proportions of nicotine, albumen, gluten, &c., in the tobacco, were too slight, and most probably too variable, from soil, climate, and mode of culture, to be relied on as tests of purity; and more especially when I found, on trial, that the dried leaves of foxglove afforded 1·96, or nearly 2 per cent. of azote, and that this plant was one likely to be used in making the adulterations. Besides, it appears that X X, which I now perceive to have contained 16 per cent. of rhubarb-leaves, afforded as much azote as O O, which was altogether tobacco. Practical chemists are aware that each of the above experiments requires no little time, as well as nicety of manipulation. The results may, I believe, be depended on; they were derived in each case from the decomposition of 50 grains of the dried tobacco. I next dried by a gentle heat, continued for several hours, as long as weight was lost, 200 grains of each sample.

		Dry.	Water at 70° F.		Spec. grav. of infusion.	Residuum dried.	Soluble matter or extract
B B lost	11·75 per ct. and	100 gr. +	1,000	=	1·017	59·5	40·5
C C "	14·5	"	"	=	1·0184	54	46
F F "	15	"	"	=	1·017	60	40
M M "	14·75	"	"	=	1·015	71	29
O O "	15·5	"	"	=	1·018	62	38
Q Q "	17·5	"	"	=	1·021	72	28
X X "	17·75	"	"	=	1·019	67	33
Virginia leaf	6·5	"	"	=	1·015	53	47

In a second series of experiments, where 100 grains of each of the dried tobaccoes, as under, were digested for two hours in 4,000 grains of distilled water, at the temperature of 176° F., the following results were obtained :—

	Dried residuum.	Soluble or extract.
B B - - - -	56·7	43·3
C C - - - -	56·0	44·0
F F - - - -	54·7	45·3
M M - - - -	63·7	36·3
O O - - - -	58·2	41·8
Q Q - - - -	54·0	46·0
X X - - - -	57·7	42·3

Thus, by a longer digestion with heat, and a larger quantity of water, more soluble matter or extract is obtained, and also in different proportions, from the same samples:

	Dried residuum.	Soluble or extract.
Havana tobacco - - -	60·1	39·9
Cuba - - - -	62·1	37·9
Virginia - - - -	53·9	46·1
Kentucky - - - -	57·2	42·8

It may, moreover, be remarked, that none of the tobaccoes, either adulterated or genuine, yielded so great a proportion of extract as Mr. G. Phillips asserts.

It will be observed from the table of the specific gravity of the infusion of 100 grains of the respective tobaccoes, in 1,000 grains of water, at 70° F. (with trituration in a mortar), that Q Q afforded the densest liquor, having a specific gravity of 1·021. I was hence led to imagine that this sample was adulterated with some soluble substances, and possibly with sugar, of which such a handle had been made in the excise prosecutions. I therefore boiled 1,000 grains of that sample with 5,000 grains of distilled water, and evaporated the soluble matter to a solid extract, which weighed 400 grains. These were next digested in 3,000 grain-measures of alcohol of 0·834, and they left 330 grains insoluble in this menstruum. The matter insoluble in alcohol should have contained the sugar if any were present; but when it was treated with nitric acid of proper density and temperature, it afforded no oxalic acid whatever; even by the test of chloride of calcium. Hence I inferred that if sugar had been mixed with that tobacco, it could not be discovered by probably the best test of sugar in common circumstances; and indeed, on looking now into the actual composition of sample Q, we find it to contain only 2 per cent. of sugar, mixed with 4 of nitrate of ammonia, 1 of common salt, 1 of the mixed nitrates of potash and muriate of potash, and one of alum. As the infusion of 100 grains of X X in 1,000 of water was next in density, being 1,019, I treated 1,000 grains of it as I had done with Q Q, and obtained 600 grains of watery extract, which, being digested in alcohol, left 330 grains like the preceding. When this also was treated with nitric acid, it afforded no oxalic. I therefore abandoned this line of research as unprofitable.

It occurred to me that muriate or nitrate of ammonia might have been employed in adulterating some of the samples of tobacco. To ascertain this point, I distilled 100 grains of each sample along with water and quicklime, condensing the vapors, and testing the distilled liquid for ammonia :—

B B afforded - - - -	0·68	of ammonia.
C C " - - - -	0·34	"
F F " - - - -	0·347	"
M M " - - - -	0·51	"
O O " - - -	0·238	"
Q Q " - - - -	0·765	"
X X " - - - -	0·68	"
Kentucky - - - -	0·58	"
Virginia - - -	0·64	"

Ammonia exists in the saline state in all tobaccoes, but here in Q Q in notable excess, corresponding to the 4 per cent. of crude nitrate of ammonia, which had been introduced by the mixers. So far this experiment has a positive result.

The filtered cold infusions of 100 grains of each dried sample in 1,000 grains of distilled water were examined by many chemical tests, as follows :—

1. Virginia taken as a standard :

Infusion pale brown; acid reaction with litmus paper; nitrate of barytes, O; nitrate of silver, a faint opalescence, but no curdy precipitate; oxalate of ammonia, a faint cloud of calcareous matter; water of ammonia, O: chlorure of tin, a faint white precipitate—hence no sulphuretted hydrogen present; chloride of platinum, a copious white precipitate, from the ammoniacal salt present; acetate of lead, an abundant whitish precipitate, soluble in nitric acid; chloride of iron caused a green tint, and sulphate of copper an olive brown, both resulting from the yellow of the iron and blue of the copper solutions with the brown of the tobacco.

B B afforded the same results with the above tests as the Virginia tobacco: hence it might be inferred to be free from soluble sulphates, muriates, carbonates, &c.

C C, acid reaction like the preceding; nitrate of barytes, a precipitate which, being drained on a filter, washed, dried, and ignited, weighed 2·2 grains; resulting, as it now appears, from the 1 per cent. of alum introduced into that sample.

F F afforded 2·6 sulphate of barytes, resulting from the sulphate of potash introduced into this sample.

M M afforded 0·6 of sulphate of barytes, a quantity belonging to this description of tobacco, derived, no doubt, from the soil—indicating possibly the proportion that should be deducted from that afforded by C C and F F.

O O afforded 0·5 of sulphate of barytes, indicating freedom from any added sulphate.

Q Q, 1 grain of sulphate of barytes, corresponding to the 1 per cent. of alum, which was possibly not uniformly diffused through the parcel; so that probably more of it existed in the portion taken for experiment of C C, than in that taken of Q Q.

X X, sulphate of barytes, 0·8; the small excess here over pure tobacco due to the admixture of rhubarb-leaves. It is to be observed that all these barytic precipitates were insoluble in nitric acid.

After separation by the filter of the barytic precipitates, from the infusions made *with heat*, a definite quantity of solution of nitrate of silver was added to each at once, because it was found impossible to define the point at which that test ceased to produce a change. The phenomena here were singular and puzzling. The phials containing the infusions of B B, C C, F F, O O, had their sides coated with a lively green film; that with X X slightly; those containing M M and Q Q, with a brown film; as also those from the Virginia, Kentucky, Havana, and Cuba tobaccoes; while the contents of F F remained turbid after many days. From these phenomena, it appears that nitrate of silver can not be advantageously used as a test upon infusions of tobacco made with hot water.

When the infusions of the tobaccoes are made in the cold, those hydrogenated principles, which seem to reduce a portion of the oxide of the nitrate of silver, and render its precipitate insoluble in ammonia, are not apparently generated. The nitrate of silver in this case gave the following results:—

B B	out of 100 grains infused, yielded - -	1·8 chlorsilver.
C C	- - - - - -	1·0 "
M M	- - - - - -	1·3 "

These quantities belong to genuine tobacco, as I found on trying the Virginia. The precipitates were insoluble in nitric acid.

My next series of experiments was instituted to determine, by fermentative action, with the addition of good yeast to the infusions of the respective samples, whether sugar could be detected in any of them by the production of alcohol. Accordingly, I infused half a pound avoird. = 3,500 grains of each in 4,000 grains of boiling water, strained off the liquor into wide-mouthed phials, introduced into each 800 grains by weight of the best fresh porter-yeast from Messrs. Meux's brewery in my neighborhood, and enclosed them all in a space kept at the temperature of 80° F. The specific gravity of each, before the yeast, was very nearly 1·08. After 40 hours, the specific gravities were found to be (at 80°) of—

B B - - -	1·055	O O - - -	1·049
C C - - -	1·062	Q Q - - -	1·0645
F F - - -	1·055	X X - - -	1·0575
M M - - -	1·056		

The contents of F F being distilled carefully in glass vessels, 700 water-grain measures of liquid were drawn off, which, at 70° F., had the specific gravity, 0·9921.

The contents of O O afforded 700 grain-measures of specific gravity, 0·9876; besides 500 grain-measures —— of 0·9974.

Contents of B B afforded 700 grain-measures of 0·9946, and 240 grain-measures of 0·998.

From 2,400 grains by weight of the yeast, 700 grain-measures of liquor were distilled off, at specific gravity, 0·983.

On the hypothesis that the liquor distilled from the infusions of the three samples of tobacco were alcoholic, the 700 grains of F F would contain about 10 per cent. of proof spirit, or nearly 70 grains.

Alcoholic spirits of 0·983 specific gravity contains 23·3 per cent. of proof spirit; hence 7×23·3= 163·1 grains, of which one third=54·4 grains, being the product of 800 grains of yeast, had been introduced into each of the tobacco worts. The product of F F is therefore 70—54·4= 15·6 grains of proof spirit, containing about 7 grains of alcohol—a paltry result, and much too fallacious, whereon to found a fiscal persecution, as we shall presently show.

O O, yielded 700 grain measures of 0·9876, equivalent to 16 per cent. of proof spirit =112 grains, besides 500 grains of 0·9974, equivalent to 3·2 per cent. of proof=16 grains of proof; together=128 grains, from which 54·4 being deducted on account of the yeast spirit, there remain 73·6 of apparent spirit, as the product of the tobacco wash of half a pound of O O.

B B afforded 760 grains at 0·9946, representing 6·7 per cent. of proof=50 grains of proof; to which 8½ grains for 240, at 0·998, the sum 58½ represents the whole obtained for this wash, and 54½ being deducted for the yeast spirit, there will remain 4 grains of proof spirit, corresponding to 2 grains of alcohol and 4 grains of sugar in 3,500 grains of the tobacco.*

The only inference that can be drawn from these results of experiments carefully conducted on the principles assumed as certain by Professor Graham and the Messrs. Phillips, is, that the sample O O contained 73.4 grains or thereby of sugar mixed in the half pound of tobacco; that F F sample contained about 15·6 grains, and B B 4; whereas, as it appears in the published report that there was no sugar in any one of the three samples, the fallacy of the excise process is manifest.

It would therefore seem, that infusions of tobacco without sugar, when mixed with brisk yeast, and placed for 40 hours in a temperature of about 80°, undergo a certain degree of decomposition, attended with a diminution of their specific gravity, or, in the vulgar language of the excise, they suffer attenuation. This phenomenon offers no difficulty to any one conversant with organic chemistry. He knows that there are no fewer than twelve different species of fermentation, all involving a specific series of decompositions and recompositions, each occupied with its appropriate subject, and generating peculiar products. See FERMENTATION in this supplement. I shall advert, in this place, merely to that marvellous metamorphosis which bitter almonds experience by contact of pure water; during which, aided by heat alone, the solid inert matter of the kernel is converted into a volatile, pungent, poisonous, ethereal oil, mixed with hydrocyanic or prussic acid, a fluid lighter than water. Such remarkable changes must be well known to Mr. R. Phillips and Professor Graham, and ought to have made them hesitate before they pronounced a distilled fluid, which is destitute of the smell and taste of alcohol, and which they do not say they had submitted to the requisite ordeal, to be this substance.

If by fermenting the infusion of 3,500 grains of tobacco, my distilled products were so slight and fallacious, what could the chemist get from 1,000 grains? or, as Mr. Graham is wont to operate, from 200 grains, or less than half an ounce? See Question 7,548. Have they ever converted their supposed alcohol into ether, have they made fulminating mercury by its means, or have they extracted olefiant gas out of it? If not, their testimony would have been scouted in any of our great courts of judicature.

If sugar be present in any notable proportion, I think that it should be found by evaporating the watery extract to dryness, digesting the extract in alcohol, and then treating the residuum properly with nitric acid. From the quantity of oxalic acid formed, the proportion of sugar might possibly be approximately estimated. I am not aware that there are any principles in tobacco itself which would give rise to the formation of oxalic acid; but this point could be easily set at rest by preliminary experiments. I tried this method, and obtained, as I have stated, no oxalic acid from the samples subjected to the process.

The last series of experiments which I made upon the samples of tobacco sent to me by the committee, was the incineration of 500 grains of each in a platinum basin, and the analysis of the ashes. The results per cent. were as follows:—

	Total ashes in 100.	Carbonate of potash.	Silica.	Phosphate of lime.	Carbonate of lime.	Sulphate of barytes.	Chloride of silver.
B B	15	1·6	2·4	2·8	7·1	1·4	2.6
C C	15·6	2·166	2·0	3·8	5·2	3·0	0·7
F F	16·3	1·82	2·9	2·4	8·1	1·5	0·5
M M	16·4	1·75	3·1	4·2	6·3	1·66	5·0
O O	13·2	1·82	2·6	1·6	5·4	1 35	0·6
Q Q	16·0	2·4	1·6	3·7	4·9	3·2	3·7
X X	14·2	2·66	1·1	2·1	6·4	1·6	0·4
Virginia leaf	12·6	1·65	1 {0·6} 2 {0·7}	2·1	6·8	1·1	0·95
Kentucky	13·25	3·00	0·6	2·2	lost	1·25	lost

* I have not deemed it necessary to convert water-grain measures into weights, or *vice versa*, in this frivolous speculation.

The results here stated may be relied on, as they were the mean of many very deliberate experiments. They show that there are great variations in the proportions of the constituents, even in the five genuine tobaccos; B B, M M, O O, Virginia and Kentucky. But the alum in C C and Q Q, is indicated by the larger proportion of sulphate of barytes, obtained by precipitating the matter soluble in water, and acidulated with nitric acid, by means of nitrate of barytes. The sulphate of potash in F F had been probably decomposed into carbonate during the ignition, along with carbonate of lime and carbonaceous matter; and has thereby escaped notice in the column of sulphate of barytes.

I tried each of the aqueous infusions of the fresh samples with solution of gelatine, but obtained no indication of tannin, as should have happened with C C, in consequence of the introduction into it, of 1 per cent. of terra japonica or catechu.

Finally, I regret exceedingly, that so short a space of time was allowed me for making and digesting all these various researches, prior to my examinations before the committee. Even my report supplementary to my oral evidence, was given in before I had finished my experiments on the action of nitric acid upon the tobacco extracts, and hence I mention there my having obtained crystals of oxalic acid, which turned out upon further examination to be no such thing.

The following analysis of 10,000 parts of fresh tobacco, by Posselt and Reimann, will show the exceeding complexity of this substance:—

Nicotine	6	Chloride of potassium	6·3
Nicotianine	1	Potash combined with malic and niric acids	9·5
Extractive matter, slightly bitter	287	Phosphate of lime	16·6
Gum with a little malate of lime	174	Lime in union with malic acid	24·2
Green resin	26.7	Silica	8·8
Vegetable albumen	26·0	Woody fibre	496 9
Substance analogous to gluten	104 8	Water (traces of starch)	8828·0
Malic acid	51·0		
Malate of ammonia	12·0		10000·0
Sulphate of potash	4·8		

In *Silliman's Journal*, vol. vii., p. 2, a chemical examination of tobacco is given by Dr. Covell, which shows its components to have been but imperfectly represented in the above German analysis. He found, 1, gum; 2, a viscid slime, equally soluble in water and alcohol, and precipitable from both by subacetate of lead; 3, tannin; 4, gallic acid; 5, chlorophyle (leaf-green); 6, a green pulverulent matter, which dissolves in boiling water, but falls down again when the water cools; 7, a yellow oil, possessing the smell, taste, and poisonous qualities of tobacco; 8, a large quantity of a pale yellow resin; 9, nicotine; 10, a white substance, analogous to morphia, soluble in hot, but hardly in cold, alcohol; 11, a beautiful orange-red dye stuff, soluble only in acids: it deflagrates in the fire, and seems to possess neutral properties; 12, nicotianine. In the infusion and decoction of the leaves of tobacco, little of this substance is found; but after they are exhausted with ether, alcohol, and water, if they be treated with sulphuric acid, and evaporated nearly 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 uncrystallizable compounds with vegetable acids.

According to Buchner, the seeds of tobacco yield a pale yellow extract to alcohol, which contains a compound of nicotine and sugar.—*Repertorium für die Pharmacie*, vol. xxxii.

MM. Henry and Boutron Charlard found in

1,000 parts of Cuba tobacco	8·64 of nicotine;	
Maryland	5·28	
Virginia	10·00	
Ile et Vilaine	11·20	
Lot et Garonne	8·20;	quantities from 12 to 19

times more than were obtained by Posselt and Reimann.

I shall conclude this examination of the tobacco report with a few remarks upon the pretences of the Messrs. Phillips and Graham to botanical and microscopic skill in distinguishing the minutest filaments of shag tobacco from those of other plants. Having applied a good achromatic microscope to this object along with my son, who is familiar with the use of that instrument, I must acknowledge that I would place exceedingly little reliance on the possibility of distinguishing such vegetable leaves as I could easily select for the adulteration of tobacco; and I will engage to set at fault even the superior accomplishments of Professor Lindley.

"6,999. When a vegetable fibrous addition is made to the ordinary tobacco, and so ground and minutely divided as not to allow an examination by the glass, could you distinguish it from tobacco?"—Mr. Graham's answer: "It would be extremely difficult to divide it so finely as not to present a sensible magnitude to the microscope. I have never met with tobacco manufactured for sale as shag-tobacco, in which I could not distinguish it."

Mr. R. Phillips, in reply to question 7,511: "Generally speaking, we did not employ any chemical tests."

"7,512. Then it was principally by mechanical analysis, and examination of the fibre of the plant, that you judged?—Yes, certainly."

Answer to question 7,523: "You may distinguish it (tobacco) not by the naked eye, but by the microscope."

"7,856. Can you [Mr. G. Phillips] distinguish the fibre of tobacco from the fibre of dock, or any other vegetable of the same family?—Yes.

"7,857. In how small a quantity can you detect it?—However small the quantity, if you take pains, you can discover it: nothing can be finer than the sample K, in which there was foxglove."

Professor Lindley and Mr. George Phillips distinguish tobacco from other plants chiefly by the structure of its hairs. But in Geiger's "Pharmaceutische Botanik," the second edition, improved by Nees von Esenbeck, and Heinrich Dierbach, a book of standard authority, the *Nicotiana tabacum* of Linnæus, which is the Florida tobacco of the French botanists, is described as having smooth (*glabra*), somewhat glutinous leaves. Several varieties of this plant are said to be cultivated under peculiar provincial names, to which the *Nicotiana petiolata*, *Nicotiana decurrens*, &c., belong; all with *smooth* and blistery leaves.

In my examination before the committee on the 15th of July, in answer to question 8,569, I said—"The conclusion to which I am led is this, that when the tobacco is brought in this shag state, it is next to impossible, by chemical means in most cases, or by physiological means, to determine the adulteration; the only case in which adulteration can be detected, in my opinion, is when sugar is mixed.

"8,570. Does the presence of alcohol, by distillation from a fermented solution, give you an invariable test that sugar is present?—If sugar is present in any quantity above 5 per cent., I think alcohol may be produced from it."

But I would never content myself with the deceptious test of the specific gravity of a minute portion of the distilled liquid. I would take at least seven pounds of the suspected tobacco, rinse it rapidly in cold water, in order to dissolve out the saccharine matter, with as little as possible of the tobacco extract; mix it with a certain quantity of yeast; take the specific gravity of the mixture; set it in a chamber heated to 80° F., and watch the phenomena of fermentation, if any occur. At the end of 40 hours, or whenever the density of the mixture had sunk to the lowest point, I would note it; then distil, rectify the distilled liquor, and expose it to the appropriate tests of alcohol, as stated above. I am quite convinced that no certainty could be obtained by operating upon the infusion of 200 grains of a tobacco containing 5 or 10 per cent. of sugar, as Professor Graham, in his evidence before the magistrates in the Gainsborough prosecution, said he had done with the tobacco then in question. The total quantity of sugar that could be present was under 20 grains, and this being mixed with tobacco-juice, which counteracts the fermentative process, would afford a most unsatisfactory quantity of alcohol—a quantity most difficult of verification; one on which, in my humble apprehension, knowing, as I do, the fallacy of chemical experiments and experimenters, no person should ever venture to seek a verdict, or to levy a heavy fine.

"8,589. Then you are of opinion that it will be impossible, if care be taken, such as you state, by chemists, for detection to be within the power of the government?—Quite impossible. I will pledge my chemical character to make such specimens as the excise can not detect.

"8,590. Then to continue the system of alleged detection by analysis might subject individuals to punishment most unjustly.

"8,591. Have any cases come under your knowledge of errors in judgment upon that point?—There is a case which has lately occurred to me of a very unjustifiable kind on the part of the excise, aad I think I might mention it. It is a case of pepper.

"8,592. Will you describe the case?—About a year ago, the excise officers entered the premises of Messrs. Mayor and Dove, large spice merchants in Little Distaff Lane, and seized a quantity of ground white pepper, alleging it to be adulterated, and carried it off. I attended the court of excise. Professor Graham and Mr. George Phillips, the two witnesses as to the adulteration on the part of the excise, were first examined, and they swore that the seized pepper contained sago to the amount of 10 or 12 per cent., and they produced a few particles like sago in a very small pill-box." [For the other details, see the article Pepper in this Supplement.]

