piece, or at the back of the folding doors. When the edges are finished, the paper is to be cut into lengths, about ½ an inch longer than the height of the room; but they must be cut so that the second will match the first, and so on. There are certain dots or marks on the edges which show where the match is, and if the length required comes between these dots, the portion down to the next dot must be cut off after each length, which will bring the match the same as where it started in the first length. Care should be taken to cut straight across, and as many lengths may be cut as will be sufficient for two sides of the room. These are to be turned altogether the plain side uppermost, and the first one may be pasted. If the paper is thin and common, it must be put on the wall immediately; but if of good quality, it is to be left to soak for two or three minutes, while for a stiff glazed or flock paper, from five to eight minutes would not be too much. The reason is, to give time for both sides to become equally damp, otherwise there is no certainty that the paper will stick. The first length is to be put up with the close-cut edge close to the woodwork round the window. Having brought the top to meet the ceiling, see that the length hangs straight, trying it if necessary by a plumb-line, then taking it by the lower end, lift it away from the wall all but about 3 inches at the top, then let it fall, and it will drop into its place without a wrinkle. Now with a soft clean cloth begin at the top and press the paper to the wall all down the centre to the bottom, then beginning from the top again, press it from the centre to each side alternately, regularly downwards. If this operation be properly done, the length will be perfectly close to the wall and smooth in every part. It is not to be pressed heavily; but the cloth being taken in the hand as a round loose lump, must be moved quickly over the surface—dab—dab—dab—with a light and clean touch, otherwise some of the colours will be apt to smear. Last of all, mark with the end of the scissors where the paper meets the skirting, cut off all that is over, and press the end carefully into its place. Proceed with the second length in the same way, bringing the close-cut edge to meet the pattern of the first one, and taking care that no gap is left between. Neglect of these precautions will convert a handsome paper into a sight that will be a constant eyesore. Try the lengths frequently with the plumb-line to avoid the chance of getting out of upright, and remember that the outside end of the piece is always the top of the paper. *Paste* is best made with old flour, water, and a little size or glue; alum is also added to paste to make it spread more freely without losing any of its tenacity or sticking quality; it should never be used while warm. The paste should be rather thicker than ordinary gruel, and laid on smoothly and equally, not putting too much, or it will squeeze out at the edges. Where this takes place, it must be removed with a clean damp sponge: any accidental smears of paste may be removed in this way, if taken off lightly as soon as they are made. Decorative paper for covering the walls of rooms is manufactured in *pieces*, which are 12 yards long and 20 inches wide.

Pavements.—Asphalte pavements made with Val de Travers compressed asphalte are laid as follows. A foundation is formed of cement or lime concrete, varying from 6 inches to 9 inches in thickness, according to the traffic. The mineral rock in its natural state, and without admixture with other ingredients, after being broken into small lumps is brought to a state of dry powder by subjecting it to considerable heat in revolving ovens; it is then put into iron carts with close-fitting covers, and brought on to the works, taken out, laid over the surface, and whilst hot compressed with heated irons into one homogeneous mass without joints. The finished thickness varies from 2 to 2½ inches, according to the traffic of the place in which it is laid, and it further compresses and consolidates under the traffic. Val de Travers liquid asphalte is laid upon a concrete bed 6 inches thick, the asphalte surface being 1½ inch thick. The rock is first ground to a fine powder, and being then placed in caldrons, from 5 to 7 per cent. of bitumen is added to solve it; heat being then applied, it forms into a semi-fluid or mastic state, and when in that condition about 60 per cent. of grit or dry shingle is added to it, and after being thoroughly mixed together, the compound is spread over the concrete in one thickness. With *Limmer asphalte*, a concrete foundation 9 inches thick is first formed, and the asphalte is used in certain proportions by the judgment of those directing the work; it is broken up and mixed with clean grit or sand of different sizes according to the place in which the pavement is to be laid; a small quantity of bitumen is then added to the materials, which are placed in caldrons on the spot, made liquid by heat, and the compound is run over the surface and smoothed with irons to the proper slopes and curvatures. It is run in two thicknesses, the lower stratum being made with grit of a larger size than that of the upper. The total thickness of the asphalte, when finished, is from 1½ to 2 inches.

Barnett's Liquid Iron Asphalte can be made either of natural or artificial asphalte, mixed with pulverized iron ore or sesquioxide of iron and a small proportion of mineral tar. The materials are put into a caldron which is brought on to the works, and are made into a liquid state by heat, run over the surface, and smoothed in the same way as the other liquid asphaltes mentioned; the thickness usually laid is about 2 inches.