"8,596. From the advance of chemical science, suppose the excise office to have your assistance, or the assistance of other experienced chemists, do you think that, with all that assistance, they could detect an adulteration that might, with perfect facility, be introduced by chemists ?—I would say that adulteration may be made upon tobacco which may defy all the chemists in Europe to find out.

"8,597. And not only chemists, but physiologists ?—Yes, and botanists."

It will be seen, from the vagueness of the results of the several series of experiments which I made on the seven samples of tobacco sent to me by the committee, with every possible attention in the short period allowed me, that it is no easy matter to detect adulterations in tobacco; and a chemist should be extremely cautious in pronouncing a decided opinion upon such slender grounds as the professional gentlemen employed in the excise board have in many cases done. Supposing a tobacco poor in extractive matter, like the Kentucky, were skilfully imbued with juice of liquorice till it came to the standard of the Virginia, neither Mr. G. Phillips, by his plan of infusion, nor Professor Graham, by that of fermentation, could detect the adulteration. The liquorice-juice assimilates with tobacco better even than sugar, but "it is incapable of undergoing the spirituous fermentation."*

I offer this one example, out of many, merely as a hint to my brother chemists to be somewhat less confident and dogmatical in their decisions. Were the questions of tobacco adulteration referred to one of our law courts in Westminster or Guildhall, the evidence of the chemists for the prosecution would be weighed in a more ticklish balance than that of a provincial justice of the peace, or even of the honorable commissioners of excise, and it might possibly be found *wanting*.

How vexatiously inquisitorial, and how abhorrent from the genius of the British constitution, must the practice of the excise board be, when the following regulations are recommended by its most influential functionary! To question 8,005, Mr. George Phillips replies—"I would make the manufacturers responsible for the samples which they gave; for instance, we know very well there are only two tobaccoes used for general cutting tobaccoes, that is, Kentucky and Virginia; we know the nature of those, and we very well know what description of tobacco the manufacturer must use to make it answer his purpose. A tobacco which will not yield 45 per cent. of extractive, is not fit for him to use. If he sent a sample which should be 35, such as Porto Rico, or got some rubbishing stuff from the sales at the tobacco warehouse, *I would not allow that sample to be used*, or at any rate to be mixed with any other; if he used that, he should use that alone; he should be confined within a range, which experience has proved to be the general range." No choice for taste is to be allowed. Again, to question 8,023, he answers, "Sometimes the seizures are made before the tobacco is examined; sometimes seizures are made afterward, upon *my* report that it is adulterated. The officers send a sample up unknown to the manufacturer: they *take a sample unknown* to the manufacturer, and then, after I have examined it, instructions are sent to the supervisor, that any tobacco of that sort that he can find on the manufacturer's premises, he should seize. If the tobacco is seized merely upon the examination of the sample, samples taken from the bulk of the seizure are then sent up and examined. I could mention cases where samples have been sent up by the supervisor or other officer, and have been examined, they have gone and seized, after the lapse of a fortnight, and it has turned out that the tobacco has been pure when it has been examined; of course, that has been returned again." Question 8,024: "How small an amount would you report to be adulterated? *Two per cent.*"

Every intelligent reader of the experimental and other evidence detailed in the present article, must perceive the precariousness of decisions based upon an adulteration of only 2 per cent., in so complex a substance as tobacco, that adulteration being sworn to in consequence of such unsatisfactory microscopic and chemical researches. What a servile spirit must be engendered among the tributaries to the excise, when thirteen eminent tobacconists of London could recently petition the House of Commons to aggravate the astringent administration of that tribunal, *praying* that adulterations detected by its officers should be prosecuted more rigorously; and the efficiency of the law be "further secured by the abolition of compromise, publicity by prosecution in the local courts or otherwise, and the substitution of *personal* for pecuniary penalties."

What powerful inducements are held out to Mr. George Phillips and his coadjutors to obtain convictions for adulterations of tobacco, may be inferred from the fact, that "all penalties and seizures are by law divisible in equal parts, between the crown and the informer;" 1, to the person by whom the information was communicated; 2, to the officers by whose instrumentality, and *subsequent aid*, proceedings for penalties are brought to a successful termination. In all other cases, liberal means of remuneration are placed at the disposal of the board of excise.—See *Memorandum as to rewards for information given to the Excise*, p. 584, *Tobacco Report*.

* Liebig, Chimie Organique, iii., 43.

TORTOISE-SHELL is manufactured in 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, the edges are in the cleanest possible state, without grease, 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.* 166, is bent like an arch in the direction of the

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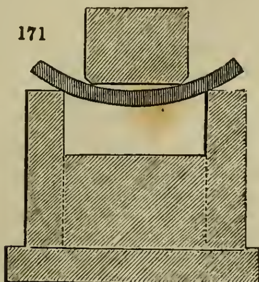

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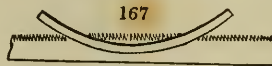

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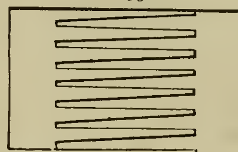

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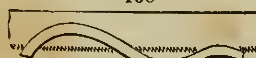

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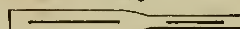

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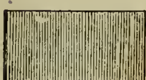

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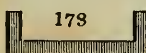

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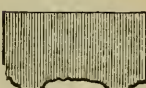

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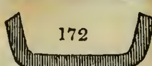

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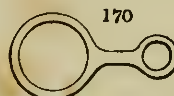

length of the teeth, as in *fig.* 167. The shell is then flattened, the points are separated with a narrow chisel or *pricker*, aud the two combs are finished, while flat, with coarse single-cut files and triangular scrapers. They are finally warmed, and bent on the knee over a wooden mould, by means 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' comb-cutting machine, *Trans. Soc. Arts*, vol. xlix., part 2, since improved by Mr. Kelly. In making the frames for eye-glasses, spectacles, &c., the apertures for the glasses were formerly cut out to the circular form, with a tool something like a carpenter's centre-bit, or with a crown saw in the lathe. The discs so cut out were used for inlaying in the tops of boxes, &c. This required a piece of shell as large as the front of the spectacle; but a piece one third of the size will now suffice, as the eyes are *strained* or *pulled*. A long narrow piece is cut out, and two slits are made in it with a saw. The shell is then warmed, the apertures are pulled open, and fastened upon a taper triblet of the appropriate shape; as illustrated by *figs.* 168, 169, and 170. The groove for the edge of the glass is cut with a small circular cutter, or sharp-edged saw, about three eighths or half an inch in diameter; and the glass is sprung in when the frame is expanded by heat.

In making tortoise-shell boxes, the round plate of shell is first placed centrally over the edge of the ring, as in *fig.* 171: it is slightly squeezed with the small round edge-block *g*, and the whole press is then lowered into the boiling water: after immersion for about half an hour, it is transferred to the bench, and *g* is pressed entirely down, so as to bend the shell into the shape of a saucer, as at *fig.* 172, 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.* 173, 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.

TURPENTINE, SPIRITS, ESSENCE, OR OIL OF. Camphen is the new name given by the continental chemists to every ethereous or volatile oil, which is composed of 5 atoms of carbon and 8 of hydrogen, and which combines directly with hydrochloric acid, either into a solid or a liquid compound, resembling camphor. Under this title the following oils are included: turpentine, citron, or lemon, orange-flower, copaiva, balsam-oil, juniper, cubebs, and pepper. Some add to this last—the oils of cloves, valerian, and bergamot. As the new patent lamps burn spirits of turpentine, they have been called Camphine. (See LAMPS.) Since that article was printed I have had occasion to test a variety of Camphine lamps during the preceding three months, and I am convinced the patent Vesta lamp of Mr. Young is not merely the best, but it is the only one hitherto made public, which can be used with comfort in closed apartments. It was the first spirit lamp constructed on right principles, keeping in view the peculiar nature of Camphine spirits, and being secured by a correct specification, leaves no room to expect another equally good. In this lamp the burner is completely insulated from the reservoir by a ring of wood, or other non-conducting material, placed between them, and as no metallic tube passes down from the flame into the volatile spirits, they remain cold; whereas, when such a tube passes down through the reservoir, for the admission of air to the inside of the flame (as in all other argand lamps), without being insulated from the flame, the spirits become 20 or 30 degrees hotter, so as to emit acrid and offensive fumes. The wick also, which embraces the heated tube becomes dry and resinous, loses its capillary power, coals at the flame, and then sends up smoke with a shower of lamp black.

The Vesta lamp is free from these defects, and when used with properly rectified spirits, never smokes nor smells; it may be easily distinguished by the above characters, and by the circumstance of the air passing between the wicks to the interior of the flame. It affords, undoubtedly, the brightest, cleanliest, and most economical light, hitherto invented, when supplied with pure spirits free from rosin. I have lighted my drawing-rooms with the Vesta lamp for several evenings successively, without having its wick trimmed or its occasioning the slightest inconvenience. I therefore deem it due to the patentee's ingenuity, as well as to the public welfare, to give this deliberate opinion at a time when the volatile spirits of turpentine are getting into general use, and when, if burned in lamps on the argand plan, they must create danger.

Great care must be taken in the choice of the spirits of turpentine as the combustible. As those very generally sold in London contain rosin and other impurities, they are quite unfit for that purpose; but the spirits manufactured by Messrs. John Tall and Co. of Hull, to be had of their agents, Ratcliffe and Co., 103 Hatton Garden, London, answer perfectly. I have subjected these spirits to careful chemical examination, and I find them to be quite pure, and very different indeed from those on common sale here. Their specific gravity is only 0·864 at 62° Fahr., while that of the average London article is from 0·874 to 0·882, the greater density being due to rosin. Messrs. Tall's spirits may be boiled off in a retort without leaving any sensible residuum, and they also boil at a lower degree of heat; but the best proof of their excellence, in the present point of view, is exhibited in the preceding notice of the Vesta lamp, for it was Messrs. Tall's spirits which were used on that occasion.

V.

VENTILATION. There are two general plans in use for at once diffusing heat and renewing the air in extensive buildings, which plans differ essentially in their principles, modes of action, and effects. The oldest, and what may be called, the *vulgar* method, consists in planting stoves in the passages or rooms, to give warmth in cold weather, and in constructing large and lofty chimney-stalks, to draw air in hot weather out of the house, by suction, so to speak, whereby fresh air flows in, to maintain, though imperfectly, an equilibrium of pressure. In apartments, thus warmed and ventilated, the atmosphere is necessarily rarer than it is out of doors, while, in cold weather, the external air rushes in at every opening and crevice of door, window, or chimney—the fruitful source of indisposition to the inmates.

The evils resulting from the stove-heating and air-rarefying system were, a few years ago, investigated by me, in a paper read before the Royal Society,* and afterward

* I had been professionally employed by a committee of the officers of the customhouse, to examine the nature of the malaria which prevailed there, but I had no concern in erecting the stoves which caused it.

published in several scientific and technological journals. It is there said that the observations of Saussure, and other scientific travellers in mountainous regions, demonstrate how difficult and painful it is to make muscular or mental exertions in rarefied air. Even the slight rarefaction of the atmosphere, corresponding to a low state of the barometer, at the level of the sea, is sufficient to occasion languor, lassitude, and uneasiness, in persons of delicate nerves; while the opposite condition of increased pressure as indicated by a high state of the barometer, has a bracing effect upon both body and mind. Thus, we see how ventilation, by the powerful draught of a high chimney-stalk, as it operates by pumping out, exhausting and attenuating the air, may prove detrimental to vivacity and health; and how ventilation, by forcing in air with a fan or a pump, is greatly to be preferred, not only for the reason above assigned, but because it prevents all regurgitation of foul air down the chimneys, an accident sure to happen in the former method. Genial air thrown in by a fan, in the basement story of a building, also prevents the stagnation of vapors from damp and miasmata, which lurk about the foundation of buildings and in sewers, and which are sucked in by the rarefying plan. Many a lordly mansion is rendered hardly tenantable from such a cause, during certain vicissitudes of wind and weather.

The condensing plan, as executed by the engineers, Messrs. Easton and Amos, at the Reform Club House, consists of a large fan, revolving rapidly in a cylindrical case, and is capable of throwing 11,000 cubic feet of air per minute, into a spacious subterranean tunnel, under the basement story. The fan is driven by an elegant steam-engine, worked on the expansion principle, of 5 horses' power. It is placed in a vault, under the flag-pavement, in front of the building; and as it moves very smoothly, and burns merely cinders from the house fires, along with some anthracite, it occasions no nuisance of any kind. The steam of condensation of the engine supplies 3 cast-iron chests with the requisite heat for warming the whole of the building. Each of these chests is a cube of 3 feet externally, and is distributed internally into 7 parallel cast-iron cases, each about 3 inches wide, which are separated by parallel alternate spaces, of the same width, for the passage of the air transversely, as it is impelled by the fan.

Fig. 174 is a transverse vertical section of the steam-chest, for heating the air; *fig.* 175 is a plan of the same; and *fig.* 176 is a perspective view, showing the outside casing, also the pipe *a*, for admitting the steam, and the stop-cock *b*, for allowing the condensed water to escape.

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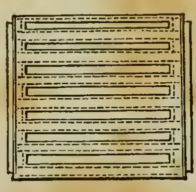

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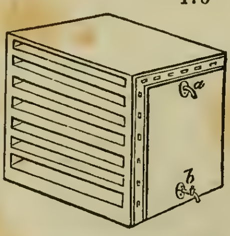


This arrangement is most judicious, economizing fuel to the utmost degree; because the steam of condensation which, in a Watt's engine, would be absorbed and carried off by the air-pump, is here turned to good account, in warming the air of ventilation during the winter months. Two hundred weight of fuel suffice for working this steam-engine during twelve hours. It pumps water for household purposes, raises the coals to the several apartments on the upper floors, and drives the fan ventilator. The air, in flowing rapidly through the series of cells, placed alternately between the steam-cases, can not be scorched, as it is generally with air stoves; but it is heated only to the genial temperature of from 75° to 85° Fahr., and it thence enters a common chamber of brickwork in the basement story, from which it is let off into a series of distinct flues, governed by dialled valves or registers, whereby it is conducted in regulated quantities to the several apartments of the building. I am of opinion that it would not be easy to devise a better plan for the purpose of warming and ventilating a large house; and I am only sorry to observe, that the plan projected by the engineers has been *injudiciously* counteracted in two particulars.

The first of these is, that the external air, which supplies the fan, is made to traverse a great heap of coke before it can enter that apparatus, whereby it suffers such friction as materially to obstruct the ventilation of the house. The following experiments, which I made recently upon this point, will place the evil in a proper light: Having fitted up Dr. Wollaston's differential barometer, as an anemometer, with oil, of specific gravity 0·900 in one leg of its syphon, and water of 1·000 in the other, covered with the said oil in the two cisterns at top, I found that the stream of air produced by the fan, in a certain part of the flue, had a velocity only as the number 8, while the air was drawn through the coke, but that it had a velocity in the same place as the number 11, whenever the air was freely admitted to the fan by opening a side door. Thus, three elevenths, both of the ventilating and warming effect of the fan, are lost. I can not divine any good reason for making the members of the Reform Club breathe an atmosphere, certainly not improved, but most probably vitiated, by being passed in a moist state through a porous sulphurous carbon, whereby it will tend to generate the two deleterious gases, carbonic oxide and sulphuretted hydrogen, in a greater or less degree. It is vain to allege that these gases may not be discoverable by chemical analysis—can the gaseous matters, which generate cholera, yellow fever, or ague, be detected by chemical reagents? No, truly; yet every one admits the reality of their specific virus. I should propose that the air be transmitted through a large sheet of wire-cloth before it reaches the fan, whereby it would be freed from the grosser particles of soot that pollute the atmosphere of London. The wire-cloth should be brushed every morning.

The second particular, which counteracts in some measure the good effects of the fan in steam ventilation, is the huge stove placed in the top story of the building. This potent furnace, consuming, when in action, 3 cwt. of coals per day, tends to draw down foul air, for its own supply, from the chimneys of the adjoining rooms, and thus to impede the upward current created by the fan. I have measured, by Dr. Wollaston's differential barometer, the ventilating influence of the said furnace stove, and find it to be perfectly insignificant—nay, most absurdly so—when compared with the fan, as to the quantity of fuel which each requires per day. The rarefaction of air in the stove chamber, in reference to the external air, was indicated by a quarter of an inch difference of level in the legs of the oil and water syphon, and this when the door of the stove-room was shut, as it usually is; the tube of the differential barometer being inserted in a hole in the door. The fan indicates a ventilating force equal to 2 inches of the water syphon, which is 20 inches of the above oil and water syphon, and therefore 80 times greater than that of the stove furnace; so that, taking into view the smaller quantity of fuel which the fan requires, the advantage in ventilation, in favor of the fan, in the enormous ratio of 120 to 1, at the lowest estimate. The said stove, in the attic, seems to me to be not only futile, but dangerous. It is a huge rectangular cast-iron chest, having a large hopper in front, kept full of coals, and it is contracted above into a round pipe, which discharges the burnt air and smoke into a series of horizontal pipes of cast-iron, about 4 inches diameter, which traverse the room under the ceiling, and terminate in a brick chimney. In consequence of this obstruction, the draught through the furnace is so feeble, that no rush of air can be perceived in its ash-pit, even when this is contracted to an area of 6 inches square: nay, when the ash-pit was momentarily luted with bricks and clay, and the tube of the differential barometer was introduced a little way under the grate, the level of the oil and water syphon in that instrument was displaced by no more than one tenth of an inch, which is only one hundredth of an inch of water—a most impotent effect under a daily consumption of 3 cwt. of coals. In fact, this stove may be fitly styled an *incendiary coal-devourer*, as it has already set fire to the house; and though now laid upon a new floor of iron rafters and stone flags, it still offers so much danger from its outlet iron pipes, should they become ignited from the combustion of charcoal deposited in them, that I think no premium of insurance adequate to cover the imminent risk of fire. The stove being, therefore, a superfluous and dangerous nuisance, should be turned out of doors as speedily as possible. Its total cost, with that of its fellow in the basement story, can not be much less than the cost of the steam-engine, with all its truly effectual warming and ventilating appurtenances.

I take leave to observe, that the system of heating and ventilating apparatus, constructed by Messrs. Easton and Amos, in the Reform Club House, offers one striking and peculiar advantage. It may be modified at little expense, so as to become the ready means of introducing, during the sultriest dog-days, refreshing currents of air, at a temperature of 10, 20, 30, or even 40 degrees under that of atmosphere. An apparatus of this nature, attached to the houses of parliament and courts of law, would prove an inestimable blessing to our legislators, lawyers, judges, and juries. Of such cool air a very gentle stream would suffice to make the most crowded apartments comfortable, without endangering the health of their inmates with gusts of wind through the doors, windows, and floors.

It is lamentable to reflect how little has been done for the well-being of the sentient and breathing functions of man in the public buildings of the metropolis, notwithstanding our boasted march of intellect, and diffusion of useful knowledge. Almost all our churches are filled on Sundays with stove-roasted air; and even the House of Commons has its atmosphere exhausted by the suction of a huge chimney-stalk, with a furnace equal, it is said, to that of a 40-horse steam-boiler. To gentlemen plunged in air so attenuated, condensation of thought and terseness of expression can hardly be the order of the day.

Nearly seven years have elapsed since I endeavored to point public attention to this important subject in the following terms: "Our legislators, when bewailing, not long ago, the fate of their fellow-creatures, doomed to breathe the polluted air of a factory, were little aware how superior the system of ventilation adopted in many cotton-mills was to that employed for their own comfort in either house of parliament. The engineers of Manchester do not, like those of the metropolis, trust for a sufficient supply of fresh air into any crowded hall, to currents physically created in the atmosphere by the difference of temperature excited by chimney-draughts, because they know them to be ineffectual to remove, with requisite rapidity, the dense carbonic acid gas generated by many hundred powerful lungs."* At page 382 of the work just quoted, there is an exact drawing and description of the factory ventilating fan.

On the 6th of June, 1836, I took occasion again, in a paper read before the Royal Society, upon the subject of the *malaria* which then prevailed in the customhouse, to investigate the principles of ventilation by the fan, and to demonstrate, by a numerous train of experiments, the great preference due to it, as to effect, economy, and comfort, over chimney-draught ventilation. Yet at this very time, the latter most objectionable plan was in progress of construction, upon a colossal scale, for the House of Commons. About the same period, however, the late ingenious Mr. Oldham, engineer of the bank of England, mounted a mechanical ventilator and steam-chest heater, for supplying a copious current of warm air to the rooms of the engraving and printing departments of that establishment. Instead of a fan, Mr. Oldham employed a large pump to force the air through the alternate cells of his steam-chest. He had introduced a similar system into the bank of Ireland about ten years before, which is now in full action.

About two years ago, Messrs. Easton and Amos were employed to ventilate the letter carriers' and inland office departments of the general post-office, of which the atmosphere was rendered not only uncomfortable but insalubrious, by the numerous gas-lights required there in the evenings. This task has been executed to the entire satisfaction of their employers, by means of fans driven by steam-engine power. The said engineers made, about the same time, a set of machinery similar to that erected at the bank of England, for warming and ventilating the bank of Vienna. They are justly entitled to the credit of having been the first to execute, in all its bearings, the system of heating and ventilating buildings, having special respect to the health of their inmates, which I urged upon the public mind many years ago.

As fans of sufficient size, driven by steam power with sufficient velocity to warm in winter, and ventilate at all times, the most extensive buildings, may be erected upon the principles above described, without causing any nuisance from smoke, it is to be hoped that the chapel of Henry VII. will not be desecrated by having a factory Vesuvius reared in its classical precincts, and that the noble pile of architecture of the new houses of parliament will not be disfigured with such a foul phenomenon.

The cheering and bracing action of condensed air, and the opposite effects of rarefied air upon human beings, formed the subject of several fine physiological experiments, made a few years ago by M. Junot, and described by him in the ninth volume of the *Archives Générales de Médecine*: "When a person is placed," says he, "in condensed air, he breathes with a new facility; he feels as if the capacity of his lungs was enlarged; his respirations become deeper and less frequent; he experiences, in the course of a short time, an agreeable glow in his chest, as if the pulmonary cells were becoming dilated with an elastic spirit, while the whole frame receives, at each inspiration, fresh vital impulsion. The functions of the brain get excited, the imagination becomes vivid, and the ideas flow with a delightful facility; digestion is rendered more active, as after gentle exercise in the air, because the secretory organs participate immediately in the increased energy of the arterial system, and there is therefore no thirst."

In rarefied air the effects on the living functions are just the reverse. The breathing is difficult, feeble, frequent, and terminates in an asthmatic paroxysm; the pulse is quick and most compressible; hœmorrhages often occur, with a tendency to fainting; the secretions are scanty or totally suppressed, and at length apathy supervenes.

These striking results obtained on one individual at a time, with a small experimental apparatus, have been recently reproduced, on a working scale, with many persons at once enclosed in a mining-shaft, encased with strong tubbing, formed of a series of large sheet-iron cylinders, riveted together, and sunk to a great depth through the bed of the river Loire, near Languin. The seams of coal, in this district of France, lie under a stratum of quicksand, from 18 to 20 metres thick (20 to 22 yards), and they had been found to be inaccessible by all the ordinary modes of mining previously practised. The obstacle had been regarded to be so perfectly insurmountable, that every

* Philosophy of Manufactures, p. 380, published by Charles Knight.—London, 1835.

portion of the great coal-basin, that extends under these alluvial deposites, though well known for centuries, had remained untouched. To endeavor, by the usual workings, to penetrate through these semi-fluid quicksands, which communicate with the waters of the Loire, was, in fact, nothing less than to try to sink a shaft in that river, or to drain the river itself. But this difficulty has been successfully grappled with, through the resources of science, boldly applied by M. Triger, an able civil engineer.

By means of the above frame of iron tubbing, furnished with an air-tight ante-chamber at its top, he has contrived to keep his workmen immersed in air, sufficiently condensed by forcing-pumps, to repel the water from the bottom of the iron cylinders, and thereby to enable them to excavate the gravel and stones to a great depth. The compartment at top has a man-hole door in its cover, and another in its floor. The men, after being introduced into it, shut the door over their heads, and then turn the stop-cock upon a pipe, in connexion with the condensed air in the under shaft. An equilibrium of pressure is soon established in the ante-chamber, by the influx of the dense air from below, whereby the man-hole door in the floor may be readily opened, to allow the men to descend. Here they work in air, maintained at a pressure of three atmospheres, by the incessant action of leathern-valved pumps, driven by a steam-engine. While the dense air thus drives the waters of the quicksand, communicating with the Loire, out of the shaft, it infuses at the same time such energy into the miners, that they can easily excavate double the work without fatigue which they could do in the open air. Upon many of them the first sensations are painful, especially upon the ears and eyes, but ere long they get quite reconciled to the bracing element. Old asthmatic men become here effective operatives; deaf persons recover their hearing, while others are sensible to the slightest whisper. The latter phenomenon proceeds from the stronger pulses of the dense air upon the membrane of the drum of the ear.

Much annoyance was at first experienced from the rapid combustion of the candles, but this was obviated by the substitution of flax for cotton thread in the wicks. The temperature of the air is raised a few degrees by the condensation.

Men who descend to considerable depths in diving-bells, experience an augmentation of muscular energy, similar to that above described. They thereby acquire the power of bending over their knees strong bars of iron, which they would find quite inflexible by their utmost efforts when drawn up to the surface.

These curious facts clearly illustrate and strongly enforce the propriety of ventilating apartments by means of condensed air, and not by air rarefied with large chimney-draughts, as has been hitherto most injudiciously, wastefully, and filthily done, in too many cases.

VERMICELLI is made with most advantage from the flour of southern countries, which is richest in gluten. It may also be made from our ordinary flour, provided an addition of gluten be made to the flour paste. Vermicelli prepared from ordinary flour is apt to melt into a paste when boiled in soups. It may, however, be well made economically by the following prescription :—

Vermicelli or Naples flour - - - - - -	21 lbs.
White potato flour - - - - - -	14 —
Boiling water - - - - - - -	12 —
Total - - - -	47 lbs.

Affording 45 lbs. of dough, and 30 of dry vermicelli. With gluten, made from common flour, the proportions are—

Flour as above - - - - - -	30 lbs.
Fresh gluten - - - - - - -	10 —
Water - - - - - - - -	7 —
Total - - - -	47 lbs.

Affording 30 lbs. of dry vermicelli or macaroni.

W.

WATERS, MINERAL. The following tables exhibit the nature and composition of the most celebrated mineral waters of Germany, according to the best analyses. The symbol N denotes nitrogen or azote; O, oxygen; CO^2, carbonic acid; SH, sulphuretted hydrogen. Therm.; cent. scale; if not, R. for Reaumur.

TABLE I.—THE MOST IMPORTANT MINERAL WATERS OF WURTEMBERG.

Classification.	Places.	Specific Gravity and Temperat.	Quantity.	Gases.			Carbonated Salts.				Muriatic Salts.			Sulphuric Salts.			Other Constituents.	Total.	Authors.
				N. O.	CO2.	SH.	Iron-oxide.	Soda.	Lime.	Magnesia.	Soda.	Lime.	Magnesia.	Soda.	Lime.	Magnesia.			
							gr.	gr.	gr.	gr.	gr.	gr.	gr.	gr.	gr.	gr.		gr.	
1. Ferriferous Waters.	Biberach, Jordansbad (Moorgrund in Molasse)	1·000206 / 8°	10000 grammes.	N + O 7·002 cub. in.	63·025 p. 3 cub. in.	cub.in.= 16 oz.	0·262 = in 16	·019 gr. oz.	2·380 = 1·83	0·344	Traces.						Silica, 0·084 gr. Organic Mat.	3·07 = 2·34 gr. in 16 oz.	C. Gmelin.
	Crailsheim (Keuper)	8°	16 oz.		2·51c. in.		0·109		3·674				0·082	1·351	8·214	2·272	Sulph. of Pot. 0·033 gr. Sulphur, 0·059 gr.	16·794	Mayer.
2. Saline.	Offenhau (Muschelkalk)	10°	16 "		2·765 "	Traces.			1·32	0·21	21·69	0·71	0·79	4·67	3·85	21·60	Silica, 0·05 gr.	33·31	Gmelin and Schulz.
	Hall (Muschelkalk)	1·049 / 10°	16 "				0·035		1·69		157·44	0·62	0·67	1·44	9·12	1·44	Organic matter, 0·41 gr.	173·16	Sandel.
	Rotenmunster. (Brine spring of Wilhelmshall)	1·19553 Spec. grav.	100 pts.								24·5537	0·3919	0·0320	0·4986				25·4762	
	Schwenningen. (Brine spring of Wilhelmshall)	1·19776 / 9°	100 "						0·0224		24·1632	0·4134	0·0254	0·5239				25·1635	
	Mergentheim (Muschelkalk)	1·012	16 oz.		13·63 "		Traces.		3·26		78·42	Potash. 0·38		32·04	16·50	2·70		134·2	C. Gmelin, 1829.
		8—9°			8·033 "		0·02		4·10	0·33	45·10		7·00	30·36	7·43	0·86	Mineral Resin, 0·10 gr. Traces of Silica	95.3	Wrede, 1836.
	Calw. Artesian Spring (Bunter Saodsteir)	1·00265 / 5—10°	100 "		21·138 "	—	0·668	6·991	20·95	2·35	2·811	4·724	0·669	2·609	Nitrate of Pot. 13·039		Phosph. lime, 0·460 gr. Silica, 1·26 gr. Extractive	66·631	Federhaff.
3. Thermal.	Wildbad (Granite) Old Spring	1006 / 27—37°	16 "	N + O 79·25 8·25 / 100 cub. in.	12·5 / 100 "		0·2	0·53	0·34	0·70	1·82			0·40			Sulph. potash, 0·20 gr. Silica, 0·39 gr. A little manganese	13·59	Sigwart and Weiss.
	Wildbad (Granite) New Spring, 1836.	26·6	100 pts.				Traces.	9·163	9·109	1·198	24·57			3·477			Sulph. potash, 1·861 gr. Silica, 6·693 gr. A little manganese	56·071	Degen.
	Liebenzell (Bunter Sandstein and Granite)	1001·3 / 17·5—19·5°	16 oz.	44·17+5·26 / 100	51·68 / 100 "	Traces.	0·10	0·80	0·82		5·14		Traces.	0·61			Silica, 8·41 gr.	7·88	Naschold
4. Cold neutral.	Tubingen (Wilhelmstifts-brunnen. Keuper)		16 "	43 + 18 / 100	39 / 100			2·56	16·00	1·12				2·40	Potash. 2·40		Traces of Mur. of Soda, Magnesia, and Silica	24·48	Sigwart.
	Lowenstein (Theusser Bad-Keuper)	10°	16 "		1·3 "				1·97	0·95			0·35	1·1	11·28	2·76	Resinous Extract	18·40	Sigwart.
	Moglingen (Christenhof-Lias)		16 "		0·06 "				2·85	0·57			0·46	0·86	10·31	2·85	Traces of Carbonate of Iron and Resin	18·05	Sigwart.
	Rietnau (Keuper)		100 "		21·8737 / 100				16·4062				2·7615	2·9192	18·750	8·4107	Sulph. Potash, 0·3967 gr. Traces of Resin, Iron-oxide, Phosh. acid, and Silico-fluoric acid, with Humus, 1·3750 Lime	77·1443	Zwink.
	Giengen by Brenz. (Jura with Torfgrund)	1·0005 / 6·8°	16 "	0·32 + 0·06 cub. in.	2·68 "			0·019	2·031	0·166	0·021	0·009	0·049		0·061		Silica, 0·09 gr. Humate of Alumina, 0·065 gr.	2·526	Salzer.
	Ulm (Grieshad)	5—6·5°	16 "				0·044		1·625	0·105			1·875				Traces of Nitric and Sulphuric Salts	3·649	Leube.
6. Acidulous Waters.	Imnau (Muschelkalk) Prince's Spring		16 "	N O = atm. air.	30·351 / 100 "		0·56		6·855	0·089	1·044		0·326		0·221	0·335	Silica, 0·029 gr. Organic mat., 1·120 gr.	11·569	Sigwart.
	Imnau (Muschelkalk) Second lower Spring		16 "	atm. air.	27·119 / 100 "		0·564		6·629	0·429	0·078		0·045		0·487	0·140	Silica, 0·092 gr. Organic mat., 0·430 gr.	8·74	
	Imnau (Muschelkalk) Fifth lower Spring		16 "	atm. air.	27·531 / 100 "				4·166	0·336	0·124		0·138		0·167	0·381	Silica, 0·205 gr. Organic mat., 0·622 gr.	6·128	
	Niedernau (Muschelkalk) Old Springs	11—12°	16 "		1·21 V.	Traces.	0·08		7·44	0·86			0·53	0·28	Potash. 1·02	1·18	Silica, 0·12 gr. Oxidulated mang., 0·01 gr.	11·57	C. Gmelin.
	Niedernau (Muschelkalk) Carls Spring	6°·8	16 "		14 cu. in.		Traces.		6·807	1·637			0·214			0·402	Asphalt, 0·010 gr.	8·07	Sigwart.

Table I.—THE MOST IMPORTANT MINERAL WATERS OF WURTEMBERG—*Continued.*

Classification.	Places.	Specific Gravity and Temperat.	Quantity.	Gases. N. O.	Gases. CO2.	Gases. SH.	Carbonated Salts. Iron-oxide.	Carbonated Salts. Soda.	Carbonated Salts. Lime.	Carbonated Salts. Magnesia.	Muriatic Salts. Soda.	Muriatic Salts. Lime.	Muriatic Salts. Magnesia.	Sulphuric Salts. Soda.	Sulphuric Salts. Lime.	Sulphuric Salts. Magnesia.	Other Constituents.	Total.	Authors.
							gr.	gr.	gr.	gr.	gr.	gr.	gr.	gr.	gr.	gr.		gr.	
5. Acidulous Waters.	Niedernau (Muschelkalk) Romer-quelle.	...	14 oz.	...	29 cub. in.?	...	0·10432	...	3·75	0·33671	0·21428	...	0·26436	With Potash. 0·03671	...	0·13326	Silica, 0·10714 gr. Extract, with Petroleum, 0·07857 gr.	6·02372	Ritter.
	Cannstadt (Muschelkalk and Keuper) Sulzerrain ...	15·5°	16 "	...	23·12 "	...	0·16	...	7·00	0·05	19.76	...	0·58	6·50	8·25	3·60	Sulph. Potash, 0·50 gr...	46·34	Morstatt.
	Zoller'sche Quelle	...	16 "	...	19·28 "	...	0·11	...	8·68	...	15·00	0·25	0·12	3·76	8·38	2·38	...	38·68	
	Frosner'sche Qu. v. 1831	16°	16 "	...	19·50 "	...	0·25	...	7·38	0·31	16·75	0·25	0·18	4·76	7·76	2·25	...	39·87	
	Wirthschaft zum Ochsen	...	16 "	...	13·00 "	...	Traces.	...	4·100	Traces.	7·00	...	...	2·40	3·00	0·78	...	17·18	
	Obere Sulz: Water ...	16·3°	16 "	...	15·56 "	...	0·231	...	9·100	0·476	19·711	...	0·272	2·679	6·776	2·617	Sulph. Potash, 0·386 gr.	44·24	
	Mud ...	...	...	...	...	...	33·35	...	26·58	1·41	...	...	...	...	32·95	...	Silica, 0·31 gr. Organic mat., 25·40 gr.	120	Sigwart.
	Neckarinsel	15—16°	16 "	...	21 "	Traces.	0·25	...	8·00	Traces.	18·50	...	0·37	8·25	7·25	1·00	...	43·62	Morstatt.
	Berg (Muschelkalk and Keuper) Stadt. Kunst-muhle.	1·00548 / 14°	16 "	...	22·1 "	Traces.	0·14	...	9·00	0·25	18·15	...	0·25	6·25	6·06	4·33		44·37	
	Privil. Fabrik der Insel	...	100·000 parts.	...	...	...	With Alumina 4·29	...	110·18	8·10	205·79	...	...	0·92	81·68	65·66	...	476·63	Degen.
	Teinach (Bunter Sandstein) Dachleins kasten	7·5°	16 oz.	...	20·677 "	...	Traces.	2·2387	3·4380	0·3979	0·3024	...	Traces.	0·6589	...	...	Silica, 0·2995 gr...	7·3254	Federhaff.
	Dinten-quelle	6·5°	16 "	...	0·213 "	...	With Mangan. 0·1216	0·4144	0·5376	0·0800	0·3152	With Potash and Magn.		Potash and Lime with Carbon. of Soda.		...	Silica, 0·0422 gr...	1·5120	
	Ueberkingen (Jurakalk with Eisenrogenstein)	9°	16 "	...	19·5 "	...	0·072	0·390	6·827	0·247	...	...	...	0·276	0·020	0·056	...	7·888	Leube.
	Dizenbach (Jurakalk) ...	7°	16 "	...	27·7 "	...	...	...	3·6096	With Magn.	0·0199	...	...	0·0960	...	Traces.	Organic matter, with Sulphur, 0·0184 gr.	3·7379	C. Gmelin.
8. Sulphurous Waters.	Boll (Bituminoser Mergelshchiefer)	1·00137 / 7—8°	16 "	N. 0·0134 V. of water.	0·003 V. to 0·006	0·1705 V.	Potash. 0·03	1·03	1·44	0.03	0·22	...	...	3·34	...	...	Silica, 0·05 gr. Asphalt.	6·19	
	Kirchheim under Teck (Liasschiefer)	10°	16 "	...	Undetermined.	...	...	0·77	0·60	0·29	0·34	...	0·67	0·53	Traces.	...	Silica, 0·06 gr. Sulphur	4·58	Mutschler.
	Reutlingen (Liasschiefer)	9—10°	16 "	N. 0·015 V.	0·087 V.	0·029 "	0·02	0·93	0·35	1·05	0·40	...	...	0·49	...	...	Carburetted Hydrogen, 0·021 V. Asphalt, Silica, 0·15 gr. Organic mat., 0·57 gr.	4·96	Sigwart & Vobringer.
	Sebastianweiler (Liasschiefer)	9—11°	16 "	N. with 3·07 per ct.	CO2 Carbonic Acid Gas.	2·26—4·33 p. Ct. V.	0·06	...	3·72	0·41	0·69	...	0·23	4·61	Trac. of Potash with Lime.	1·61	Silica, 0·18 gr. Traces of Iodine and Manganese. Asphalt, 0·02 gr.	11·33	Sigwart.
	Hechingen (Liasschiefer)	8—9°	16 "	...	Undetermined.	0·0564V.	...	...	3·0878	1·2296	...	...	0·5181	3·4821	0·2167	1·4971	Sulph. Potash, 0·0187 gr. Silica, 0·1373 gr.	10·1874	C. Gmelin.
	Roigheim near Mokmuhl (Muschelkalk)	9·5—10°	16 "	...	1·00 V.	0·27 "	0·03125	...	1·7825	0·31125	0·24632	Alum. 0.00625	0·04921	0·34341	0·4375	0·34093	Silica, 0·04687 gr. Clay with Phosp. Acid, 0·05. Extractive, 0·13875 gr.	4·7830175	Sigwart & Heuffel.
	Neustadtchen a. d. Rems. (Muschelk) Water ...	1·0005 / 9·7°	16 "	...	Insignificant.	...	0·44	...	2·184	0·23	...	...	0·17	With Potash. 0·353	0·456	0·33	Silica, 0·102. Traces of Organic matter	3·869	C. Gmelin.
	Dried Mud ...	...	20 gr.	...	...	Sulph. of Zinc, ·06	Iron-oxide. 0·37	...	0·6	0·38	...	...	...	...	...	...	Quarzsand, 6·21 gr. Organic matter, 1·56 gr. Alum., 1·107 gr. Loss, 0·03 gr.	20·0	
	Winterbach (Keuper) First Spring	8—9°	16 oz.	...	2·0 cub. in.	·28 cu. in.	...	...	0·285	0·143	0·285	With Magn.	...	...	1·567	1·142	...	3·422	Sig. & Buhl.
	Second Spring.	8—9°	16 "	...	Undetermined.	0·67 "	...	0·25	0·55	...	0·83	...	0·25	...	1·66	0·55	...	4·09	Grunzwaig.

Table II.—CONSTITUENTS OF THE MOST IMPORTANT MINERAL WATERS OF GERMANY, EXCEPTING THOSE OF WURTEMBERG.

N denotes with O Atmospherical Air (Nitrogen and Oxygen),—CO_2 Carbonic Acid Gas.

Classification.	Places.	Specific Gravity and Temperat.	Quantity.	Gases.		Carbonated Salts.				Muriatic Salts.			Sulphuric Salts.			Other Constituents.	Total solid Parts.	Authors.
				N. O.	CO_2.	Iron-oxide.	Soda.	Lime.	Magnesia.	Soda.	Lime.	Magnesia.	Soda.	Lime.	Magnesia.			
1. *Chalybeate Waters.*			oz.			gr.	gr.	gr.	gr.	gr.	gr.	gr.	gr.	gr.	gr.	gr.	gr.	
	Pyrmont, Trinkquelle (eisenschuss. Sandstein.)	1·005 / 10° R.	16	Atm. air. 50—55 p. C. SH: 3·14/100 cub. in.	168·5/100 cub. in.	0·7389	4·5102	5·8733	0·3150	0·4046	(Hydrosulphuret of Soda: 0·0657)	0·8274	3·5181	7·6148	5·005	Sulphate of Lithia, 0·0030; Phosphate of Potash and Lime, 1·012; Carbonate of Manganese, 0·0200; Sulphate of Strontia and Baryta, 0·0222; Silica and Resin, 0·0954. 0·1133	29·7246	Brandes and Kruger.
	Meinberg, Trinkquelle	1·0012 / 6—10° R.	16	OO OO N=0·505/100 O=0·085/100	131·217/100	0·0800 0·0100 Manganese oxidulated.	....	1·4500	0·1536	....	....	0·8134	1·1547 0·0185 Pot. (0·027 Sulphuret of Sodium.	0·2805 0·0042 Strontian. 0·0002 Baryt.	1·491	Iod. magn.: Traces; Subphosphate of Alumina, 10·0008; Phosphate of Lime, 0·0001; Silica, 0·0600; Resin and other extracts, 0·6600	5·9621	Brandes.
a) Earthy-saline Chalybeate Waters	Driburg, Trinkquelle (dolomitischer Muschelkalk)	1·004 / 8° R.	16	....	41·65	0·512	0·072 Oxidul. Mang.	9·123	....	....	....	0·535	3·883	8·425	4·250	....	25·805	Du Mesnil.
	Hofgeismar, Trinkquelle (Braunkohlen Formation)	1·003 / 12·5° R.	16	N=0·389 O=0·046	16·62	0·300540	0·000020 Mangan.	4·724643	....	8·196180	0·178268 Potash.	0·132857	2·249553	....	2·194586	Subphosphate of Alumina, 0·0142; Silica, 0·414812. Resinous matter, 0·000018	18·402902	Wurzer.
	Liebenstein	7·5° R.	16	....	26·0	2·00	....	3·923	....	2·300	1·111	3·060	1·600	0·500	....	....	14·494	Trommsdorff.
	Boklet, Ludwigsquelle (Flotzkalk)	1·008 / 9° R.	16	....	....	0·65	....	7·25	1·25	27·50	1·25 Potash.	0·75	6·25	0·5 with humus.	....	Silica, 0·50	45·90	Vogel.
	Bruckenau (Basaltgebirge)	1·006 / 7—8° R.	16	....	35·5	0·25	....	0·55	0·15	0·30	0·65 Potash.	....	....	0·2 with animal substance.	0·60	Silica: Traces	2·70	....
	Rohitsch (grobkorniger Kalk)	1·0048 / 9° R.	16	....	58·0	1·200	2·250	7·900	2·900	0·56	0·111	0·625	21·333	4·14[illegible]	2·875	Alumina, 0·333; Extractive, 0·100	43.935	Suess.
	Riepoltsau, Josephsquelle (Urgebirg)	1·005 / 8° R.	16	....	32·04	0·76 0·57 Mang.	....	9·78	0·16	0·12 Potash: Trace.	Fluate of Lime: Trace.	0·24	15·60	0·48	....	Phosp. of Soda, 0·24; —Magnesia and Alumina, 0·18; Silicate of Alumina, 1·09; Bituminous extract 0·12	29·04	Kolreuter.
	Griesbach (Urgebirg)..	1·002 / 8° R.	16	....	22·07	3·0	....	....	....	0·5	....	....	6·25	19·0	....	....	23·75	....
b) Alkaline, &c.	Eger, Franzensbad (Flotzgebirge with Steinkohlenlagern)	1·0058 / 9·3° R	16	....	40·85	0·235 0·043 Mang.	5·1886	0·0376 Lith 1·8002 0·0031 Stro.	0·672	9·2306	....	....	24·5047	....	....	Phos. of Lime, 0·0230; —Alumina, 0·0123; Silica, 0·4731	42·2452	Berzelius.