Tar Pavement.—Made by mixing with fine breeze, or small coke, just enough of thick refuse coal-tar to make it somewhat sticky; put a thin layer on the smooth and hardened surface, on this spread a couple of inches of metal, or pebbles, or coarse gravel, then a thin layer of the prepared breeze, covered lightly with fine gravel, and beat or press together. It is cheap, slightly elastic, and durable.

Concrete Pavements.—1. The terraza floors used in Italy at the present day are made in the following manner:—1st coat; a concrete consisting of common lime ¼, sand and fine gravel ¾, laid 6 inches thick and well beaten with wooden rammers; after two days in that climate, it is sufficiently dry for the next coat. 2nd coat; a terraza, consisting of pounded brick or tile ⅛, common lime ⅜, sand ⅜, of the consistency of mortar, laid 1¼ inch thick, well beaten with a light flat rammer. After two or three days it is hard enough for the next coat. 3rd coat; a similar terraza, but with the grit of broken stones instead of sand in it, laid on like a coat of plaster with a trowel. After this has been laid for one day, a layer of small hard broken stones is pressed into it; these stones should be of some substance that will take a polish, and be of uniform size (they are passed through a gravel screen) of about a walnut; these being afterwards rubbed to a smooth even surface with some smooth hard stone, form a kind of mosaic-work; the stones are frequently selected by colour, and laid in the third coat to a rough pattern. They should be moistened with oil or water till hard set. 2. Dig the earth out about 8 inches, fill in with coarse gravel and stones, well rammed, and levelled about 5 inches. Mix Portland cement to the consistence of cream and pour over, spreading it with a stiff broom; when hard mix finer gravel with cement and water, and fill up to within ¾ inch of the surface; when hard mix clean sharp sand and Portland cement, half-and-half, with water to about the thickness of mortar, and finish, slightly rounding. It should not be walked on for a day or two. Cement must be Portland, and fresh.

Lathing and Plastering.—The plaster used for covering the walls of buildings is a mortar composed of lime or cement, and sand, mixed in various proportions, generally with a little hair or some such material to give it elasticity. It is laid on by hand with a trowel in several thicknesses of about ⅛ to ¼ inch each, and either on the bare masonry wall or on a special screen of *lathing* made for it, to either of which it adheres by entering into and keying itself in the joints and openings, and by its adhesive quality. With some variations in the materials and mixing, it is used for exterior and interior work and for ceilings. For the purpose of assisting to keep the interior of the rooms of a house dry, it is advantageous to employ lathing, which being detached from the masonry of the walls forms a lining, distinct in itself, and not liable to the effect of moisture which may be in the walls. It is of the utmost importance, in plasterers' work, that the lime should be most thoroughly slaked, or the consequence will be blisters thrown out upon the work after it is finished. Many plasterers keep their stuffs a considerable period before they are wanted to be used in the building, by which the chance of blistering is much lessened. When a wall is to be plastered, it is called rendering; in other cases the first operation, as in ceilings, partitions, &c., is

Lathing, nailing the laths to the joists, quarters, or battens. If the laths are of oak, wrought-iron nails must be used for nailing them, but cast-iron nails may be employed if the laths are of fir. The lath is made in 3 or 4 foot lengths, and, according to its thickness, is called single, something less than a ¼ of an inch thick, lath and half, or double. The first is the thinnest and cheapest, the second is about one-third thicker than the single lath, and the double lath is twice the thickness. When the plasterer laths ceilings, both lengths of laths should be used, by which, in nailing, he will have the opportunity of breaking the joints, which will not only help in improving the general key (or plastering insinuated behind the lath, which spreads there beyond the distance that the laths are apart), but will strengthen the ceiling generally. The thinnest laths may be used in partitions, because in a vertical position the strain of the plaster upon them is not so great; but for ceilings the strongest laths should be employed. In lathing, the ends of the laths should not be lapped upon each other where they terminate upon a quarter or batten, which is often done to save a row of nails and the trouble of cutting them, for such a practice leaves only a ¼ of an inch for the thickness of the plaster; and if the laths are very crooked, which is frequently the case, sufficient space will not be left to straighten the plaster.

Laying.—After lathing, the next operation is laying, commonly called plastering. It is the first coat on laths, when the plaster has two coats or set work, and is not scratched with the scratcher, but the surface is roughed by sweeping it with a broom. On brickwork it is also the first coat, and is called rendering. The mere laying or rendering is the most economical sort of plastering, and does for inferior rooms or cottages. What is called pricking up is the first coat of three-coat work upon laths. The material used for it is

Coarse Stuff, being only the preparation for a more perfect kind of work. Coarse stuff is made with chalk-lime prepared as for common mortar, but slaked with a quantity of water, afterwards evaporated, mixed with an equal quantity of clean, sharp sand and ox-hair, at the rate of 1 lb. of hair to 3 cub. feet of stuff. After the coat is laid on, it is scored in diagonal directions with a scratcher (the end of a lath), to give it a key or tie for the coat that is to follow it.