TABLE II.—THE MOST IMPORTANT MINERAL WATERS OF GERMANY—*Continued.*

Classification.	Places.	Specific Gravity and Temperat.	Quantity.	Gases.		Carbonated Salts.				Muriatic Salts.			Sulphuric Salts.			Other Constituents.	Total solid Parts.	Authors.
				N. O.	CO2.	Iron-oxide.	Soda.	Lime.	Magnesia.	Soda.	Lime.	Magnesia.	Soda.	Lime.	Magnesia.			
			oz.			gr.	gr.	gr.	gr.	gr.	gr.	gr.	gr.	gr.	gr.	gr.	gr.	
b) Alkaline saline Chalybeate Waters	Marienbad, Ferdinandsquelle (porphyrartiger Granit)	1·0046 / 7·5° R.	......	....	13,736	0·3993 0·092 Mang.	6·1302	4·0112	3·0489	3·9963	....	....	22·6362	....	(Silica 0·6697)	Carbonate of Lithia, 0·0676 —Strontia, 0·0054 Phosphate of Alumina, 0·0054	45·962	Berzelius.
	Godelheim, Stahlquelle (Braunkohlenlager)	....	......	....	40·0	1·76 0·16 Mang.	....	2·75	1·25	6·50	0·50	0·50	2·50	2·00	1·76	Silica, 0·75; Extractive 0·20; Resin, 0·50; Phosph. Potash & lime. Traces.	21·11	Witting.
	Schwalbach, Weinbrunnen.	1·001 / 9° R.	16	....	22·0 cu. in.	0·66351	0·50000	1·69649	4·24324	0·25225	....	0·20270	0·37837	0·48648	....	Alumina, 0·32432	8·6873	Ruhe.
	Konigswarth, Trinkquelle (Basaltgebirge with Torflagern)	....	......	....	161·37 / 100	0·431	0·443	3·938	....	0·047 0·062 P.	....	....	0·089 Pot.	....	....	Subphosphate of Alumina, 0·019 Silica, 0·653. Humic Acid, 0·157	6·772	Steinmann and Berzelius.
	Cudowa, Trinquelle (Urgeb. and Sandstein)	1·006 / 7—9° R.	16	....	43·0	0·9062	12·1325	1·8713	13·614	1·9492	....	....	4·3608	....	....	Extractive, 0·8654	36·6894	Kneissler.
	Reinerz, tepid Spring (Urgebirge)	1·02 / 14° R.	18	....	20·28	....	13·850	5·200	1·340	0·560	....	....	2·027	....	....	Potash and Manganese, carbonate of iron in the cold springs.	22·977	Mogalla and Gunther.
	Niederlangenau (Quadersandstein)	....	16	....	30·7	0·421	0·871	0·947	0·115	2·720	....	1·767	0·132	....	....	....	7·973	Trommsdorff
	Steben (Thonschiefer)	1·002 / 7—8° R.	16	....	27·6	0·65	0·76	1·65	0·20	0·08	....	....	0·05	....	....	Humic Acid, 0·12. Silica, 0·6	4·00	Vogel. Funke.
	Tonnstein (Trass)	....	16	....	21·04	0·10	7·26	9·00	....	0·95	....	....	0·80	....	....	....	18·10	
c) Earthy and Coperas-holding Chalyb. Waters	Wildnagen, Thalbrunnen (Uebergangsgebirge)	1·0011 / 8° R.	16	....	21·33	0·500	....	2·500	2·213	0·125	....	....	....	....	0·357	Silica, 0·42. Resin, 0·05	6·165	Stuke.
	Freudenthal (Maximiliansquelle)	6° R.	16	....	49·62	0·26	....	1·89	1·3	0·065	....	....	0·17	0.39	....	Silica, 0·13	4·311	Scholz.
	Alexishad, Selkenbrunnen	6·5 R.	......	....	....	0·574 Sulphuretted Oxule. Iron.	....	....	....	1·083 Oxidule of Iron.	....	0·231	0·676	0·739	0·651	Sulphate of Manganese, 0·328. Resin, 0·436. Silica, 0·109	4·876	Trommsdorff.
	Bukowina, Niederquella	9·5 R.	......	....	....	1·960 Sulphuretted Oxule. Iron.	....	....	....	0·920 Oxidule of Iron.	....	....	....	0·480	2·080 Alumina	Alumina, 0·380. Oxide of Iron, 0·16 Silica, 0·120. Extractive, 0·120	6·220	Lachmund.
	Bilin, Josephsquelle (Klingsteinporphyr)	1·00653 / 9—10° R.	16	0·215 cu. in.	33·58	0·049 0·011 Mangan.	23·948 8·88 Lithion.	2·349 0·014 Strontian.	1·976	2·927	....	....	6·539	1.891 pot.	....	Subphosphate of Alumina, 0·014 —— Lime, 0·005 Silica, 0·388	39·204	Steinmann
2. *Cold Salt Springs*	Fachingen (Thonschiefer)	8° R.	16	....	19·6874	0·0892	43·2578	2·4965	1·7313	4·3119	....	....	0·3836	....	....	Phosphate of Soda, 0·0186. Silica, 0·0873 Nitrate of Magnesia, 20·274	62·3762	Bischof.
	Saidschutz, Hauptbrunnen (Volcanic Formation)	1·01761 / 16—20° R.	16	0·105	3·304	0·108 0·028 Mangan.	0·024 Strontian.	4·838	1·100	....	....	2·606	27·113	2·496 22·932 Pot.	78·753	Subphosphate of Alumina, 0·018 Silica, 0·061. Humic Extract, 0·385	160.718	Steinmann

	Pullna, Bitterwasser	7° R.	Dried Salts.	......	6·939	......	......	0·770	6·406	......	......	16·666	123·800	2·6 4·8 Pot.	93·086	Subphosphate of Lime, 0·003 Silica, 0·176	242·307	Struve.
	Marienbad, Krenzbrunnen (porphyrartiger Granit)	1·00941 / 9·59 R.	16	......	8·384	0·1750 0·0384 Mangan.	7·1332 0·1144 Lith.	3·9345 0·0038 Strontia.	2·7187	13·5636	......	......	38·1168	......	......	Subphosphate of Alumina, 0·0031 Silica, 0·3878	66·1892	Berzelius
	Pyrmont, saline Spring (bunter Sandstein)	1·0112 / 8·80 R.	16	......	100 / 100	0·065 with Mangan.	6·238	6·920	......	65·498	......	12·076	12·246	6·616	0·087 L.	Resin, 0·100......	108·746	Brandes.
	Elmen near Schonbeck, Brine spring (Kalkstein)	......	16	......	Undetermined.	0·025	......	0·065	......	146·98	0·120 P.	1·680	1·800 0·120 Pot	2480	0·300	......	153·57	Herrmann.
	Nenndorf, Trinkquelle (Muschelkalk)	1·003 / 8° R.	16	N. 0·53 O. 0·13	1·31 cu. in. 1·66 SH.	0·0062825	0·007177 Mangan.	1·707539	0·865046	0·987476	......	0·549313	4·613480	7·292484	0·797390	Resin, 0·038615. Fluate of lime—traces Alumina with Silica, 0·011453 Azote with Sulphur, 0·268595	17·210393	Wurzer.
	Ischl, Brine (Salzformation)	......	16	......	......	......	......	......	......	223·00	0·780	7·100	4·855	1·027	1·820	......	238·591	......
	Kissingen, Ragozibrunnen (Flotzkalk and Sandstein)	8·5—9·5° R.	16	......	26·25 cub. in.	0·68 with Mangan.	0·82 with traces of Lithion.	3·55 with traces of Strontia.	2·50	62·05	0·91 Pot. 0·05 Am.	6·85	2·00	2·60	(HydAc 0.70)	Phosphate of Soda, 0·17. Extract, 0·15 Alumina, 0·18. Silica, 2·25	85·36	Kastner.
3. *Thermal.*	Baden Baden, Hauptquelle (Flotzkalk)	43—54° R.	16	......	0·333 cub. in.	0·111	......	......	......	17·500	1·600	0·600	......	2·75	......	......	22·361	......
	Wisebaden, Kochbrunnen (Thonschiefer)	1·0047 / 56° R.	16	N. CO_2—54:	46	0·078	......	1·650	0·700	44·225	6·480 1·200 Pot	0·790	0·700	0·42	......	Extractive, 1·750 Silicate of Magnesia, 0·600	57·593	......
	Ems, Kesselbrunnen (Uebergangsgebirge)	37—40 R.	16	......	......	0·0625 0·1250 Mang.	20·0000	2·0000	2·0000	3·0000	0·5000	0·2500	1·0000	......	......	......	28·9375	......
	Schlangenbad, alter Brunen (Thonschiefer)	1·00056 / 21—23° R.	16	N. 0·025 cub. in.	1·875	......	3·25	......	......	1·10	......	......	......	......	......	......	4·36	......
a) Non-sulphurous Thermal.	Teplitz, Hauptquelle (Urgeb. and Basalt)	39·5° R.	16	......	2·4	0·036	12·240	0·340	......	0·776	......	......	1·696	......	......	Resin and extractive, 0·1. Silica, 0·42	15·608	Ambrozi.
	Gastein (Urgebirge)	37° R.	16	......	......	0·0484 0·0138 Mang.	0·0697	0·3394	0·0100	0·2834	0·1405 Pot.	......	1·4331 0·0292	......	......	Silica, 0·3315 Phosphate of Alumina, 0·0292	2·7182	Hunefeld.
	Carlsbad, Sprudel (Urgeb. and Basalt formation)	59—60° R.	16	......	11·85	0·0278 0·00645 Mang.	9·69500	10·05005 0·00737 Strn.	1·36965	7·97583	......	......	19·86916	......	......	Silica, 0·57715.—Fluor spar, 0·02458. Subphosphate of Alumina, 0·00246	49·60719	Berzelius.
	Bertrich (Grauwackenschiefer)	1·00165 / 25—26° R.	16	......	0·1	0·480	0·740	0·720	0·080	1·200	......	......	8·160	0·560	0·860	Silica, 0·400......	13·200	Mohr.
	Burtscheid (Uebergangskalk) — Hottest non-sulphurous Spring.	1·004 / 62°	16	N. 19·000 O. 0·040	7·60	0·055 Strn.	6·722	0·295	0·242	22·057	0·673 Flr. Spar.	......	3·465	......	(0.656 Silica)	Phosphate of Soda, 0·161, with Lithia, 0·0006 Animal mat., 0·232.	34·5586	Monheim.
	Burtscheid — Sulphurous Trinkquelle	1·003 / 46·5° R.	16	N. 18·867 SH. 0·053	7·712	0·042 Strn.	6·599	0·241	0·113	21·625	0·485 Flr. Spar.	......	2·567 0·624	......	(0·553 Silica)	Phosphate of Soda, 0·142, with Lithia, 0·0005 Animal mat., 0·208	32·8715	......
b) Sulphurous Thermal.	Aachen, Kaiserquelle (Uebergangskalk with Thonschiefer)	1·004 / 37—46° R.	16	N. 18·533 SH. 0·133	8·00	0·043 Strn.	6·610	0·232	0·152	20·716	0·479 Flr. Spar.	......	2·121 0·620	......	(0·640 Silica)	Phosphate of Soda, 0·146, with Lithia, 0.0006 Animal mat., 0·294	31·9536	......
	Warmbrunn, Grafenbad (Urgebirge)	1·00035 / 30° R.	16	......	8·00	......	6·072	1·101	......	0·833	......	......	2·814	0·463	......	Resin, 0·605......	10·688	Tschorner.

TABLE II.—THE MOST IMPORTANT MINERAL WATERS OF GERMANY—*Continued.*

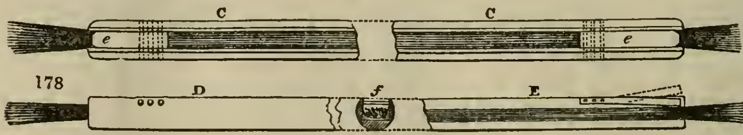
Classification.	Places.	Specific Gravity and Temperat.	Quantity.	Gases. N. O.	Gases. CO2.	Carbonated Salts. Iron-oxide.	Carbonated Salts. Soda.	Carbonated Salts. Lime.	Carbonated Salts. Magnesia.	Muriatic Salts. Soda.	Muriatic Salts. Lime.	Muriatic Salts. Magnesia.	Sulphuric Salts. Soda.	Sulphuric Salts. Lime.	Sulphuric Salts. Magnesia.	Other Constituents.	Total solid Parts.	Authors.
			oz.			gr.	gr.	gr.	gr.	gr.	gr.	gr.	gr.	gr.	gr.	gr	gr.	
	Oestr. Baden (Flotzkalkstein)	1·004 / 29·30 R.	16	SH. 3·33	1·77	....	....	0·252	0·184	....	0·323	0·117	0·298	0·402	0·408	Silica, 0·012	2·100	Schenk.
	Landeck, St. Georgenbad (Gneus)	23·6° R.	16	SH. 4·333	1·25	....	....	0·132	....	0·026	0·066	....	0·858	0·400	....	Alumina, 0·1. Silica, 0·3. Extractive, 0·016	1·897	Mogalla and Gunther.
4. *Acidulous Waters.*	Selters (eisenhaltige Thonlager)	1·00369 / 14° R.	16	....	15·67	0·1542 with Mangan.	16·4093	1·8672	1·6953	16·2855	....	....	0·6653	....	....	Phosphate of Soda, 0·7233 Silica, 0·2892	36·8893	Bischoff.
	Roisdorf, Trinkquelle	1·00449 / 9·5° R.	16	....	19·86	0·0557 with Mangan.	6·0406	2·1657	3·0628	14·6997	....	....	3·6727	....	....	Phosphate of Soda, 0·0505 Silica, 0·1240. Alumina, 0·008.	20·7797	....
	Schwalheim (Basalt)	1·0022 / 8·5° R.	16	N. 0·367 O· 0·122	37·55	0·191377	0·775683	4·254243	....	0·777800	0·681530 Pot.	....	0·965254	0·571334 Pt.	....	Alumina, 0·053657 Silica, 0·089429	17·260307	Wurzer.
	Kissingen, Maximilians brunnen (Flotzkalk and Flotztra. p)	9·5° R.	16	....	30·24	....	0.85	2·70	1·82	18·24	1·02 Pot.	3·06	1·85	0·77	....	Phosphate of Soda, 0·12. Traces of Hydrobromate of Magnesia Silica, 0·47.	30·39	Kastner.
	Soden, Winklerbrunnen	1·00742 / 14° R.	16	....	18·569	0·253 with Mangan.	....	5·068	3·847	40·611	0·407 Pot.	....	....	0·322	....	Alumina, 0·029. Silica, 0·629 Brome and humic Salts	51·171	Schweinsberg.
	Salzbrunn, Oberbrunnen (Uebergangsgebirge)	1·00241 / 5—6° R.	16	....	98 / 100	0·018	8·000	2·003	1·001	1·012	....	....	3·002	....	....	Silica, 0·024	15·059	Fischer.
	Franzensbad, kalter Sprudel (vulkanische Gebirge)	1·00588 / 9·3° R.	16	....	39·4	0·2000 0·0040 Mang.	7·1733	1·6000 0·0013 Strn.	0·0133	8·6000	....	....	26·92000	....	....	Phosphate of Lime and Magnesia, 0·0280 Silica, 0·560 Resin, 0·0080	44·6079	Trommsdorff.
	Pyrmont, acidulous, (bunter Sandstein)	1·0001 / 8·3° R.	16	....	83·5 / 100	....	0·3062	1·8110	0·1684	0·0118	....	0·1262	0·3782	0·3156	0·6030	Traces of Lithia, Baryta, and Strontia.	3·7284	Brandes.
	Sironabad (Basalt)	....	16	SH. 0·767 cub. in.	0·834	0·042	0·226	0·883	0·037	1·970	....	0·214	1·364	0·209	....	Extractive. Resinous, 0·053 Watery, 0·069	6·067	Buchner.
6. *Sulphurous Waters.*	Weilbach - - -	15° R.	16	SH. 4 0	9·0	....	4·500	2·126	1·250	0·750	....	0·930	1·125	....	....	Sulphurous Resin, 0·375	11·055	Creve.
	Nenndorf, Spring under the Vault (Steinkohlenlager)	1·0032 / 8° R.	16	N·072 SH. 1·19	2·61	0·136193 with Mang	....	2·690182	0·418832	0·799002	....	0·782087	5·187053	7·635612	0·708092	Resin, 0·004326. Azote, 0·032215 Sulphur, 0·1395. Alumina, 0·008054 Silica, 0·020938	18·467790	Wurzer.
	Eilsen, Georgenbrunnen (Muschelkalk and Schieferthon)	1·00373 / 9—10° R.	16	SH. 7·68	6·72	....	....	1·400 10·9 Sulphuretted Hydrogen.	0·264	0·338	0·462	1·200	5·726	12·066	3·000	Extractive, 0·066. Azote, 0·132 Silica, 0·132. Alumina 0·060	36·847	Westrumb.

Meinberg, Schwefel-quelle (Schwarzes Moorlager)	7·5—13° R.	16	N. 1·41 O. 0·08 SH. 2·13	8·11 / 100	0.0080 with Mangan.	....	2·1494	0·1723	....	....	....	5·8444 0·0677	8·3353 3·0057 Pot.	1·7333 0·008 Stront.	Subphosphate of Alumina, 0·0100 Silica, 0·12. Animal matter	19·4894	Brandes.
Winslar. Sulphur Spring..............	1·0005 / 11° R.	16	SH. 15·0	10·0	....	....	1·950	....	0·500	0·626	0·350	2·750	17·166	5·125	Alumina, 0·100. Silica, 0·150	28·616	Usinger.
Langensalza............	10° R.	16	SH. 3·732	1·628	....	....	2·200	0·650	....	1·250 Sulphd. hydrogen.	0·250 0·150 Sul. Hyd.	1·950	11·150	2·000	Sulphur-resin, 0·1. Alumina, 0·25 Silica, 0·15. Extractive, 0·075	20·075	Trommsdorff.
Kreuth, Stinkergraben:	9° R.	16	SH. 1·35	2·625	0·125	....	7·0625	0·375	....	....	0·125	....	5·876	2·76	Silica, 0·5625. Humus, 0·125	17·00	Vogel.
Boklet, Schwefelquelle (Flotzkalk with Basalt)	1·0085 / 9° R.	16	SH. 0·2	21·0	0·40	0·50	2·50	0·50	0·25	0·50 Pot.	....	0·25	....	....	Silica, 0·10	6·00	
Rosenheim............	....	16	SH. 0·1	....	0·01	0·06	1·01	0·05	0·01 with Potash.	....	....	0·08	....	....	Humus, 0·01. Silica, 0·01	1·24	

Classif.	Places.	Authors.	Quantity	Combustible Matters. Sulphur.	Resin.	Extractive.	Fibre.	Salts.	Oxides. Iron-oxide.	Silica.	Alumina.
			parts.	gr.	gr.	gr.	gr.	gr.	gr.	gr.	gr.
6. Mud Baths.	Eilsen	Westrumb	100	4·25	0·12	......	6·6 1·12 Slime.	2·4	3·0 calcareous earth.	21·36 and with Carbon.	5·2
	Fiestel......	Witting..	100	0·75	1·75	3·0 4·0 Hum.	0·5	33·3 Sol. 29·81 Insol.	3·45 with Mangan.	80·25	3·25
	Gunthersbad	Buchholz	1000	......	4·0 Wax.	0·75	110·0 Carbon.	168·0 8·60 Soluble.	3·0	92·25 Sand.	42·0
	Oestr. Baden	Schenk ..	240	215·8	......	....	....	15·60 Insol.			
	Marienbad ..	Steinmann	2128	......	......	14·18 Soluble.	8·5267 Combustible with water.	3·61 Soluble Salts.	9·539	128·139	0·562

Classif.	Places.	Quantity.	Muriatic Salts. Soda.	Lime.	Magnesia.	Sulphuric Salts. Soda.	Lime.	Magnesia.	Other Matters, with the Total.		Authors.
		oz.	gr.	gr.	gr.	gr.	gr.	gr.		gr.	
7. Sea Baths.	Norderney	16	174·000	....	62·666	1·333	8·000	....	....	245·0	Bluhm.
	Cuxhaven	16	116·0	1·0	58·0	2·0	6·0	10·0	Veget. soil, 1·0...	240	Schmeisser.
	Fohr.......	16	179·33	....	67·0	....	7·0	11·0	Extractive, 0·66..	264·99	Becker.
	Dusterbrock ...	16	92·0	Traces of Potash.	30·0	....	3·6	6.0	Carb. of Lime, 0·4 Resinous mat. 0·5	132·4	Pfaff.
	Dobberan, Salzquelle..	16	109·502 1·0 Potash.	5·075	16·208	3·782	10·600	9.213	Carb. of Lime and Magnesia, 4·204 Red Carb. of Iron, 0·35 Extract., 0·88 Silica, 0·200 =	160·116	Hermbstadt.
	Carbonic Acid, 3·572 cub. in. Azote, 0·832 cub. in.										

WEAVING OF HAIR CLOTH. In addition to the description of this art, under "Hair" in the Dictionary, I shall give here a short notice of the best kind of shuttle for weaving hair. *Fig.* 177, shows in plan A, and in longitudinal section B, a



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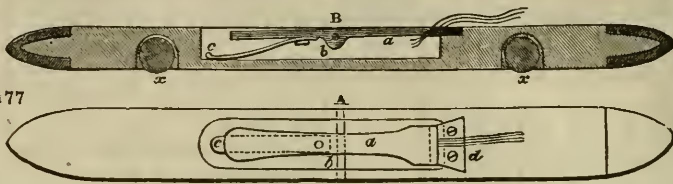

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shuttle which differs from that of the common cloth weaver only in not having a pirn enclosed in the body of the box-wood, but merely an iron trap *a*, which turns in the middle upon the pin *b*. This trap-piece is pressed up at the one end, by the 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 hair 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 can not be thrown swiftly from side to side. The hand which receives the shuttle opens at the same time the trap, in order to insert another hair, after the preceding has been drawn through the warp on both sides and secured to the list. A child attends to count and stretch the hairs. This assistant may, however, be dispensed with by means of the following implement, represented in *fig.* 178. 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 each end. They are therein pressed by elastic slips *e*, of Indian rubber, so that the others remain, when one or more are drawn out by the ends. The ends of the grooves are flat where the Indian rubber spring exerts its pressure, as shown by the dotted line at F. The spring is formed by cutting out a double piece from the curvature of the neck of a caoutchouc bottle or flask, fastening the one end of the piece by a wire staple in the groove of the shuttle, whereby the other end, which alone can yield, presses upon the inlaid hairs. Wire staples like *f* (in the section E) are passed obliquely through two places of the groove or gutter, to present 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.

WHALEBONE. 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 purpose by bending the strips together, introducing them into a steam chest, thereby softening them, and in that state compressing them into a compact mass by appropriate machinery; for a description, with figures, of which, see *Newton's Journal*, C. S. xxi. 444.

WHITE LEAD. Mr. Thomas Richardson of Newcastle, one of the most distinguished chemists of Liebig's school, obtained a patent in December, 1839, for a preparation of sulphate of lead, applicable to some of the purposes to which the carbonate is applied. His plan is to put 56 pounds of flake litharge into a tub, to mix it with one pound of acetic acid (and water) of specific gravity 1·046, and to agitate the mixture till the oxide of lead becomes an acetate. But whenever this change is partially effected, he pours into the tub, through a pipe, sulphuric acid of specific gravity 1·5975, at the rate of about 1 pound per minute, until a sufficient quantity of sulphuric acid has been added to convert all the lead into a sulphate; being about 20 parts of acid to 112 of the litharge. The sulphate is afterward washed and dried in stoves for the market. I have examined the particles of this white lead with a good achromatic microscope, and found them to be semi-crystalline, and semi-transparent, like all the varieties of carbonate precipitated from saline solutions of the metal.

Mr. Leigh, surgeon in Manchester, prepares his patent white lead, by precipitating a carbonate from a solution of the chloride of the metal by means of carbonate of ammonia. On this process, in a commercial point of view, no remarks need be made. In Liebig and Woehler's Annalen for May, 1843, Chr. Link has communicated his investigation of two sorts of lead, prepared in the Dutch way, by the slow action of vinegar and carbonic acid upon metallic lead, under the heat of fermenting horse-dung. The one sort was manufactured by Sprenger, the other by Klagenfurth of Krems. He also examined 3 specimens of the Offenbach white lead. They all agreed in composition; affording 11·29 per cent. of carbonic acid, and 2·23 of water; corresponding to the formula, $2\ (PbO,\ CO_2) + PbO,\ H_2O$; that is, in words, 2 atoms of carbonate of lead with 1 atom of oxide and 1 atom of water—in round numbers, thus, $\overline{2 \times 134} + 112 + 9$.

Mulder observed specimens of white lead, of different atomic proportions of carbonate, oxide, and water, from the above, and discovered that the quality improved as the carbonate increased. The white lead by the Dutch process, as made by Messrs. Blackett of Newcastle, is certainly superior as a covering oil pigment to all others. Its particles are amorphous and opaque.

A patent was granted to Mr. Hugh Lee Pattinson in September, 1841, for improvements in the manufacture of white lead, &c. This invention consists in dissolving carbonate of magnesia in water impregnated with carbonic acid gas, by acting upon magnesian limestone, or other earthy substances containing magnesia in a soluble form, or upon rough hydrate of magnesia in the mode hereafter described, and in applying this solution to the manufacture of magnesia and its salts, and to 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 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 ot magnesia in water impregnated with carbonic acid gas, or, as I shall hereafter call it, a solution of bicarbonate of magnesia, having a specific gravity of about 1·028, and containing about 1,600 grains of carbonate of magnesia to the imperial gallon.

I consider it the best mode of obtaining a solution of bicarbonate of magnesia from magnesian limestone, to operate upon the limestone after being calcined at a red heat in the way described; but the process may be varied by using in the cylinder the mixed hydrates of lime and magnesia, obtained by completely burning magnesian limestone in a kiln, as commonly practised, and slaking it with water in the usual manner; or, to lessen the expenditure of carbonic acid gas, the mixed hydrates may be exposed to the air a few weeks till the lime has become less caustic by the absorption of carbonic acid from the atmosphere. Or the mixed hydrates may be treated with water, as practised by some manufacturers of Epsom salts, till the lime is wholly or principally removed; after which the residual rough hydrate of magnesia may be acted upon in the cylinder, as described; or hydrate of magnesia may be prepared for solution in the cylinder, by dissolving magnesian limestone in hydrochloric acid, and treating the solution, or a solution of chloride of magnesium, obtained from sea-water by salt-makers in the form of bittern, with its equivalent quantity of hydrate of lime, or of the mixed hydrates of lime and magnesia, obtained by completely burning magnesian limestone, and 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 old 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 neutralize the solution of bicarbonate of magnesia with sulphuric acid, boil down, and crystallize; 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 crystallize as before. When using this solution of bicarbonate of magnesia for the purpose of preparing carbonate of lead, I make a saturated solution of chloride of lead in water, which, at the temperature of 50° or 60° Fahr., has a specific gravity of about 1·008, and consists of 1 part of chloride of lead dissolved in 126 parts of water. I then mix the two solutions together, when carbonate of lead is immediately precipitated; but in this operation I find it necessary to use certain precautions, otherwise a considerable quantity of chloride of lead is carried down along with the carbonate. These precautions are, first, to use an excess of the solution of magnesia, and secondly, to mix the two solutions together as rapidly as possible. As to the first, when using a magnesian solution, containing 1,600 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 $8\frac{1}{2}$ 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 color 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 ley 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 ley 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 crystallized carbonate of soda (which, being cheaper than carbonate of potash, I prefer) and 8 parts of water. The clear and colorless caustic lie, 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.

WINES. In a case tried before the court of exchequer, at the instance of the board of customs, in December, 1843, of an attempt to obtain the drawback upon a large quantity of damaged claret offered for exportation, I had observed, in my examination of the wine, that on the addition to it of water of ammonia to super-saturate its acidity, a large flocculent precipitate of decomposed gluten fell, and the supernatant liquor lost its ruby color, and became yellow-brown. I have tried sound samples of genuine claret, very old, as well as new, by the same test, and I have found the ruby color to remain but little impaired; contrary to the allegation of the chemist of the defendants in the lawsuit. The wine was declared by the verdict of a jury and the decision of the judge, to be unworthy of being admitted for drawback, and therefore forfeited to the crown.

WINES, BRITISH, are made either from infusions of dried grapes (raisins) or from the juices of native fruits, properly fermented. These wines are called *sweets* in the language of the excise, under whose superintendence they were placed till 1834, when the duties upon them were repealed as onerous to the trade and unproductive to the revenue. The raisins called Lexias are said to produce a dry flavored 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 flavor, and also to modify the fermentative action; it is afterward set to ripen in casks, clarified by being repeatedly racked off, and fined with isinglass.

WOOD PAVING. Among the numerous illustrations of the durability and resistance of wood paving, reference may be made to the specimens:—

	Yrs.	Mths.
At Whitehall, 1093 yards, laid in December, 1839 - - - -	3	4
In Fore Street, 521 yards, laid in October, 1840 - - - -	2	6
Under the arch in Scotland Yard, 54 yards (8 feet wide), laid in Oct., 1841	1	6

The first, in every respect a perfect piece of pavement, has been more than 3 years subjected to a constant traffic, including the utmost amount of percussion from velocity, and the extremest pressure from the ponderous engines which have been transported over its surface. Scarce less may be said of that in Fore street, while the specimen in Scotland Yard has successfully withstood at least a like amount of pressure, the traffic from the wharfs in Great Scotland Yard being no less than 78,000 tons per annum; the passage, narrowed within the limit of a single carriage line, exposing the wood to the most critical test of resistance.

Slipperyness is not a natural defect in wood paving. The accumulations on wood pavement are drawn from the proximate areas of granite and macadam. In granite the imperfect structure admits of the constant oozing of dust and filth; in macadam the surface is always wearing into dirt and slop. In dry, hot, or cold weather, the stone-paved streets of London are proverbially as slippery as glass, while slipperyness on wood pavement may be altogether obviated by cleanliness; and that may now be ensured by the use of Whitworth's cleansing machine, which has already been successfully tried in some of the principal streets—thanks to the commissioners of woods and forests.

It is impossible not to perceive the great amount of suffering and loss that may be saved in horses by the wood pavement. Cabmen and omnibus drivers assure us that, in the winter season, for a month or two only, there is any serious cause for complaint, and then there is as much or more danger on other pavements; whereas, during the summer months, the advantages of wood over all other pavements is immense; the great mortality of horses in the streets of London, from over-driving during the hot weather, is well known; so far as wood is concerned, the reduction of effort must necessarily decrease the destruction in a greater ratio than even 5 to 2.

WOOD-PRESERVING. Mr. Bethell's invention consists in impregnating wood throughout with oil of tar and other bituminous matters, containing creosote, and also with pyrolignite of iron, which holds more creosote in solution than any other watery menstruum.

The wood is put in a close iron tank, like a high-pressure steam-boiler, which is then closed and filled with the tar oil or pyrolignite. The air is then exhausted by air-pumps, and afterward 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. Pritchard, at Shoreham Harbor, that the *teredo navalis*, or naval worm, will not touch it.

Wood thus prepared for sleepers, piles, post, fencing, &c., is not at all affected by alternate exposure to wet and dry; it requires no painting, and after it has been exposed to the air for some days it loses every unpleasant smell.

This process has been adopted by the following eminent engineers, viz.: Mr. Robert Stephenson, Mr. Brunel, Mr. Bidder, Mr. Brathwaite, Mr. Buck, Mr. Harris, Mr. Wickstead, Mr. Pritchard, and others; and has been used with the greatest success on the Great Western railway, the Bristol and Exeter railway, the Manchester and Birmingham railway, the North Eastern, the South Eastern, the Stockton and Darlington, and at Shoreham Harbor; and lately, in consequence of the excellent appearance of the prepared sleepers, after three years' exposure to the weather, an order has been issued by Mr. Robert Stephenson, that the sleepers hereafter to be used on the London and Birmingham railway are to be prepared with it before being put down.

The expense of preparing the wood varies from 10*s.* to 15*s.* per load, according to situation, and the distance from the manufactories where the material is made.

Mr. Bethell supplies the material at a low price from his manufactories, either at Nine Elms, Vauxhall; Bow Common; or Birmingham; and parties prepare the timber themselves.

For railway sleepers it is highly useful, as the commonest Scotch fir sleeper, when thus prepared, will last for centuries. Those which have been in use 3 years and upward, look much better now than when first laid down, having become harder, more consolidated, and perfectly waterproof; which qualities, combined with that of perfectly resisting the worm, render this process eminently useful for piles, and all other woodwork placed under water. Posts for gates or fencing, if prepared in this manner, may be made of Scotch fir, or the cheapest wood that can be obtained, and will not decay like oak posts, which invariably become rotten near the earth after a few years.

Y.

YEAST, ARTIFICIAL. Mix two parts, by weight, of the fine flour of pale barley malt with one part of wheat flour. Stir 50 pounds of this mixture 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 to 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 " days. It should be occasionally stirred.

When beer-barm has become old and flat, but not sour, it may be revived by mixing with every quart of it a small potato, boiled, peeled, and rubbed down into a paste. The mixture is to be placed in a warm situation, where it will speedily show its renewed activity, by throwing up a froth upon its surface. It must be forthwith incorporated with the dough, for the purpose of baking bread. When the barm has become sour, its acid should be neutralized with a little powdered carbonate of soda, and then treated as above, when it will, in like manner, be revived. A bottle of brisk small beer may furnish ferment enough to form, in this way, a supply of good yeast for a small baking.

The German yeast imported into this country in large quantities, and employed by our bakers, in baking cakes, and other *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 afterward enclosed in waxed cloth, for exportation. The yeast cake may also be rammed hard into a pitched cask, which is to be closed air-tight. In this state, if kept cool, it may be preserved active for a considerable time. When this is to be used for beer, the proportion required should be mixed with a quantity of worts at 60° Fahr., and the mixture left for a little to work, and send up a lively froth; when it is quite ready for adding to the cooled worts in the fermenting back.

Yeast, Patent. Boil 6 ounces of hops in 3 gallons of water 3 hours; strain it off, and let it stand 10 minutes; then add half a peck of ground malt, stir it well up, and cover it over; return the hops, and put the same quantity of water to them again, boiling them the same time as before, straining it off to the first mash; stir it up, and let it remain 4 hours, then strain it off, and set it to work at 90°, with 3 pints of patent yeast; let it stand about 20 hours; take the scum off the top, and strain it through a hair sieve; it will be then fit for use. One pint is sufficient to make a bushel of bread.

Z.

ZINC. Mr. Nicholas Troughton, of Swansea, obtained a patent in May, 1839, for improvements in the manufacture of this metal. His invention relates to the application of a peculiar apparatus in roasting the ores, and in smelting the zinc. *Fig.* 179,

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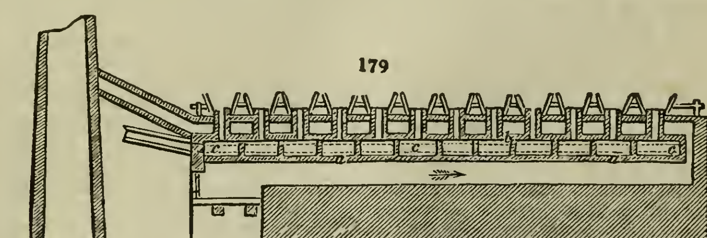

represents the section of a series of retorts for calcining zinc ores, arranged and constructed according to this invention. The retorts shown in this figure are composed of a series of fire-tiles or parallelogram slabs. *a*, *a*, *a*, are the slabs or tiles, which constitute the bottoms of the retorts; *b*, *b*, are the slabs, which constitute the upper surfaces or tops of the retorts; and *c*, *c*, are slabs, placed vertically, to produce the sides of the retorts. The back ends of the retorts are closed by similar tiles or slabs, having a hole through them for the passage of the vapors evolved from the ores; these vapors are conveyed in any direction by the flue at that end, and being thus separated from the products of combustion, may be separately acted on, according to either of the patentee's former inventions, which treat of the separated vapors of copper ores in the process of calcining or roasting such ores; or the separated products of the ore may be allowed to pass into the atmosphere. The patentee states, that by treating zinc ores in furnaces or retorts, such as are above described, considerable saving of fuel will result, and the zinc ore will be more evenly roasted or calcined.

The front ends of the retorts are closed by means of tiles or doors, having a small hole or opening in each, for the passage of atmospheric air; and the holes may be closed, or more or less open, according to the object required. The retorts are charged through the hoppers above, which have proper slides to close the openings into the retorts; the quantity charged into each retort being sufficient to cover the lower surface thereof two or three inches deep. During the operation the ore must be raked from time to time, to change the surfaces, and the retorts should be kept to a moderate red heat.

The second part of this invention relates to an arrangement of apparatus or furnace for calcining zinc ores, wherein the ore is subjected to the direct action of the products of combustion. *Fig.* 180, shows a longitudinal section of the furnace, which is so constructed that while one portion of the zinc ore is being heated in a manner similar to the working of an ordinary calcining surface, other zinc ore is going through a preparatory process by the heat that has passed away from the ore which is undergoing the completing process of calcining. This furnace may be heated by a separate fire, to burn by blast or by draught; or the flue from the smelting furnace may be conducted into the entrance of this furnace, and the otherwise waste heat of the smelting furnace will be thus brought into useful application for calcining or roasting of zinc ore; and this part of the invention is applicable, whether it be applied to the furnace, or to the retorts herein-before explained, and will be found a means of saving much fuel in the processes of obtaining zinc from ore. *a*, *fig.* 180, represents the furnace, which is suitable for blast, and a constant supply of fuel is kept up in the chamber *b*, there being a close cover, with a sand-joint. *c*, is the bed or floor on which the ore is spread, in like manner to an ordinary reverberatory furnace; the ore is stirred about on the floor by passing the ordinary rakes or instruments through the openings, *d*, *d;* and when the process has been sufficiently carried on, the ore is discharged through the openings *e*, *e*, which, at other times, remain closed by fire-tiles. The heat of the fire, and the flame thereof, passing in contact with the ore on the floor or bed, *c*, also acts on the roof, *f*, and that roof, *f*, being hot, reverberates the heat on to the floor or bed, at the same time the heat, which passes through the roof, heats the ore in the upper chamber, *g;* and, in addition to such heat passing through the roof, the flame and heat from the furnace, having passed over the zinc ore, in the lower compartment of the apparatus, enters into and passes over the ore in the chamber *g;* and, in doing so, heats the roof *h*, of that chamber, and also the ore contained therein; and it will be seen that there is a third chamber, *i;* the heat, therefore, which passes through the roof *h*, heats the ore in the chamber *i*. In working this arrangement of calcining furnace or apparatus, when the charge is withdrawn from the lower chamber, the charge in the chamber *g* is to be raked into the lower chamber, through the openings for that purpose, which, at other times, are kept covered with fire-tiles, as shown in the drawing; and the charge in the chamber *i* is to be raked into the chamber *g*, and a fresh supply of ore charged into the chamber *i*.

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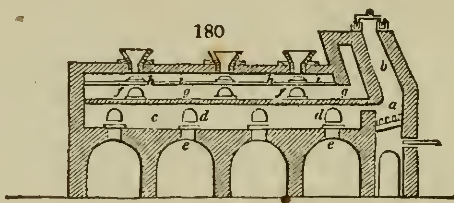

The third part of this invention relates to a mode of arranging a series of retorts side by side, and of applying heat thereto in the process of smelting or distilling zinc from the ore. According to the practice most generally pursued in smelting zinc, the ore is submitted to the action of heat in crucibles, having descending iron pipes, which enter into vessels containing water: all which is well understood, as well as the process of smelting or distilling zinc from the ores. *Fig.* 181, is a side elevation of two sets of

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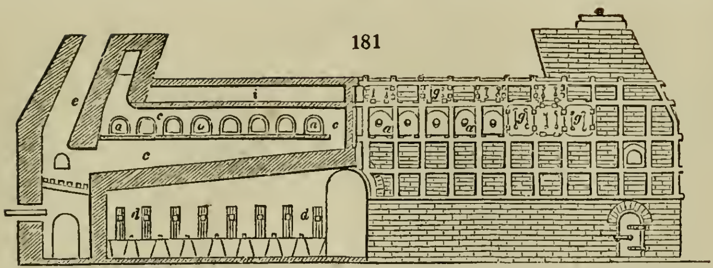

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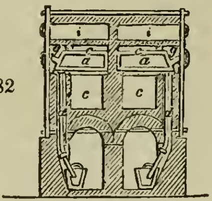

furnaces and retorts, arranged according to this invention, one of the furnaces being in section; and *fig.* 182, is a transverse section of the same. *a*, *a*, are a series of retorts of fire-clay, arranged, side by side, on a shelf of slabs or fire-tiles. These retorts are each closed at one end and open at each other, such open end being closed, when in operation, by a tile or door, *b*, fitting closely, and luted with fire-clay, as will readily be traced in the drawing. Each series of retorts is placed in a chamber, *c*, *c*, in such a manner that the heat and flame of the fire will pass from the fireplace or furnace, and act on one side of the retorts; and having passed along all the series, will proceed to the upper part of the chamber, *c*, *c*, and heat the other side of the retorts; and as the fires are maintained and urged by means of blasts of atmospheric air, the heat may be maintained and regulated with great advantage, and at comparatively small cost. The blasts of air may be produced by any ordinary blowing machinery, but rotatory blowers are preferred, and the air may be cold or heated. When anthracite coal is used as the fuel, the patentee prefers adopting the hot blast, at a temperature of at least 500° Fahr., and such heating may be performed by any of the well-known means now very generally resorted to for heating the blasts of air for smelting iron. *d*, *d*, are iron pipes, descending from the retorts and entering into vessels containing water, similar to the apparatus at present in use for like purposes. Each chamber, *c*, is heated by its separate furnace or fireplace, which have openings, to be closed when at work; and in order to keep up a supply of fuel to the fire, each fireplace has an inclined chamber, *e*, which is filled with fuel, and then closed air-tight by the cover, *f*, fitting into a sand-bath or joint, in order to prevent draught upward. By this means the lower portion only of the fuel will be in an ignited state when at work. *g*, *g*, are a series of iron doors, one opposite the mouth of each retort; these doors are capable of being removed by sliding them upward, till the portions cut out at the sides come opposite the dips or holders, *h*, *h*, when the doors may be removed, in order to get at the retorts. *i*, is a chamber in which the ore is heated previous to its being placed in the retorts. The arrangement of the brickwork, the construction and setting of the furnaces, being clearly shown in the drawing, no further description need be given.