Lath layed or *plastered and set* is only two-coat work, as mentioned under laying, the setting being the gauge or mixture of putty and plaster, or, in common work, of

Fine Stuff, with which, when very dry, a little sand is used. Fine stuff is a mortar made of fine white lime exceedingly well slaked with water, or rather formed into a paste in water to make the slaking complete: for some purposes a small quantity of hair is mixed up with it. Fine stuff very carefully prepared, and so completely macerated as to be held in solution in water, which is allowed to evaporate till it is of sufficient consistence for working, is called putty, plasterers' putty.

Setting may be either a second coat upon laying or rendering, or a third coat upon *floating*, which will be hereafter described. The term finishing is applied to the third coat when of stucco, but setting for paper. The setting is spread with the smoothing trowel, which the workman uses with his right hand, while in his left he uses a large flat-formed brush of hog's bristles. As he lays on the putty or set with the trowel, he draws the brush, full of water, backwards and forwards over its surface, thus producing a tolerably fair face for the work.

Floating.—Work which consists of three coats is called floated: it takes its name from an instrument called a float, which is an implement or rule moved in every direction on the plaster while it is soft, for giving a perfectly plane surface to the second coat of work. Floats are of three sorts: the hand float, which is a short rule that a man by himself may use; the quirk float, which is used on or in angles; and the Derby, which is of such a length as to require two men to use it.

Plaster, float and set is the term for three coats of plaster on laths. The first or pricking-up coat is of coarse stuff put on with a trowel to form a key behind the laths, and about ¼ or ⅜ inch thick on the laths: while it is still moist it is scratched or scored all over with the end of a lath in parallel lines 3 or 4 inches apart, the scorings being made as deep as possible without exposing the laths; the rougher the edges are the better, as the object is to produce a good key for the next coat. When the pricking-up coat is sufficiently dry not to yield to pressure in the slightest degree, the second coat or floating is put on. The floating is of fine stuff with a little hair mixed with it; ledges or margins, 6 or 8 inches wide, and extending across the whole width of a ceiling or height of a wall, are made at the angles and at intervals of about 4 feet apart throughout: these must be made perfectly in one plane with each other with the help of straight-edges. These ledges are technically called screeds. They form gauges for the rest of the work, and when they are a little set the spaces between them are filled up flush, for which a Derby float or a long straight-edge is used. The screeds on ceilings ought to be levelled, and those on the walls plumbed. When the floating is sufficiently set it is swept with a birch broom for the third coat or setting. The third, or setting coat, should be of plasterers' putty if the ceiling or wall is to be whitened or coloured. If it is to be papered, the third coat should be of fine stuff, with a little hair in it. If it is to be painted, the third coat should be of bastard stucco trowelled.

Bastard stucco is of three coats, the first is roughing in or rendering, the second is floating, as in trowelled stucco; but the finishing coat contains a small quantity of hair behind the sand. This work is not hand-floated, and the trowelling is done with less labour than what is termed trowelled stucco.

Trowelled stucco, which is the best sort of plastering for the reception of paint, is formed on a floated coat of work, and such floating should be as dry as possible before the stucco is applied. In the last process, the plasterer uses the hand float, which is made of a piece of half-inch deal, about 9 inches long and 3 inches wide, planed smooth, with its lower edges a little rounded off, and having a handle on the upper surface. The ground to be stuccoed being made as smooth as possible, the stucco is spread upon it to the extent of 4 or 5 feet square, and moistening it continually with a brush as he proceeds, the workman trowels its surface with the float, alternately sprinkling and rubbing the face of the stucco, till the whole is reduced to a fine even surface. Thus, by small portions at a time, he proceeds till the whole is completed. The water applied to it has the effect of hardening the face of the stucco, which, when finished, becomes as smooth as glass.