The patentee remarks, that he is aware attempts have been made to employ retorts in the smelting of zinc, and he does not, therefore, claim the same generally; but he does claim, in respect to the third part of this invention, the mode of placing a series of retorts in a chamber, *c*, and causing the heat and flame to pass along, under and over, such series of retorts, as above described; and he also claims the mode of smelting zinc by means of blast, whether the heat of the fuel is caused to act on a series of retorts or vessels, in the manner shown, or on other arrangements of retorts or vessels, placed in a suitable chamber or chambers.—*Newton's Journal*, xxiii., p. 81. *C. S.*

APPENDIX.

ALKALIMETRY. Twenty-eight years have elapsed since I was led, by peculiar circumstances, to construct a very simple method of testing alkalis, the principle of which I soon afterward applied to acids, bleaching powder, dye-stuffs, and most other chemical substances extensively used in manufactures.* In 1814 and 1815, during the summer vacation of my Glasgow classes, I was engaged in delivering courses of lectures on chemistry in the Belfast Academical Institution, and had many of the most eminent members of the Linen Board of that town for my pupils. Being occasionally consulted upon the qualities of the alkalis, which were used to the value of 200,000*l.* by the linen bleachers of Ireland, I saw the importance to them of a simple alkalimetrical test, both for purchasing and for using their barillas and potashes. The following extract from the Belfast *News Letter*, of July 9th, 1816, will show the nature of my contrivance:—

"This day one of the porters of the Linen Hall, Belfast, was called into the library-room at the request of Dr. Ure, who being quite unknown to Dr. Ure, and never having seen any experiments made with acids and alkalis, he took the instrument at our desire, which being filled with colored acid, by pouring it slowly on adulterated alkali, which we had previously prepared, he ascertained exactly the per-centage of genuine alkali in the mixture. Belfast, 25th June, 1816.

"John S. Ferguson, Chairman.
James M'Donnel, M. D.
John M. Stoupe.
S. Thomson, M. D."

Of these gentlemen, two were leading members of the Linen Board, and the others the two principal physicians of the town. The publication of the details of my method of alkalimetry was delayed till arrangements were made for its general introduction, under the direction of the Linen Board of Dublin, whose professor of chemistry, Mr. W. Higgins, as well as Dr. Barker, professor of chemistry in Trinity College, granted certificates of the "accuracy and the national importance" of the instrument. The alkaline matter then imported into Ireland was often largely contaminated with common salt, even to the extent of 80 or 90 per cent. During the procrastination of the Board, I lent my Treatise on Alkalimetry to Dr. Henry, of Manchester, who inadvertently published an account of it, though with reference to me, in the next edition of his *Elements of Chemistry*. Having, in the long interval since, contrived many modifications of the instrument, and having extended its principle to testing other articles I am induced to offer it now to the world, in consequence of the recent appearance of a publication upon the same subject, by two very ingenious chemists of Liebig's school, Drs. R. Fresenius and H. Will. Of their system of alkalimetry, &c., a copious abstract appeared in the *Annalen der Chimie und Pharmacie* for July last, and about the same time a pamphlet was published by Winter, at Heidelberg, under the title *Neue Verfahrungsweisen zur Bestimmung des Werthes der Pottasche und Soda, der Saüren, und des Braunstein;* or "New Processes for determining the Value of Potash and Soda, of Acids, and Black Oxide of Manganese." However accurate these processes may be, and however apt for a German or French student of chemistry, they are, in my apprehension, not at all fitted for the familiar use of manufacturers and dealers in any country, and certainly not for those of the United Kingdom.

Descroizilles was the first person who contrived an instrument, called an alkalimeter, to ascertain the alkaline strength of potash and soda, without much calculation. His method was described in the *Annales de Chimie* for 1806, tom. lx., and a translation of it appeared in our *Philosophical Magazine*, vol. xxviii., for July

* Among others to nitrate of potash, nitrate of soda, and to white lead, either in powder or in paint. My nitrometer enables a person not at all versant in chemistry to ascertain in a quarter of an hour, but by two distinct processes, the quantity of pure nitrate in either of these salts, to one part in 200. The cerussa-meter is equally simple and expeditious.

and August of the following year. His apparatus consisted of a glass tube, 8 or 9 inches long, and 7 or 8 lines in diameter, closed at one end, but terminated at the other in a kind of small funnel (with a beak or spout), connected to the tube by a narrow neck, having a calibre of two lines and a half. Upon the shoulder, under the throat, there was a hole for admitting air to the long tube in the act of being emptied, by sloping its mouth downward. This cylindrical vessel was to contain 38 grammes of water, which space was divided into 76 equal parts, which it was extremely important to proportion accurately. The liquor was prepared by taking concentrated sulphuric acid, at 66° Baumé (1·845 spec. grav.), and diluting it with nine times its weight of water. The instrument being poised in a balance, he introduced into it very exactly two grammes of the above test acid, and when the instrument stood upright, he scratched a line at the level of the liquor, and thus proceeded by addition of successive grammes to graduate the whole, till 36 were added, after which he subdivided these spaces by lines into 72 demi-gramme volumes. He then proceeds to describe eight different subsidiary articles required for his operations:—

"*Alkalimetrical trials of potash.*—Weigh exactly one demi-gramme of potash, put it into a glass, and pour upon it about four fifths of a decilitre of water; facilitate the solution of the potash by stirring it with a small chip of wood, three or four times in an hour and a half, a minute at each time. When the solution is effected, pour it into the small tin measure, No. 4, which is to be then filled up with water; pour it back again into the glass, in which you must still pour a measure full of pure water; stir this new mixture also three or four times within half an hour, in order to facilitate the precipitation of a slight sediment, which soon falls down. This sediment being completely formed, slope the glass with caution, in order to fill with clear liquor the small measure; then empty this last into another large glass; after this place round the edges of a plate drops of syrup of violets; pour also into the alkalimeter test liquor until the line marks 0; take it afterward with the left hand, inclining it upon the glass which contains the moiety of the clean alkaline solution: the acid liquor will fall into it by hasty drops, or in a very small thread, which you may moderate at pleasure, by retarding the entrance of the air at the lateral hole or vent, upon which must be placed the end of the finger; at the same time, with a small stick or match, assist the mixture and facilitate the development of the carbonic acid which is manifested by effervescence. When you have emptied the alkalimeter to about the line 40, try if the saturation approaches, by drawing your small stick from the mixture, and resting it upon the drops of syrup of violets, which should become green, if the potash is not of a very inferior quality. If, on the contrary, the violet color is not altered, or what would be worse, if it be changed into red, there would be, in the first case, an indication of saturation, and in the second a proof of super-saturation. But this is not the case with good potashes; at that line, the liquor tried can alter the syrup of violets into green only; or cause to return to the violet, and even to the green, the drops which had been changed into red at the time of a former trial; we must, therefore, in general add more acid, which occasions a new effervescence. This addition must always be made with caution, and we must touch every time a drop of syrup of violets in order to stop. When at last the latter assumes a red hue, then, after having restored the alkalimeter to a perpendicular position, in order to see at what line the testing liquor stops, you must reckon one degree less, in order to compensate the excess of saturation. The mean term of potashes is 56; this implies that they require for their saturation *fifty-five hundredths* of their weight of sulphuric acid."

For the analysis of commercial sodas of all kinds, M. Descroizilles prescribes using ten and a half deci-grammes of this alkali, instead of the ten deci-grammes for potashes, and proceeds as above detailed. In his table of results annexed, we find American potashes called 60° to 63°.

American pearlashes - - -	50° to 55°
Dantzic potash - - - -	45 to 55
Alicant soda - - - -	20 to 33

It is obvious, from these statements, that the alkalimeter so made and graduated denoted comparative, but not absolute, quantities of alkalis present in the commercial samples. The rest of his very long memoir is occupied with what he calls the graduation of potashes and sodas, the economy of their graduation, the proportions of carbonic acid in them, the processes of caustification, the presence of potash in all lime which is burnt by a wood fire, origin of neutral soda, and probable origin of natrum; without any more explicit instructions. The instrument, as left in this vague state, never was employed, nor could it come into use, among English manufacturers and dealers

The next alkalimeter, of which an account has been published, was my own. In constructing this instrument, I availed myself of the lights recently shed on chemical proportions by Dr. Dalton's atomic theory, and I thus made it to represent, not relative, but absolute measures of the amount of real alkali existing in any commercial sample. The test-liquor used at that time was sulphuric acid, which is most readily and accurately diluted to the requisite degree by means of a glass bead, very carefully made, of the specific gravity that the standard acid should have. In order to make the test-liquor, therefore, nothing more is requisite than to put the bead into distilled water, and to add to it somewhat dilute but pure sulphuric acid, slowly and with agitation, till the bead rises from the bottom, and floats in the middle of the liquor at the temperature of 60° Fahr. The delicacy of this means of adjustment is so great, that a single degree of increase of heat will cause the bead to sink to the bottom—a precision which no hydrometer can rival. The test-tube, about 14 inches long, contains generally 1,000 grains of water, and is graduated into 100 equal parts by means of equal measures of mercury. The test-liquor is faintly tinged with red cabbage or litmus; so that the change of color, as it approaches to the saturating pitch, on adding it to 100 grains of the commercial alkali, becomes a sure guide in conducting the experiment to a successful issue. One hundred measures of this test-liquor neutralize exactly 100 grains of absolute soda (oxide of sodium), and of course very nearly 150 of potash. A bead may also be adjusted for test-liquors, of which 1,000 grain measures neutralize 100 of potash, and therefore $66\frac{2}{3}$ of soda, as well as other proportions, for special purposes of greater minuteness of research. One may be so graduated as to indicate clearly a difference of $\frac{1}{100}$ of a grain of ammonia. In making such nice experiments, it is of course requisite to free the alkaline matter beforehand from sulphurets, sulphites, and hyposulphites, by igniting it in contact with chlorate of potash, as long since recommended by Gay-Lussac. With such means in careful hands, all the problems of alkalimetry may be accurately solved by an ordinary operator.

On the same principle, my *Acidimeter* is constructed; pure water of ammonia is made of such a standard strength by an adjusted glass bead, as that 1,000 grain measures of it neutralize exactly a quantity of any one real acid, denoted by its atomic weight, upon either the hydrogen or oxygen scale or radix; as for example, 40 grains of sulphuric acid. Hence it becomes a universal acidimeter; after the neutralization of 10 or 100 grains of any acid, as denoted by the well-defined color in the litmus-tinted ammonia, the test-tube measures of ammonia expended being multiplied by the atomic weight of the acid, the product denotes the quantity of it present in 10 or 100 grains. The proportion of any one free acid in any substance may thus be determined with precision, or to one fiftieth of a grain, in the course of five minutes. Like methods are applied to Chlorometry, and other analytical purposes, with equal facility; adapting the test-liquor to the particular object in view. Instead of using beads for preparing the alkalimetric and acidimetric test-liquors, specific gravity bottles, or hydrometers, may of course be employed; but they furnish incomparably more tedious, and less delicate means of adjustment. To adapt the above methods to the French weights and measures, now used generally also by the German chemists, we need only substitute 100 *deci-grammes* for 100 grains, and proceed in the graduation, &c., as already described.

The possession of two reciprocal test-liquids affords ready and rigid means of verification. For microscopic analyses of alkaline and acid matter, a graduated tube of small bore, mounted in a frame with a valve apparatus at top, so as to let fall drops of any size, and at any interval, is desirable; and such I have employed for many years. Of this kind is my ammonia-meter, used in the ultimate analysis of guanos and other azotized products, in conjunction with a modified apparatus on the principle of that of Varrentrapp and Will. It may be remarked, that when the crude alkali contains some hyposulphite, it should not be calcined with chlorate of potash, because one atom of hyposulphurous acid is thereby converted into two atoms of sulphuric, which of course saturate double the quantity of alkali, previously in combination with the hyposulphurous acid. In such cases it is preferable to change the condition of the sulphurets, sulphites, and hyposulphites, by adding a little neutral chromate of potash to the alkaline solution, whence result sulphate of chromium, water, and sulphur, three bodies, which will not affect the accuracy of the above alkalimetrical process.

In the *Annals of Philosophy* for October, 1817, I described a new instrument for analyzing the earthy and alkaline carbonates, and for determining the quantity of base present in them from the volume of carbonic acid, disengaged by their solution in acids, upon the data of the atomic theory. This method was applied to the analysis of the carbonates of ammonia, soda, potash, lime, magnesian limestone (dolomite), &c.

"The indications of the above analytical instrument are so minute as to enable us, by the help of the old and well-known theorem for computing the proportions of two metals from the specific gravity of an alloy to deduce the proportions of the bases from the volume of gas disengaged by a given weight of a mixed carbonate."*

That small instrument consisted of a bent glass tube, open at one end, and terminated at the other with an egg-shaped bulb from two to three inches in diameter, and it required for operating with it, about five pounds of quicksilver. The following glass apparatus (*fig.* 183) will be found more generally convenient, and equally exact. A is a cylinder, 2 inches in diameter, and 14 inches long. It contains 10,000 grains of water in the graduated portion; 0, or zero being at the top. It has a tubulure in the side close to the bottom, through the cork of which a short tube passes tight, and is connected to a collar of caoutchouc, E, which serves for a joint to the upright tube, B, resting near its open upper end in a hooked wire. Through the cork in the *mouth* of the cylinder, the taper tail of the flask C passes air-tight. The small tube F, open at both ends, is cemented at bottom into the tail of C, and rises to the shoulder of the flask. The cork of C is perforated, and receives air-tight the taper tube D, which can also be closed with the stopcock.

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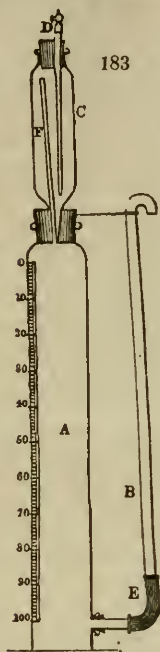

In operating with this apparatus, proceed as follows:—

Fill the cylinder with water, and cover its surface with half an inch of oil. Insert the tail of the flask. Put into the flask C, 58·6 grains of carbonate of potash, or 45·2 of carbonate of soda, according as common pearl-ash or soda-ash is to be tested, along with as much water as will cover fully the lower end of D, and then introduce this tube. Have a bottle containing about 40 parts of oil of vitriol, previously mixed with 60 of water, and cooled. Take of this, in a pouring or dropping glass, 100 water grain measures, and suck this quantity gradually up into the tube D, then shut the stopcock. On opening it slightly the acid will fall into C, and as slowly as may be prudent. The carbonic acid gas, forthwith disengaged, will depress the water in A, cause an overflow of it from the tube B, which, being held in the left hand, must have its swanbeak placed over a basin, and progressively lowered to the level of the descending water in the cylinder. When all the sulphuric acid has been introduced by the right hand, the orifice of D is to be corked, and the tube B continually lowered with the left, till the effervescence being finished, the water in A remains stationary. The number on the centigrade scale, opposite to the surface of the oil, deducting 100 grain measures for the bulk of dilute acid added, denotes the per-centage of pure carbonate of potash, or of soda, in the sample under examination. The above prescribed weights of these two carbonates, when pure, disengage each by the action of sulphuric acid (used here in small excess) 10,000 water grain measures of carbonic acid gas, or 100 measures of the scale on A. The cylinder which I employ contains about 12,000 water grain measures, so that the bottom of the centigrade scale is fully two inches above the level of the lower tubulure. This capacity and the graduation into 120 parts, will be found convenient in certain cases, particularly in analyzing bicarbonates of potash and soda.†

We may estimate 10,000 water grain measures of carbonic acid at 60° Fahr., to weigh 18·4 grains, and we thus perceive what a magnified scale we should possess, if we applied the *vernier* contrivance here, as we do to barometers. At any rate, he must be an awkward operator who can not determine the value of an alkaline carbonate, by the above means, to one part in a thousand.

In operating upon limestones, marles, &c., 42·1 grains should be taken as the standard weight of assay, because that weight of pure carbonate of lime should give out on solution in dilute muriatic acid 10,000 water grain measures of carbonic acid gas. Since 100 water grain measures of liquid hydrochloric acid, specific gravity 1·14, will supersaturate the lime in the above weight of carbonates, that quantity may be used in the experiment. The preceding instrument will be found more convenient in experimenting, as also the system of indication, than one on similar principles constructed by the ingenious Dr. Mohr, of Coblenz.

In examining bicarbonates of potash and of soda, the weights to be used in the above apparatus are 42 grains of the former, and 35¼ grains of the latter, each of which

* *Dictionary of Chemistry*, 1821.

† For the greatest precision hot acid may be used in the above experiment, by taking in a graduated test-tube seventy-five grains of water, and filling it up to the line 100 with concentrated sulphuric acid. This mixture being poured in successive portions into the flask C (represented much too large in proportion to the cylinder A), will ensure the expulsion of all the carbonic acid from C, which may be afterward cooled by wrapping round it a towel dipped in cold water.

quantities, if the salts be perfect, will disengage 10,000 water grain measures of carbonic acid gas, by the action of sulphuric acid. There will be no harm in taking the formerly prescribed measure of the sulphuric acid though considerably less would answer the purpose. The centigrade measures of gas obtained in A will indicate the carbonated state of the two alkalis respectively. Their alkaline force may be most readily ascertained by my old alkalimeter, with colored test acid. Since the bicarbonates usually sold in our shops, especially that of soda, are far from being exact atomic compounds, they should be always examined, both for their base and acid, which may also be well done in the following way, where the quantity of carbonic acid gas is determined by weight instead of by volume.

For this purpose, a small compact apparatus of the annexed form (*fig.* 184) will be found convenient; it is to be used in conjunction with my alkalimeter. A in the dotted line is the phial for receiving the carbonate to be tested. B, the funnel into which the test acid is to be poured; C C, an inverted syphon filled with pieces of chloride of calcium for absorbing the aqueous vapors exhaled by the carbonic acid. The loss of weight in the phial above that in the tube of test acid shows the quantity of acid gas, and the indication of the alkalimeter tube, that of alkaline base, from which data the proportion of neutral carbonate and bicarbonate may be immediately deduced. Thus, 100 grains of bicarbonate of soda should give out $51\frac{3}{4}$ grains of carbonic acid, and saturate 37·6 centigrade measures of the test acid, equivalent to 37·6 grains of real soda. But if neutral carbonate of soda be present, less gas will be given out, and more or less alkali may be indicated, according to the degree of dryness of the neutral soda. The amount of water in the bicarbonate may be determined by igniting 20 grains in a test tube, connected with the chlorcalcium inverted syphon; $10\frac{1}{3}$ grains of carbonic acid gas should be expelled, and $2\frac{1}{8}$ of water, making a total loss of $12\frac{11}{24}$ grains, of which $2\frac{1}{8}$ will be found as water absorbed by the chlorcalcium. But since a very moderate heat suffices to expel the second atom of carbonic acid from the bicarbonate of soda, the readiest mode of estimating its quality is to heat, over a spirit lamp, in a small flask, or retort, connected air-tight by a tube with the mouth of the cylinder A, (*fig.* 183), $70\frac{3}{4}$ grains of the supposed bicarbonate. Of the perfect salt this quantity should give out pretty exactly 10,000 grain measures of gas; and whatever aliquot part of this volume is evolved will indicate, without calculation, the relative value of the substance as a bisalt. Thus if 8,500 grain measures of gas are obtained, 85 parts of bicarbonate of soda are present in 100. The crystalline form of bicarbonate of potash is a tolerably good criterion of its quality.

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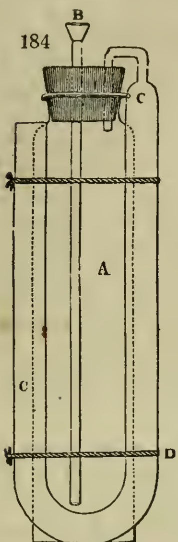

The quantity of caustic alkali mixed with carbonate may be readily determined, with sufficient accuracy, by the expert use of my alkalimeter; because, till the caustic portion be nearly neutralized, little or no carbonic gas is expelled. When the effervescence at length begins, the test measures already expended denote the percentage of caustic alkali. It is not right to disregard the alkali which is present in the state of sulphuret, because as such it is effective in many processes of the chemical arts; in the manufacture of yellow soap, crown glass, in the bleaching of linen and cotton goods, &c. The alkalimeter, directly applied, will show the alkali present in this form, when compared with that indicated after ignition of the crude alkali with chlorate of potash, or after its treatment with yellow chromate of potash.*

A few years ago I had the following apparatus made for the ready analysis of carbonates, by ascertaining the loss of weight they suffered from the disengagement of their carbonic acid gas, during their solution in an acid. A, B (*fig.* 185) are two globes, of about two inches in diameter each; A has its inferior neck strangled into a bore nearly capillary; B stands lower, with its centre line on a level with the narrow neck of B. The tubes of these globes are about one half inch in diameter. C is shut at top with a perforated cork, through which enters, air-tight, a small glass tube, which is bent across to the mouth of the tube E, and then passes down into it a little below the centre line of

* If the alkaline carbonate contains sulphuret, sulphite, or hyposulphite, a teaspoonful of yellow chromate of potash may be added to it, wherefrom result su'phate of chromium, water, and sulphur, which remain in the apparatus without effecting its weight. The mutual action of neutral chromate of potash, and of sulphuret of potash, &c., has been discussed in an ingenious paper published by Dopping, in the *Annalen der Chimie* for May, 1843, *p.* 172.

the globe B. This globe is rather more than half filled with sulphuric acid, when the instrument is employed in the analysis of the carbonates. The standard weight of carbonate of soda = $24\frac{1}{8}$ grains, or of carbonate of potash = $31\frac{1}{3}$ grains, is then put into A, having previously laid a minute globe of glass over the lower orifice; the cork, with its small tube, is now firmly adjusted; and the apparatus is weighed in its upright position, either by suspension with a hook to the end of the beam, or by resting it on the scale in a light socket of any kind. It is next laid hold of, and inclined so as to cause a little of the acid in B to pass over into A. Effervescence ensues with greater or less vehemence, according to the nature of the carbonate and quantity of the acid introduced. Should it be too violent, and threaten an overflow by intumescence, it can be instantly abated to any degree by the slightest slope of the instrument. Now, this power of control forms the peculiar feature and advantage of this contrivance; whereas in all other forms of such apparatus that I know, whether by sucking over or pouring in, if a little too much acid comes upon the carbonate, the experiment is effectually marred. The gas disengaged in A must necessarily traverse the sulphuric acid in B, and be stripped of its moisture before escaping into the air. Having supersaturated the alkaline base, and cooled the apparatus, we weigh it again, and the loss of weight in grains and tenths denotes the per-centage of soda or potash, provided their neutral carbonates had been the subjects of experiment. For limestone, on the same plan of computation, $22\frac{3}{4}$ grains may be taken. It deserves to be noted, that the present instrument has only one junction, and needs no chloride of calcium, a substance so apt by its swelling to burst the glass tubes that contain it.*

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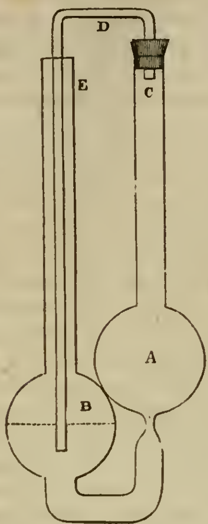

II. ACIDIMETRY.

I have already stated, that water of ammonia of standard strength, faintly tinted with litmus, affords a most exact and convenient acidimeter, when poured or let fall from a graduated dropping-tube. Bicarbonate of potash also, when dissolved in water, so that 1,000 grain measures contain one atom of the salt counted in grains, is a good test-liquor for the same purpose; for if the centigrade measures expended in effecting neutralization are multiplied by the atomic weight of the given acid, the product is the quantity in grains of acid present.

Acidimetry may be likewise exactly performed by measuring in the cylindric gasmeter (*fig.* 183) the volumes of carbonic acid gas disengaged from pure bicarbonate of potash or soda, by a given weight of any acid, taking care to use a small excess of the salt. Thus, for example, 16·8 grains of dry and $20\frac{2}{3}$ of hydrated sulphuric acid disengage 10,000 water grain measures of gas from bicarbonate of potash. Therefore, if $20\frac{2}{3}$ grains of a given sulphuric acid be poured into the flask of *fig.* 183, upon about 50 grains of the bicarbonate, powdered and covered with a little water, it will cause the evolution of a volume of gas proportioned to its strength. If the acid be pure oil of vitriol, that weight of it will disengage 10,000 grain measures of gas; but if it be weaker, so much less gas—the centigrade measures of which will denote the per-centage value of the acid. If the question be put, how much dry acid is present per cent. in a given sulphuric acid, then 16·8 grains of the acid under trial must be used; and the resulting volume of carbonic acid gas read on the scale will denote the per-centage of dry acid.†

For nitric acid, we should take 22·6 grains; for hydrochloric or muriatic acid, 15·34; for acetic acid, 21·6; for citric acid, 24·6; for tartaric acid, 28 grains: then in each case we shall obtain a volume of carbonic acid gas proportioned to the strength and purity of these acids respectively. The nitric, hydrochloric, and acetic acids are referred to in their anhydrous state; the tartaric and citric in their crystalline. If the latter two acids be pure, a solution of 24·6 grains of the first and of 28 of the last

* 1,000 water grain measures of sulphuric acid of specific gravity 1·032, or 32 above water, neutralize 32 grains of soda, and, consequently, one atom, on the hydrogen scale, of each of the other bases, reckoned in grains.

Having in the course of many years subjected my tables of sulphuric, nitric, and muriatic acids, as well as of ammonia, to strict cross-examination, I have found them trustworthy for all alkalimetrical and acidimetrical purposes.

† The bicarbonate must be free from carbonate, a point easily secured by washing its powder with cold water, and drying it in the air.

will disengage from 50 grains of bicarbonate of potash 10,000 grain measures of carbonic acid gas.*

Acidimetrical operations may likewise be performed by determining the *weight* of carbonic acid gas expelled from the bicarbonate of potash or soda, by a given quantity of any acid, in the apparatus either *fig.* 184, or *fig.* 185. Here the weights to be taken are as follows, in reference to

	Grains.
Dry Sulphuric acid - - -	9·127
" Nitric - - - - - -	12·33
" Hydrochloric - - -	8·29
" Acetic - - - -	11·67
Crystallized Tartaric - - -	13·31
" Citric - - -	15·13

Each of these quantities of real acid, with 25 or 26 grains of bicarbonate of potash, will give off 10 grains of carbonic acid gas; and hence whatever weight the apparatus loses, being reckoned in grains and tenths of a grain, denotes the per-centage of acid in the sample under trial, without the necessity of any arithmetical reduction. Persons accustomed to the French metrical system may use deci-grammes instead of grains, and they will arrive at the same per-centage results.

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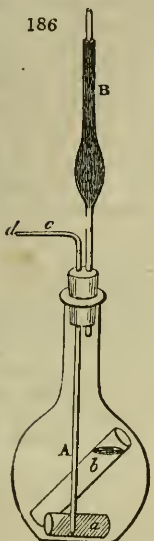

The preceding experiments, in reference to the weight of carbonic acid gas expelled for the purpose of either alkalimetry or acidimetry, may also be made by means of the ordinary apparatus represented in *fig.* 186. A is a small matrass which contains the acid or carbonated alkali at its bottom; and conversely the alkali or acid, for their mutual decomposition in the small test-tube, shown first at *b* nearly upright and filled, but afterward at *a*, horizontal and emptied. B is a bulbous tube filled with fragments of chlorcalcium for absorbing the aqueous vapor that rises with the carbonic acid gas, and *d c* is a small bent tube which dips into the liquid in the matrass. The weighings, &c., may be conducted as already detailed; and when the effervescence is completed, the residuary gas is sucked up through B, while the atmospheric air enters to replace it at the orifice *d* of the bent tube.

The NEW methods which pervade the whole treatise of Drs. Fresenius and Will are all based on the principle of estimating alkalinity, acidity, and the oxygen in manganese (or chlorometry) by the weight of carbonic acid gas evolved. As in taking these measures the gas must be discharged without carrying water off with it, an elegant and ingenious little piece of apparatus has been invented by the authors for effecting that purpose, and it will do it well. A and B (*fig.* 187) are two flasks (wide-mouthed medicine-bottles may be employed). A must have a capacity of from 2 ounces to $2\frac{1}{2}$ ounces of water; it is advisable that B should be somewhat smaller, say of a capacity of about 1 to $1\frac{1}{2}$ ounces. Both flasks are closed by means of doubly perforated corks. These perforations serve for the reception of the tubes *a*, *c*, and *d*. *c* is a tube bent twice at right angles, which enters at its one end just into the flask A, but descends at its other end, near to the bottom of B. These tubes are open at both ends when operating; except the top end *b* of the tube *a*, which is closed by means of a pellet of wax. The substance to be examined is weighed and put into the flask A, into which water is then poured to the extent of one third of its capacity. B is filled with common English sulphuric acid to about half its capacity. Both flasks are then corked (by which they become united by the rectangular tube), and the apparatus is weighed.

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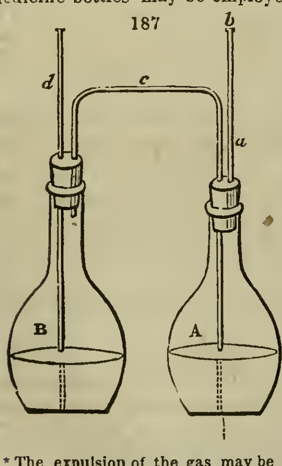


The air of the whole apparatus is next rarefied by applying suction to the tube *d*: the consequence is, that the sulphuric acid contained in B ascends into

* The expulsion of the gas may be completed by surrounding the flask with a towel dipped in hot water.

the tube c, and thus a portion of it flows over into B. Immediately upon its coming into contact with the carbonate contained in A, carbonic acid gas is disengaged, and in its escape must necessarily traverse the oil of vitriol in B, and therein deposite all its aqueous vapor before issuing from *d*. The sulphuric acid in passing over into A heats the mixture at the same time, and thus promotes the expulsion of the gas. Whenever this ceases to flow, a little more sulphuric acid must be sent over into A by suction from *d* (or rather from a recurved tube attached, *pro tempore*, to it); an artifice which may be repeated till no more gas can be expelled, even when the contents of A are heated, as they must be at the end by the excess of oil of vitriol.

"From the aperture *b* of the tube *a*, which has been all the time closed, the bit of wax is now to be removed, and to the tube connected with *d*, suction is to be applied, till all the carbonic acid lodged in the apparatus be replaced by atmospheric air. The whole is to be then cooled, wiped, and weighed; the loss of weight indicates exactly the quantity of carbonic acid which existed in the carbonate submitted to experiment. The process is no less neat than it is simple, and does honor to the ingenuity of its inventors. Their mode of deducing the per-centage of alkali from the quantity of carbonic acid discharged in the operation is also quite exact, and suitable for continental chemists familiar with gramme weights and calculations, but certainly not for persons conversant only with ounces, drams, and scruples, or even with grain subdivisions. The whole book, however excellent, needs, for the British public, transposition, before it can serve in this country the purpose intended by its scientific authors. Thus, in section 4, where several results of their analyses are given, the statements have a somewhat mysterious aspect. Should any one ask why the oracular number of 4·83 grammes of carbonate of soda is used as their standard weight for analysis, he can obtain no response in the book, either in a note or anywhere else. A German or French student, familiar with chemical computation, will probably be able to discover that 4·83 grammes of pure carbonate of soda contain, by Berzelius's tables of atomic weights, 2 grammes of carbonic acid; for 53·47 (1 atom of carbonate): 22·15 (1 of carbonic acid):: 4·83 : 2·00. Such is the simple solution of this apparent enigma, and of some other similar puzzles in the book. Indeed, unless the reader is aware of that proportion, he can not see the grounds of the accordance in the results between experiment and theory, or why the numbers 2·010, 1.993, and 2·020, are presented as specimens of great precision. This accordance gives satisfaction when it is known that these numbers, in experiments 1, 2, and 3, oscillate on one side or other so near to the theoretical number 2·00. But 4 grammes and 83 centi-grammes, as also 1 gramme and 995 milli-grammes, are awkward weights for an ordinary English chemist or apothecary, which would require a month or two's residence in the laboratories of Giessen and Paris to manipulate with readiness.

Again, in testing carbonate of potash, our authors take 6·29 grammes as their unity of weight, undoubtedly, because, if pure, it should discharge, by saturation with the sulphuric acid, 2 grammes of carbonic acid. Here, however, they have not stuck so rigidly as the school of Giessen usually does to Berzelius's atomic numbers; for his atom of carbonate of potash is 69·42; whence, 22·15 : 69·42 : : 2·00 : 6·68, hydrogen = 1·00; or 276·44 : 866·33 : : 2·00 : 6·268 oxygen = 100.

Admitting the value of the new method in testing neutral carbonates, it can not be directly applied to the mixed carbonate and bicarbonate of soda, so commonly sold in this country for bicarbonate; nor is it applicable to the case of a mixture of caustic and carbonated alkali, without the tedious process of previous treatment with carbonate of ammonia and heat.

The new German method of *acidimetry* consists in determining how much carbonic acid gas is disengaged from a standard bicarbonate of soda, by a given weight of any acid. The twin-flask apparatus (*fig.* 187) is used. The weighed portion of acid is put into A, and a sufficient quantity of the soda into a test-tube, which is suspended upright with a silk thread fastened by the pressure of the cork to the mouth of the flask. On letting the thread loose, the test-tube falls, and the cork being instantly replaced, the whole gas evolved is forced to pass through the sulphuric acid in B, and there to deposite its moisture. The experiment is conducted in other respects as already described for alkalimetry.

The following extract from Drs. Fresenius and Will's *New Methods of Alkalimetry*, &c., will show the Giessen plan of calculating results:—

"The amount of anhydrous acid contained in the hydrated acid under examination is determined from the amount of carbonic acid escaped, as follows:—

"Two measures of carbonic acid bear the same proportion to one measure of the anhydrous acid in question, as the amount of carbonic acid expelled does to the amount sought of anhydrous acid. Thus, let us suppose, for instance, we have examined dilute sulphuric acid, and obtained 1·5 grammes of carbonic acid, the arrangement would be:—

$$550\ (2 \times 275) : 501 = 1{\cdot}5 : x$$
$$x = 1{\cdot}36.$$

The amount of sulphuric acid operated upon consequently would contain 1·36 grammes of anhydrous acid. Let us suppose the weight of this amount to have been 15 grammes, the sulphuric acid under examination would contain a per-centage amount of 9·06; for

$$15 : 1{\cdot}36 = 100 : x$$
$$x = 9{\cdot}06.\text{"*}$$

"SECTION XXIX. *Stating the Quantities of the various Acids to be used in their Examination.*—To enable our readers at once, without the trouble of calculation, to determine from the weight of carbonic acid expelled, the exact amount of anhydrous acid contained in those acids which are of most frequent occurrence, we have subjoined lists of certain quantities to be taken of each acid for experiment, so that the number of centi-grammes of carbonic acid expelled will directly indicate the per-centage amount of anhydrous acid in the acid under examination.

"Multiples of those weights may of course be substituted for the numbers given, according to the degree of dilution of the acid under examination. In such cases the number of centi-grammes of the carbonic acid expelled must be divided by the same number, which has served as the multiplier.

"These numbers are obtained by dividing the atomic weight of the acid by 550 (2 × 275, one eq. of carbon),† as follows:—

"Two eq. of carbonic acid, corresponding to one eq. of the acid to be examined, how much should be taken of the latter to expel 1·00 grammes of carbonic acid?

"The arrangement of sulphuric acid, for instance, is as follows:—

$$550 : 501 = 1{\cdot}00 : x$$
$$x = 0{\cdot}91 \text{ (or, more correctly, } 0{\cdot}911).$$

"When examining acids, it is most advisable to use that multiple of the unity (according to the degree of concentration) which will expel from one to two grammes of carbonic acid.

"I. SULPHURIC ACID.

"Unity 0·91 grammes (or, more correctly, 0·911 grammes).

"Multiples:—

2 × 0·911 =	1·822	grammes.
3 × 0·911 =	2·733	"
4 × 0·911 =	3·644	"
5 × 0·911 =	4·555	"
6 × 0·911 =	5·466	"
7 × 0·911 =	6·377	"
8 × 0·911 =	7·288	"
9 × 0·911 =	8·199	"
10 × 0·911 =	9·110	"
15 × 0·911 =	13·665	"
20 × 0·911 =	18·220	"
30 × 0·911 =	27·330	" &c.

"Thus, knowing that 0·91 of anhydrous sulphuric acid will expel 1·00 of carbonic acid, it will be easy to determine what multiple ought to be used, according to the degree of concentration of the acid to be examined."‡

III. CHLOROMETRY,

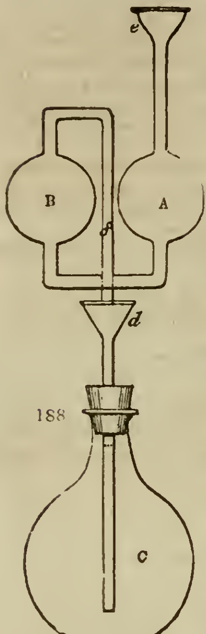
And the testing of Black Oxide of Manganese for its available Oxygen.

The value of manganese may be estimated very exactly by measuring the quantity of chlorine which a given weight of it produces with hydrochloric acid; the chlorine being at the same time estimated by the quantity of solution of green sulphate of iron, which it will peroxidize. A process of this kind was long ago practised with chloride of lime (bleaching powder or liquor) by Dr. Dalton; and it has been since improved by Mr. Waltercrum. As the conversion of two atoms of green sulphate of iron into red sulphate requires only one atom of oxygen, this change may be effected by the reaction of one atom of chlorine in liberating one atom of oxygen, while this appropriates one of hydrogen from the hydrochloric acid.

* *New Methods of Alkalimetry, &c.*, pp. 93, 94.
† A typographical error in Mr. Bullock's edition; it should be *carbonic acid.*
‡ *New Methods of Alkalimetry, &c.*, pp. 103–105.

The weight of 2 atoms of green sulphate of iron is 278 = (139 × 2), consisting of 2 atoms of protoxide = 72, × 2 of sulphuric acid = 80, × 14 of water = 126; in all = 278; and this weight is equivalent to 36 of chlorine, to 8 of oxygen, and to 44 of peroxide of manganese.* Therefore, if we take a solution of copperas, containing 278 grains in 1,000 water grain measures, that volume of liquid will represent, by the conversion of its protoxide into peroxide, exactly one atom, either of peroxide of manganese = 44 grains, or 1 atom of chlorine = 36. Hence the following plan of research :—

Into the flask or phial C of my chlorometric apparatus (*fig.* 188), put 100 grains of the manganese to be tested, and into the globes A, B, pour out of an alkalimetrical tube charged with 1,000 grain measures of the above *equivalent* copperas solution, from 200 to 500 grain measures, according to the supposed quality of the manganese; then introduce through the funnel *d*, some hydrochloric acid of known specific gravity (suppose 1·1), containing nearly 20 per cent. of chlorine, also from a charged alkalimetrical tube, and apply gentle heat to the bottom of the flask by placing it in a capsule of water standing over a spirit-lamp. The chlorine evolved will rise up through the tube *f*, which passes merely beyond the cork, and will enter into the solution in B and A, converting it into red sulphate. Have ready some dry paper imbued with solution of red ferrocyanide of potassium (red prussiate of iron). Dip a slip of whalebone into the liquor in the globe A, through the funnel *e* (represented in the figure rather too high above the globe), and touch the paper with its point. As long as it forms a blue spot, some of the iron still exists as black oxide, and the process is to be urged by the addition of a little more hydrochloric acid to the manganese, as long as chlorine gas continues to be disengaged, and while it maintains the level of the liquor in A above that in B. Whenever the liquor, by the reaction of the chlorine, ceases to stain the test-paper blue, more of the solution from the graduated tube must be added till it begins to do so. By the cautious administration of the hydrochloric acid on the one hand, and of the copperas liquor on the other, the term of saturation will be arrived at in a few minutes. The manganese has then produced all the chlorine which it can yield. The number of water grain measures, of the liquor, or degrees of its alkalimeter scale being multiplied by 44, will give a product denoting the per-centage of pure manganese present in the sample; or being multiplied by 36, a product which will denote the quantity of chlorine by weight which 100 grains of it can serve to generate.



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Since one atom of pure manganese (44 grains), in producing 36 grains of chlorine, consumes 2 atoms = 74 grains of hydrochloric acid, the quantity of this acid expended from the graduated tubes, beyond the due proportion of chlorine obtained, will show how much of the acid is unprofitably consumed by foreign substances in the manganese. In fact, every grain of chlorine should, with pyrolusite, be generated by an expenditure of little more than 2 grains of real muriatic acid, or 10 grains weight of the dilute acid, = about 9 grain measures of the graduated tube. Liquid hydrochloric acid of spec. grav. 1·093 contains in 1,000 grain measures exactly 200 grains of real acid. Hence 100 grains of pure pyrosulite should produce about 82 grains of chlorine, and consume about 169 of real muriatic acid = 845 grain measures of liquid acid, spec. grav. 1·093. Instead of taking 100 grains of manganese as the testing dose, 10 or 20 grains may be taken, according to the dimensions of the apparatus and the exactness of the operator.