Ceilings are set in two different ways; that is the best wherein the setting coat is composed of plaster and putty, commonly called gauge. Common ceilings are formed with plaster without hair, as in the finishing coat for walls set for paper

Pugging is plaster laid on boards, fitted in between the joists of the floor to prevent the passage of sound between two stories, and is executed with coarse stuff. In the country, for the interior coating of dwellings and outbuildings, a species of plastering is used called roughcast. It is cheaper than stucco or Parker's cement, and therefore suitable to such purposes. In the process of executing it, the wall is first pricked up with a coat of lime and hair, on which, when tolerably well set, a second coat is laid on of the same materials as the first, both as smooth as possible. As fast as the workman finishes this surface, another follows him with a pailful of the roughcast, with which he bespatters the new plastering, so that the whole dries together. The roughcast is a composition of small gravel, finely washed, to free it from all earthy particles, and mixed with pure lime and water in a state of semi-fluid consistency. It is thrown from the pail upon the wall, with a wooden float, about 5 or 6 inches long, and as many wide, formed of ½-inch deal, and fitted with a round deal handle. With this tool the plasterer throws on the roughcast with his right hand, while in his left he holds a common whitewashers' brush dipped in the roughcast, with which he brushes and colours the mortar and the roughcast already spread, to give them, when finished, a uniform colour and appearance.

Builders' Waterproof Mastic Cement.—1. 5 parts river sand; 5, ground stone lime; 10, red-lead, in powder. 2. 10, sand; 5, powdered whiting; 1, powdered red-lead. 3. 100, sand; 25, plaster of Paris; 10, red-lead; 5, yellow ochre, all in powder. Each of these cements must be mixed with boiled oil.

Concrete for Foundations.—5 parts gravel and sand to 1 part fresh-burned stone lime, ground to powder, without slaking, and measured dry. Well turn and shovel together, with sufficient water to slack the lime into the state of very thick mortar. Chips and small pieces of stone may be added with advantage.

CONCRETE FOR MASONRY.—1. Screened sand, 9 parts by measure; slaked lime, 7; forge ashes, 1; puzzolana, 1. 2. 1, slaked lime; 1, sea sand; ½, furnace ashes.

CONCRETE FOR BRICKWORK.—Slaked lime, 7 parts by measure; sand, 12 parts.

Hydraulic Mortars.—1. 2½ parts burnt clay; 1 part blue lias lime, pulverized and ground together between rollers. Use immediately 2. 2 parts fresh stone lime; 3, wood ashes, mixed as for common mortar, but must lie until cold and be beaten several times before being used. 3. 4 parts blue lias lime. 6, river sand; 1, puzzolana; 1, calcined ironstone.

BUILDERS' MORTAR.—1. 3 parts by measure of good sharp sand to 2 parts grey stone lime, mixed with water, or 2 of sand to 1 chalk lime. Sharp road scrapings may be used instead of sand; and where taken from roads kept in order with flint or gravel, form a very good mortar. 2. 1 part grey stone lime to 3 river-sand coarse mortar. 3. 1, stone lime; 4, coarse gravelly sand. 4. 1, lime; 2, river sand; 1, blacksmiths' ashes. 5. 1, lime; 2, sand; 1, rough ground coke.

Composition for Picture Frames.—1. To make compo ornaments for picture frames: Boil 7 lbs. of the best glue in 7 half-pints of water, melt 3 lbs. of white resin in 3 pints of raw linseed oil; when the ingredients are well boiled put them into a large vessel and simmer them for half an hour, stirring the mixture and taking care that it does not boil over. When this is done, pour the mixture into a large quantity of whiting, previously rolled and sifted very fine, mix it to the consistence of dough, and it is ready for use. 2. Dissolve 1 lb. of glue in 1 gall. of water; in another kettle boil together 2 lbs of resin, 1 gill of Venice turpentine, and 1 pint of linseed oil; mix altogether in one kettle, and continue to boil and stir them together till the water has evaporated from the other ingredients; then add finely-pulverized whiting till the mass is brought to the consistence of soft putty. This composition will be hard when cold, but being warmed, it may be moulded to any shape by carved stamps or prints, and the moulded figures will soon become dry and hard,' and will retain their shape and form permanently.

Firework Making.—The three prime materials of the art of pyrotechny are nitre, sulphur, and charcoal, along with filings of iron, steel, copper, zinc, and resin, camphor, lycopodium, &c. Gunpowder is used either in grain, half crushed or finely ground, for different purposes. The longer the iron filings, the brighter red and white sparks they give; those being preferred which are made with a coarse file and quite free from rust. Steel filings and cast-iron borings contain carbon, and afford a very brilliant fire, with wavy radiations. Copper filings give a greenish tint to flame; those of zinc, a fine blue colour; the sulphuret of antimony gives a less greenish blue than zinc, but with much smoke; amber affords a yellow fire as well as colophony and common salt, but the last must be very dry. Lampblack produces a very red colour with gunpowder, and a pink with nitre in excess. It serves for making golden showers. The yellow sand, or glistening mica, communicates to fireworks golden radiations. Verdigris imparts a pale green; sulphate of copper and sal ammoniac, a palm-tree green. Camphor yields a very white flame and aromatic fumes, which mask the bad smell of other substances. Benzoin and storax are used also on account of their agreeable odour. Lycopodium burns with a rose colour and a magnificent flame.

Iron tools must never be used in making fireworks of any kind, as they are liable to throw out sparks when striking against a hard stony substance, besides which the sulphur used would injure the iron. Brass tools may be used, but copper tools are preferable.

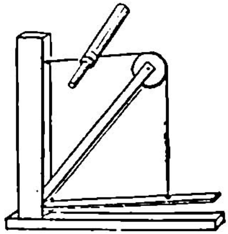
ROCKETS.—Of all fireworks, rockets are among the most noble and effective. The ingredients for these, the apparatus employed, and the detail of the manufacture of them may be considered the foundation of all fireworks, and to make them well involves the same principles, and requires the same caution, as in making all others.

Size of Rockets.—The size of rockets is indicated by ounces or pounds; thus we say, an eight-ounce rocket, a pound rocket, and so on; by this expression it is not meant that the rockets weigh so much as their name indicates, but that the bore or cavity will just suffer a leaden bullet of that weight to pass down them. For example, a pound rocket will admit a leaden bullet that weighs a pound. Rockets may be made of any size from 1 oz. up to 50 or more pounds.

Rocket Cases or Cartridges.—These may be made of any kind of stiff thick paper, either cartridge paper or what is equally good and much cheaper, namely, common bag-cap paper. To roll up the cases you must have a smooth round ruler, or, as it is called, a former, exactly the size of the cavity of the rocket, and 10 or 12 times as long. Then lay a sheet of the paper upon a slab of slate, marble, or glass, and paste 4 or 5 in. along the end of it, leaving the rest of the sheet of paper without paste; then roll it smoothly over the former, dry end first, until the whole is rolled up, when of course the paste will stick and a thin case be formed. Keep rolling it along the slab with the hands, in the same way as a rolling-pin is used, for two or three minutes, until the various folds of the paper set close and tight to each other; then put on another sheet in the same way, and so on, till the case is thick enough. This is known by the measurement across it. If the former without the case measures five parts, when the case is upon it they must measure together eight parts. That is, the paper must be rolled on till it forms a case, the thickness of the sides of which are a trifle more than one-third of the thickness of the former. The length of the rocket case, and consequently the width that the sheets of brown paper are to be cut before pasting, varies with the size of the rockets; in small rockets the length of the case may be six times the diameter, in larger rockets four or five times is sufficient. When the case has proceeded thus far, it is to be choked while yet damp, that is, to be contracted in diameter near one end, and for this purpose a simple contrivance is requisite, called a choking cord, and also the former is made with a hole drilled at one end, and a second joint made to fit on by means of a wire projecting at one end of it, and which fits into the hole of the former, Fig. 10. To choke the case, draw the former partly out, until you can see about 1 inch of the inner cavity of the case, then put on the second joint (the wire of which fits into the hole of the former), and pass this on until its end is

FIG. 10.

FIG. 11.



about ½ an inch within the case, leaving a space of about ½ an inch between the two joints occupied by the wire alone. Then going to an apparatus similar to that shown in Fig. 11, turn the cord once round the case where the cavity is, put the foot upon the treadle, which tightens the cord and squeezes the paper case at the point required, and that it may squeeze it equally and neatly on all sides the case should be held in the hands and moved up and down upon the cord until the operator sees that it is sufficiently and properly compressed. Let it be observed that although the choking apparatus used by the firework maker is represented and above alluded to, yet to the amateur it is by no means necessary. What will do quite as well is a thin cord fastened at one end to a staple in the wall, and by the other tied round the waist of the operator; as he may lean back, of course the cord would be tightened, and the desired purpose accomplished. When the case is sufficiently compressed it is to be tied with two or three turns of strong string. The case is now complete, except that the part of it where it is choked is perhaps rather rough and uneven inside; this must be compressed down, for much of the effect of the rocket will depend upon the perfect regularity on this part, as it is through the hole left by the wire in the middle of the choke that the fire is afterwards to issue. To compress this part properly a mould is necessary.

The Rocket Mould is represented in Fig. 12. It consists of a solid foot of wood; upon the centre of this stands a short cylinder about ½ an inch high, and exactly of the size of the mould, to be placed over it, as afterwards described;

FIG. 12.