But if it be wished to obtain direct per-centage of *manganese* by the graduated tubes without the trouble of reduction, then for a dose of 10 grains take a solution of fresh green copperas (free from adhering moisture), containing 632 grains in 10,000 grain measures. Proceed as above directed. If the manganese be a pure peroxide, 10 grains of it

* Berzelius, in the 4th edition of his *Lehrbuch*, rates the atom of the green sulphate of iron (ferrous sulphate) at 129·43, hydrogen = 1, and considers it, after Mitscherlich, to contain only 6 atoms of water. I have ascertained, by the most careful experiments, that it contains 7 atoms of water; and that 139 grains of it, or 138·44 (Berzelius) are equivalent to 1 atom of chlorbarium, and to very nearly 40 grains of peroxide of iron.

This remarkable error has probably arisen from an attempt to measure the proportion of water in the salt from its loss of weight by desiccation. But I have found it impossible by this means to expel more than 6 atoms of water without causing partial decomposition of the salt by disengagement of sulphuric acid. The copperas so dried acquires such an affinity for water, that it absorbs fully one tenth of its weight of moisture from the atmosphere in the course of an hour.

will generate as much chlorine as will peroxidize exactly 1,000 grain measures, or 100 degrees by the test-tube of the copperas solution. But if the manganese contain only 40 or 50 per cent. of peroxide, then 40 or 50 centigrade measures of the said solution will be equivalent to the chlorine evolved from it by the reaction of hydrochloric acid.

If the object is on the other hand to obtain direct indications as to *chlorine*, then a test solution of copperas, containing 772 grains in 10,000 grain measures, will serve to show, by the peroxidizement of each 10 grain measures, or of one degree of the centestimal scale of the test-tube, the reaction of one grain of chlorine available for bleaching, &c., in the chloride of lime or of soda, &c. The test solutions of copperas should be kept in well-corked bottles, containing a little powdered sulphuret of iron at their bottom, which is to be shaken up occasionally in order to preserve the iron in the state of protoxide.

The manganese should always be treated with dilute nitric acid before submitting it to the above-described ordeal; and if it exhibits effervescence, 100 grains of it should be digested with the acid for a sufficient time to dissolve out all the carbonates present, then thrown upon a filter, washed and dried before weighing it for the testing operation. The loss of weight thereby sustained denotes the per-centage of carbonates, and if calcareous it will measure the waste of acid that would ensue from that source alone, in using that manganese for the production of chlorine.

That manganese is most *chlorogenous* which contains no carbonates, the least proportion of oxide of iron, and of sesquioxide of manganese.

The plan of testing manganese with oxalic and sulphuric acids was originally practised by M. Berthier and Dr. Thomson, but is lately modified by Drs. Fresenius and Will, who employ oxalate of potash, as likely to afford more exact results. They prescribe a multiple by 3 of 993 milli-grammes = 2·979 grammes, as the quantity of manganese best adapted to experiment; but this quantity will not be found convenient by ordinary British operators.

I, therefore, take leave to prescribe the following proportions: Into the vessel A of my twin-globe apparatus (*fig.* 185), put 100 grains of the ground manganese under trial, along with 250 grains of oxalate of potash and a little water; poise the whole in the scale of a balance; then, by gentle inclination, cause a little of the strong sulphuric acid to pass from B up into A. The oxygen thereby liberated from the manganese, reacting in its nascent state upon the oxalic acid, will convert it into carbonic acid gas; which, in passing through B, will deposite its moisture before escaping into the air. Whenever the extrication of gas ceases, after such a quantity of oil of vitriol has been introduced into the globe A, as both to complete the decomposition of the oxalic acid and to heat the mixture, withdraw the cork for a moment, to replace the carbonic acid with air, then cool, and weigh the apparatus. The loss of weight, in grains, will denote the per-centage value of the manganese; that is, the proportion per cent. of perfect peroxide in the sample. If the manganese be pure no black powder should remain.

The preceding experiment is founded upon the following principle: One atom of peroxide of manganese = 44, contains one atom of oxygen separable by sulphuric acid, and capable of converting one atom of oxalic acid into two atoms of carbonic acid, also = 44, which fly off; and cause therefore a loss of weight equal to that of the whole peroxide. To one atom of oxalic acid, which consists of three atoms of oxygen, and two of carbon—if one atom of oxygen be added, the sum is obviously four atoms of oxygen and two of carbon = 2 atoms of carbonic acid.

The apparatus (*fig.* 187) of Drs. Fresenius and Will will answer perfectly well for making the same experiment, the manganese being put into A, with about two and a half times its weight of oxalate of potash, and the sulphuric acid being drawn over into the mixture by suction, as above described.

The economy of any sample of manganese in reference to its consumption of acid, in generating a given quantity of chlorine, may be ascertained also by the oxalic acid test: 44 grains of the pure peroxide, with 93 grains of neutral oxalate of potash, and 98 of oil of vitriol disengage 44 grains of carbonic acid, and afford a complete neutral solution; because the one half of the sulphuric acid, = 49 grains, goes to form an atom of sulphate of manganese, and the other half to form an atom of sulphate of potash.

The deficiency in the weight of carbonic acid thrown off will show the deficiency of peroxide of manganese; the quantity of free sulphuric acid may be measured by a test solution of bicarbonate of potash, and the quantity neutralized, compared to the carbonic gas produced, will show, by the ratio of 98 to 44, the amount of acid unprofitably consumed.

In *fig*. 183, the tube, D, may also be graduated, and may contain the quantity of acid, for the purpose either of alkalimetry or acidimetry; and if the lower orifice be capillary, it will allow none of its contents to flow out, till the stopcock in the top orifice is opened.

In *fig*. 184, such a tube as D (*fig*. 183) may be substituted with advantage for the funnel, B; and as that tube, D, may be made of such dimensions as to contain enough of acid to supersaturate the bases of the carbonates in the phial, A, there will be no necessity for a separate vessel to hold the decomposing acid. Thus the apparatus becomes very light, convenient, and may be placed in the small scale of a fine balance; whereas the twin matrasses of Drs. Fresenius and Will (*fig*. 187), as furnished by Mr. Bullock, require a very large pan or scale to stand in. I flatter myself that the instrument, *fig*. 184, so mounted, will be found an acceptable present to practical chemists, and that it will enable them readily to examine, not only carbonates, but also manganese and bleaching substances, with great precision, by the weight of carbonic acid gas disengaged, on the principles above explained.

Into the twin globe apparatus (*fig*. 185), after the sulphuric acid is poured into B, a little water should be poured into C, before the carbonate is introduced into the latter. By this means, the capillary throat of the tube under A will not be apt to get choked with concrete salt.

The following quotations are from the work of Drs. Fresenius and Will, as edited by Mr. Bullock for the English reader. An accurate comparison may thus be made between the relative utility of their methods and mine to the practice of ordinary operators:—

"SECTION XXXIV. *Examination of Manganese: having at the same time due regard to the amount of Acid required for its complete Decomposition.*—We have stated, at Section 30, that it is not a matter of indifference, with regard to the amount of acid employed in the production of chlorine from manganese, what are the minerals which this substance contains in admixture with the peroxide. The following modification of our method will give the most correct information on this point:—

"Sulphuric acid of commerce is taken, and its amount of anhydrous acid determined, as directed at Section 26, or by means of an accurate hydrometer. Of this sulphuric acid as much is weighed into A (*fig*. 187), as to give an amount of 5·47 grammes of anhydrous acid.

"The following table will show the amount which ought to be taken, according to the various degree of concentration of the acid:—

Specific weight found.	Per-centage amount of anhydrous acid found.	Amount to be used for the examination.	Specific weight found.	Per-centage amount of anhydrous acid found.	Amount to be used for the examination.
1·8485	81·54	6·708	1·8336	76·65	7·136
1·8480	81·13	6·742	1·8313	76·24	7·174
1·8475	80·72	6·776	1·8290	75·83	7·213
1·8467	80·31	6·811	1·8261	75·42	7·252
1·8460	79·90	6·846	1·8233	75·02	7·291
1·8449	79·49	6·881	1·8206	74·61	7·331
1·8439	79·09	6·916	1·8179	74·20	7·371
1·8424	78·68	6·951	1·8147	73·79	7·412
1·8410	78·28	6·987	1·8115	73·39	7·453
1·8393	77·84	7·027	1·8079	72·97	7·495
1·8376	77·40	7·067	1·8043	72·57	7·537
1·8356	77·02	7·101			

"As much water is then poured into A as will fill the flask to about one fourth; and, lastly, from 6·5 to 7 grammes of neutral oxalate of potash, or from 5·5 to 6 grammes of neutral oxalate of soda, are added; 2·98 grammes of the (finely-pounded) manganese to be examined are then weighed (the manganese must have been previously tested for carbonate alkaline earths: compare this section at the end) into a small glass tube, such as used in acidimetry, and described in Section 25. About the same quantity of pure pyrolusite,* in powder, is then put into another similar tube. The tube, with the manganese to be examined, is then suspended in A (*fig*. 187), as described at Section 26, and the apparatus prepared, as directed at Section 3. The

* "Any variety of pyrolusite will serve this purpose, provided it be free from other manganese ores. If it contains heavy spar, it may be employed directly; but should it contain alumina or lime, it must be treated first with dilute nitric acid, at a gentle heat, until all soluble parts have been dissolved; it is then washed and dried. Artificially prepared, hydrated peroxide of manganese may be substituted for pyrolusite."

apparatus is then placed on one scale of a balance, together with the other little tube containing the pyrosulite, and exactly weighed.

"The cork of A is then somewhat raised to allow the little tube with the manganese to fall into the flask. The evolution of carbonic acid commences immediately, and continues until all the manganese is decomposed. When the operation begins to get on more slowly, the flask, A, is placed in boiling water, and allowed to remain there until no more bubbles appear. The little wax-stopper is then removed* from *a*, the flask, A, taken out of the hot water, and suction applied to *d*, until the sucked air tastes no longer of carbonic acid. The apparatus, after having been allowed to cool, is wiped dry, and replaced in the original scale, where the little tube with the pyrolusite still remains; weights are then substituted for the loss of carbonic acid. The number of centigrammes required, divided by three, directly indicates the per-centage amount of peroxide of manganese (*vide* Section 32). The centigrammes substituted for the loss of carbonic acid are then removed from the balance, and the little tube with the pyrosulite is thrown into A. (The little wax-stopper must of course previously be replaced on *a*). If no fresh evolution of carbonic acid takes place, the manganese examined consists of pure pyrosulite, and the experiment is at an end. But should a fresh evolution of carbonic acid take place, the operation must be further conducted, and brought to a close, exactly as just stated (*vide suprà*). The apparatus is then replaced on the balance, with an additional weight of three grammes on the same scale. If this is sufficient to restore a perfect equilibrium, no loss of acid has taken place; the manganese, indeed, contains other matters in admixture, but only such as do not consume any acid. But if the scale with the apparatus sinks, this is a certain sign that a portion of the acid has been lost by combining with the oxides which the manganese under examination contains. The number of centigrammes required to restore the perfect equilibrium of the balance, multiplied by 0·6114, immediately indicates how much anhydrous sulphuric acid has been wasted in the decomposition of 100 parts of the manganese under examination. The same number, multiplied by 0·333, indicates the amount of acid wasted in every 100 parts of sulphuric acid employed for the decomposition of the manganese in question. The same number, multiplied by 0·5552, indicate how much anhydrous hydrochloric acid would be wasted in the decomposition of 100 parts of the manganese. The same number, multiplied by 0·333, indicates also how much acid would be wasted in every 100 parts of hydrochloric acid employed for the decomposition of the manganese.

"These figures result from the following equations:—

"I. 275 (eq. of carbonic acid) : 501 (eq. of sulphuric acid) = the carbonic acid obtained *minus* (in proportion to the sulphuric acid used) : x.

$$x = \text{this carbonic acid} \times \tfrac{501}{275},\ i.\ e.\ \times 1{\cdot}822.$$

Thus, the number obtained for x indicates the amount of sulphuric acid corresponding to the amount of carbonic acid obtained *minus*.

"II. 2·98 of manganese: 100 = x of equation I. : x.

$$x = x \text{ of I.} \times \tfrac{100}{298},\ i.\ e.\ \times 0{\cdot}33557.$$

"The x of the first equation tells us how much sulphuric acid has been wasted without contributing to the decomposition of 2·98 grammes of the manganese; the x of the second equation tells us the same for 100 parts of manganese.

"If, therefore, the amount of carbonic acid obtained *minus* be directly multiplied by the product of the quotients of I. and II.,

1·822 and 0·33557,

i. e. with 0·61141 (the number given above), the amount of anhydrous sulphuric acid wasted in the decomposition of every 100 parts of manganese will immediately be found.

"III. 5·47 (the amount of sulphuric acid used):

100 = the x of I. : x.

$$x = \text{the } x \text{ of I.} \times \tfrac{100}{547},\ i.\ e.\ \times 0{\cdot}18282.$$

"Of 5·47 of sulphuric acid, the x of I. has been wasted, 100 corresponds to the x of III.

"The x of III. is, therefore, found directly by multiplying the amount of carbonic acid obtained *minus* with the product of the quotients, 1·822 and 0·18282, *i. e.* = 0·33301.

"The figures for hydrochloric acid are found in the same manner (4·967 of hydrochloric acid must be taken instead of 5·47 of the sulphuric acid)."†

* "This must of necessity be done while the flask is still standing in the hot water, or else the sulphuric acid will recede upon the apparatus being removed from the hot water."

† *New Methods of Alkalimetry, and of determining the Commercial Value of Acids and Manganese.* By Drs. C. R. Fresenius and H Will. Edited by J. Lloyd Bullock; pp. 123–128.

ARTESIAN WELLS. *Fig.* 189, is that referred to in the foot-note of page 10.

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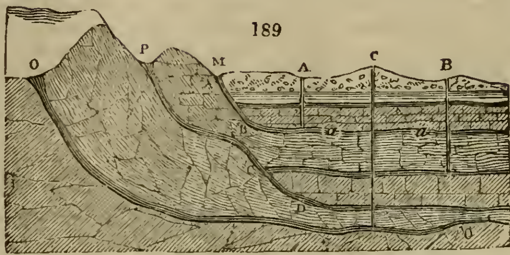

BEER. A gentleman well acquainted with the brewing of porter in London has favored me with the following information.

Essentia bina has been discontinued by the London porter brewers since the employment of black malt, which is prepared by roasting in such a cylinder as coffee is usually roasted in over a fire. A peculiar flavor has sometimes been imparted by using roasted barley instead of malt. The usual quantity of yeast employed in the London porter breweries is from 5 to 7 tenths per cent. The grist, as it is technically termed, or charge for a mash-tun, is composed of from $\frac{2}{3}$ to $\frac{4}{5}$ pale malt, and the rest of high dried malt, of which about from $\frac{1}{15}$ to $\frac{1}{25}$ black. The oil of birch bark is not used by any respectable brewers in this country. The proportion of hops for double stout is seldom more than 15 pounds to the 8 bushels of malt.

FLAX. The new roving machine, called by the ingenious inventor, Mr. W. K. Westley, of Leeds, the Sliver Roving Frame, seems to be a *philosophical induction* happily drawn from the nature of the material itself, and accommodated to its peculiar constitution. It is remarkable for the simplicity of its construction, and, at the same time, for its comprehensiveness; requiring no nicety of adjustment in its application, and no tedious apprenticeship to be able to work it.

It is known, that the glutinous matter of the plant may be softened by water, and hardened again by heat; of this fact advantage is taken, in order to produce a roving wholly without twist; that is, in the form of a riband or sliver, in which the fibres are held together by the glutinous matter which may be natural to them; or which may, for that purpose, be artificially applied. The sliver roving, as long as it remains dry, possesses all requisite tenacity, and freely unwinds from the bobbin, but on becoming again wetted in the spinning frame, it readily admits, with a slight force, of being drawn into yarn, preserving the fibres quite parallel.

The diagram, *fig.* 190, shows in explanation, that

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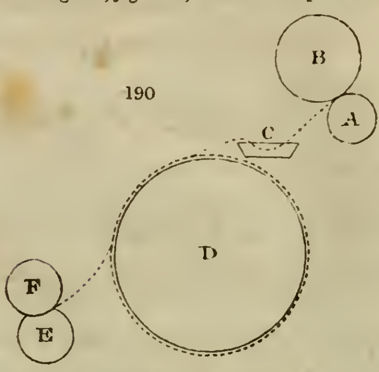

A, is the drawing roller of the roving frame in front of the usual comb.

B, the pressing drawing roller.

C, a shallow trough of water.

D, a cylinder heated by steam.

E, a plain iron roller for winding.

F, a bobbin lying loose upon the winding roller, and revolving upon it, by the friction of its own weight.

The roving, or sliver, as shown by the dotted line, after leaving the drawing rollers A B, passes through the water, in the trough C, which softens the gluten of the fibres; and then it is carried round by the steam cylinder D, which dries it, and delivers it hard and tenacious to the bobbin F, on which it is wound by the action of the roller E.

This is the whole of the mechanism required in producing the sliver roving. All the complex arrangements of the common cone roving are superseded, and the machine at once becomes incomparably more durable, and easier to manage; requiring only half the motive power, and occupying only half the room. A frame of 48 bobbins is only 6 feet long, and affords rovings sufficient to supply 1,200 spinning spindles.

The machine is very general in its application, being equally well adapted for heavy as for fine rovings.

In making a roving in the usual way, the twist, in addition to other circumstances, sets a limit to the degree to which a materal of a given fineness may be roved; because the quantity of twist required to give a roving the necessary cohesion, increases in proportion as the number of fibres composing that roving diminishes, till it accumulates to such a degree, that the fibres are prevented from drawing regularly, or, if drawn, are broken and scattered by the violence of the action. It is impossible, therefore, to make a light roving, good for anything, out of a coarse material; but in the sliver roving, there is no difficulty in making a roving of almost any fineness, with little reference to the quality of the material employed, because, while one fibre can be glued to another by any portion of its extremity, a roving may be made.

It becomes easy, with a sliver roving, to use a double or triple roving on the spinning frame. The great advantage of this practice has long been well known, and acted upon, in the spinning of cotton; but in that of flax, it has hitherto been unattainable: yet the vast benefit to be expected, from doubling on the spinning frame all the equalization of the previous preparation, is too self-evident to be insisted upon.

The sliver roving, made however fine, is perfectly solid, tenacious, and compact; no fibres in it, when once laid straight, can afterward be ruffled or disturbed; and, as they are placed in the yarn in the exact position in which they leave the combs, being kept straight without any ruffling or tangling from twist, the inelastic nature of the material is not injured, and the yarn acquires a superior lustre, roundness, and strength.

The sliver roving is drawn with less force than the twisted roving, and is therefore less liable to make *snarls* in the yarn; while it has another advantage arising from the absence of twist. The fibres of flax and tow being various in length, a uniform twist upon them will naturally retain the longer fibres more effectually than the shorter ones, which will hence have a tendency to run into thick places in the yarn. From this inconvenience the sliver roving is completely free.

In the spinning frame, there is also a benefit derived from the bruising action of the detaining roller: the pressure is supposed to split the fibres laterally, and thereby make them finer, in the same way as a board would be split by being passed through iron rollers, under a pressure; but it is evident that in a twisted roving a portion of each fibre must escape this action, by winding round the body of the roving, and, consequently, the fibres can be but partially split. By this circumstance, in addition to the direct loss of benefit, a new and serious evil is created; a fibre split has always, in the split portion, one end longer than another, and the longest end, of course, arrives first at the drawing rollers. Now, if the fibre be only partially split; if that portion whose end arrives first be not wholly separated from the rest of the fibre; it follows, that when the longer end is seized by the drawing rollers, the shorter end will be drawn into a knot, or thickening; because its fore end is still held back by the adhesion of its contiguous fibres, while its back end is drawn forward, by being still attached to its original fibre. In the sliver roving, the fibres, being perfectly straight and parallel, are exposed to the bruising of the rollers equally, and are split uniformly and entirely from end to end.

The sliver roving, being so much simpler in construction than any other, is capable of running quicker; but if running only at the same speed, it will produce from 25 to 30 per cent. more work, because it is never stopped in order to be doffed. The bobbins are so placed, that the attendant has only to remove a filled bobbin, and replace it with an empty one, without the slightest interruption to the progress of the machine. Owing to this circumstance, the attendant is provided with an easy and uniform employment for her time, instead of occasionally doing nothing, and again hurrying through the labor of doffing; and the work also, being simpler, may be performed by cheaper hands.

It must be noted that doffing is of frequent occurrence, especially in heavy numbers, and occupies much time where one person has to doff a great many spindles, and it is often inconvenient, where other hands are called from their work to assist: but it is not only in doffing that time is lost; it is in wiping, picking, and oiling the numerous flyers and spindles carefully, and which should not be hurried; and, moreover, when the machine requires thorough cleaning, the complication of its mechanism materially increases the loss of time as well as expense; so that the saving effected by not stopping the frame to doff becomes very considerable, and soon repays the whole cost of the machine.

Each bobbin has in fact its own regulating motion, independent of the rest; and this is at all times correct, without requiring any fresh adjustment or adaptation to different thicknesses of roving, enabling the spinner to rove at the same time, on the same frame, as many sorts or thicknesses of roving as there are bobbins in a frame; whereas on the common machine he is compelled to rove but one sort or thickness at a time; and whenever he alters the sort, the mechanism requires a fresh adjustment, involving the chances of error, and attended with loss of time and waste of material.

THE END.

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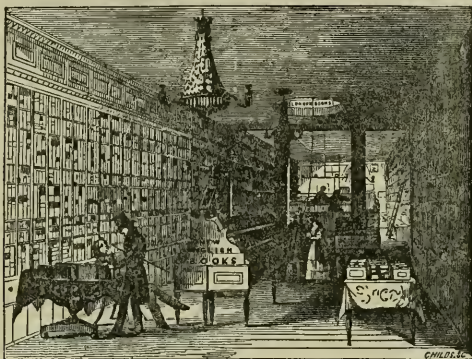

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