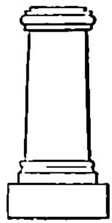
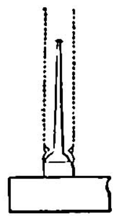
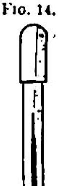


FIG. 13.



this short cylinder has a shoulder above, and terminates in a round top. Out of the middle of the top is a tapering thick brass wire, projecting some inches upwards, as is seen in Fig. 13. The whole is so arranged, that when one of the newly-made cases is put upon the wire and forced down, the wire fills up the choke-hole, the round top fits into the small parts of the case below the choke, the shoulder of the cylinder bears the extreme end of the case, and the short cylinder agrees in size with the outsides of the case. There fits over this (case and all) a strong wooden or metal tube; so that it is seen that there is no cavity anywhere, except the inside of the rocket case, and even in this a thick wire runs up to nearly the top of that part of the case where the composition is rammed, or nearly ⅔ of the whole case from the choke upwards. The wire above mentioned is called the piercer. All rockets must be placed in the mould to be filled, as well as to smooth and consolidate the part choked. With the mould are used rammers, Fig. 14, formed of hard wood, of the shape of a popgun-stick; these rammers being rather less than the diameter of the cavity, and having a hole bored up their centre, in order to admit the piercer. It is evident that

FIG. 14.



there must be a complete mould, piercer, and one or more rammers for every size rocket. But to proceed with the string; put it in the mould and the rammer down into it, and give this, the latter, a blow or two with a mallet, which driving it down while yet damp with the paste, will render the whole compact and smooth; and the case being taken out may be placed in an oven, or near the fire, to dry. If it is desired to ornament it in any way or cover it with white paper, this must be done before choking.

Charging Rockets.—The next process after drying the case is to charge them with the requisite composition. Put the cases in the mould with the piercer in it and put enough composition in to fill about 1 inch of the case; then, taking the rammer, ram it down with three or four strong blows with a mallet. Then put in the same quantity of composition again and ram that down in the same manner, and so on till the case is filled to the top of the piercer and one diameter above it. Then separate some of the central folds of the paper which it has been observed is not parted, and turn them down upon the composition, ramming them down hard upon it, or, what will do as well, put in a piece of paper as wadding. When this is rammed down, and firm, bore with a brass bradawl three or four holes through it. These holes serve to make the requisite communication between two parts of the rocket. Or, having charged the case, take some common potters' clay in dry powder, and ram it down hard upon the top of the composition, then bore a hole through it about $\frac{3}{16}$ of an inch diameter, which will allow of the necessary connection between the rammed composition and the stars in the head or pot of the rocket.

Priming Rockets.—The rocket is now supposed to be closed at one end. It only requires to be primed at the other end, and that it will be observed is the end which was choked, which is still open, and which has a hole passing up it which the piercer occupied. To prime it fill up the hole with loose gunpowder made into a stiff paste with very weak gum water, and paste a piece of touch-paper over it.

Rocket Pot or Head.—The rocket being then charged, the head or pot must be fixed. The pot is a paper case made upon a wooden former turned cylindrical, about 4 inches in length, and a shade larger in diameter than the exterior of the rocket case. Take some thick brown paper and cut it in strips large enough to go twice round the former, paste and roll as for the case, then pinch one end, and a cylinder of paper will be thus made which should fit nicely over the clay end of the rocket. There should now be fixed upon the pinched end a conical cap, made upon a former of like shape, Fig. 15. This cap by cleaving the air assists the rocket in rising into it.

FIG. 15.

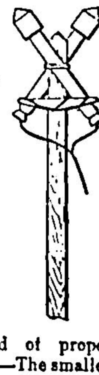
Loading Rockets. — The loading the pots with stars is all that now remains to be done to complete the rocket. A ½-lb. rocket should carry about 1 oz. of stars. Weigh out the proper quantity of stars and mix them with meal powder, 6 parts, to fine charcoal 1 part, fill up the pot and glue it securely over the clay or upper end of the rocket case.

Rocket Sticks.—Next fasten the stick to the rocket by two strings, as seen in any of the figures 16 to 19.—The sticks

FIG. 16.

FIG. 17.

FIG 18.



being previously prepared of proper length and size, as follows:—The smaller ones are easily and best made of those laths called by bricklayers double laths,

FIG. 19.

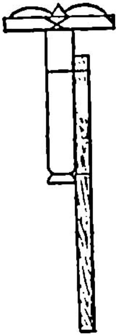


FIG. 20.

and the larger ones pantile laths; but any slip of deal will answer the purpose. 2-lb. rockets require sticks 9 feet 4 inches long, 1 inch square at top, and rather more than ½ inch square at bottom. 1-lb. rocket sticks are 8 feet 2 inches long, ¾ inch square at top and ⅜ inch at bottom. 8-oz. rocket sticks are 6 feet 2 inches long, ⅝ inch square at top, and ⅜ inch at bottom. 4-oz. rocket sticks are 5 feet 3 inches long, ⅜ inch by ½ inch at top, and ¼ inch square at bottom. 2-oz. rocket sticks are 5 feet 1 inch long, $\frac{5}{16}$ inch by ½ inch at top, $\frac{3}{16}$ inch at bottom. 1-oz. rocket sticks 3 feet 6 inches long, and so on for other various sizes. The weight and the length of the stick must be such, as that when tied on, the rocket shall balance on the finger, at a point about 1 inch from the part choked.

ROCKET COMPOSITIONS.—The brilliancy of the rocket depends upon the composition in the cases, and great care is required in the mixture of the ingredients, which should be well dried and carefully sifted through a hair sieve before mixing. For a ½-lb. rocket, to 12 oz. of saltpetre add 6 of charcoal and 4 of sulphur; or for signal rockets the proportions are, saltpetre, 4 lbs.; dogwood charcoal, 1 lb. 12 oz.; sublimed sulphur, 1 lb. Powder separately, and mix with the hand or a wooden spoon. Saltpetre increases the rapidity of the fire, whilst sulphur retards it, and the charcoal emits those volumes of sparks which form the golden train of an ascending rocket. Rockets are primed with mealed powder and spirits of wine.

PYROTECHNIC AND ROCKET STARS.—The stars that are used as decorations to the different species of fireworks are of various kinds, sizes, and shapes, according to the purpose for which they are intended.

The ordinary rocket stars, which are called "brilliant" or "bright," are made in small cubes. Their composition is moistened with gum water, and while moist flattened to the thickness required. It is then scored or cut across with a knife, and allowed to dry. When dry it can be easily broken up into cubes at the places where it was divided by the knife. Tailed stars are also made in the same way and of the same size.

Roman-candle stars are small cylinders of composition made of a size proportioned to that of the case out of which they are to be thrown.

Coloured rocket stars are made by driving the coloured composition, slightly moistened, into small cases, which go under the name of pill-box cases. If the star is to consist of one colour only, these pill-boxes are open at both ends, and a piece of quick-match is placed between the composition and the inside of the pill-box, and allowed to project about ¼ an inch beyond each end of it. When fired, these stars burn at both ends at the same time, and so produce a great amount of fire in proportion to their size.

If it is required to make stars consisting of more than one colour (in which case they are called "changeable stars") the pill-boxes are left open at one end only. The composition is thus prevented from burning at more than one of its surfaces at a time. These stars generally contain two colours; the pill-boxes are half-filled with one coloured composition and the remaining space filled with another. These changeable stars burn much longer than the others, and therefore produce a more beautiful effect; but being larger they require to be used in larger rockets, the ½ lb. size being the smallest that is adapted for this purpose.

There is another and exceedingly beautiful decoration for rocket-heads which is called golden rain. This is by no means a difficult thing to make. Some small paper cases are made, about 2 inches long and of the size of goosequills; these are filled with a sparkling composition and primed with wetted gunpowder. They are placed, mouth downwards, in the head of the rocket, and arranged in such a manner that they may all be ignited. At the bursting of the rocket they will describe a series of beautiful ringlets of sparkling fire.

Common Brilliant Stars.—Nitre, 16 parts; sulphur, 8; sulphuret of antimony, 4; meal-powder, 3. Let all the ingredients be in as fine a powder as possible; and, having carefully weighed out the quantities, mix them thoroughly. Next, take some weak gum water made by dissolving 2 oz. of gum-arabic in a pint of warm water. Spread the star composition upon a piece of zinc plate or slate, and add to it a little of the gum water at a time, taking care to stir the composition about well till all the moisture is equally diffused. It is not necessary that this composition should be made wet, but only something like brown sugar in moistness, so that it will bind well when pressed together. When this is sufficiently done, roll or press the composition into a flat shape like a thick pancake, and make it as square as possible. Its thickness should be about ½ of an inch. Take a blunt knife spatula, and with it score the composition across both ways, so that it is divided into a number of little cubes.

Tailed Stars.—These stars are not moistened with plain gum water, but with a mixture of gum water and linseed oil. The gum water should be of the strength given above, and should be made quite hot by placing the bottle which contains it in a jug of boiling water. When it is sufficiently hot, to every 8 oz. of gum water add 1 oz. of linseed oil. Shake the bottle till these are thoroughly mixed and no oil can be seen. Use the moistening fluid, while hot, in the same manner as directed above for brilliant stars. The following is the composition for tailed stars:—Nitre, 16 parts; meal-powder, 12; antimony (sulphuret), 8; fine charcoal, 4½; sulphur, 4.

Coloured Stars.—These require considerable care in their preparation, the beauty of their performance depending entirely upon the uniform fineness, the intimate union, and the dryness of their ingredients. The various preparations which enter into their composition should always be kept ready for use in fine dry powder, preserved in well-corked or stoppered bottles. The pill-boxes for coloured stars are made in the following manner:—Procure a piece of straight iron rod, 12 inches long, and from ⅜ to ½ an inch in size; the usual size for this former is about $\frac{7}{16}$ of an inch. Now cut some cartridge paper into strips about 8 inches wide, and from 9 to 10 inches long; paste these strips all over, and roll them round the iron rod closely and neatly. When this is done, remove the case thus formed from the rod without tearing or breaking it, and set it aside to dry. When dry it will be very hard and stiff. It can then be cut, by means of a very sharp knife, into little lengths of ½ an inch each. These lengths are the open pill-boxes, into which composition is to be rammed for coloured rocket stars. In order to accomplish the filling of these cases with the least amount of trouble, procure a piece of stick, of a convenient length, and of such a size round that it will pass easily into the pill-boxes, and with a short groove cut in the side, sufficient to allow it to pass the quick-match without injuring it. Next take a small piece of quick-match, about 1½ inch long, and pass it through the pill-box in such a manner that it may project beyond each end about ½ an inch. The composition pressed with the stick into these boxes is always slightly moistened; and by this means, when once dry, will not be liable to be shaken out again. The fluid employed for moistening these coloured compositions is a solution of shellac in methylated spirit of wine. Care must be taken not to make these compositions *wet*. A very slight moistening is sufficient to make them bind well when pressed into their cases.

Crimson Stars.—1. Chlorate of potash, 24 parts; nitrate of strontia, 32; calomel, 12; sulphur, 6; shellac in fine powder, 6; sulphide of copper, 2; fine charcoal, 2. 2. Chlorate of potash, 12 parts; nitrate of strontia, 20; sulphur, 11; charcoal, 2; antimony, 2; mastic, 1. 3. Nitrate of strontia, 72; sulphur, 20; gunpowder, 6; coal-dust, 2.

Rose-coloured Stars.—Chlorate of potash, 20 parts; carbonate of strontia, 8; calomel, 10; shellac, 2; sulphur, 3; fine charcoal, 1. The advantage of this composition is that it is not at all liable to suffer from damp in winter. The carbonate of strontia is a salt not absorbent of moisture like the nitrate, and is, moreover, always to be had in a state of fine powder.

Green Stars.—1. Chlorate of potash, 20 parts; nitrate of baryta, 40; calomel, 10; sulphur, 8; shellac, 3; fine charcoal, 1; fused sulphide of copper, 1. 2. Nitrate of baryta, 42 parts; realgar, 2; sulphur, 8; lampblack, 1. 3. Chlorate of potash, 28 parts; nitrate of baryta, 12; sulphur, 15; mastic, 1.

Pale Rose-coloured Stars.—Nitrate of strontia, 8 parts; chlorate of potash, 4; sulphur, 3; sulphuret of antimony, 2. Take especial care that the nitrate of strontia used in this formula is very dry.

Pale Green Stars.—Nitrate of baryta, 16 parts; chlorate of potash, 8; sulphur, 6; antimony, 3.

Yellow Stars.—1. Chlorate of potash, 20 parts; bicarbonate of soda, 10; sulphur, 5; mastic, 1. 2. Chlorate of potash, 30; dried soda, 12; sulphur, 8.

Golden Yellow Stars.—Chlorate of potash, 20 parts; nitrate of baryta, 30; oxalate of soda, 15; sulphur, 8; shellac, 4. If it is thought advisable to give the stars made from this formula a tailed appearance, add one part of fine charcoal. The composition is to be moistened with the shellac solution. The stars form a beautiful contrast with those of an intense blue.

Blue Stars.—1. Chlorate of potash, 8 parts; sulphide of copper, 6; Chertier's copper, 5; sulphur, 4. 2. Chlorate of potash, 12 parts; Chertier's copper, 6; sulphur, 4; calomel, 1. 3. Chlorate of potash, 16 parts; Chertier's copper, 12; calomel, 8; stearine, 2; sulphur, 2; shellac, 1. This gives a most intense blue. 4. Chlorate of potash, 20 parts; carbonate of copper, 14; sulphur, 12; mastic, 1. 5. Nitre, 12 parts; sulphuret of antimony, 2; sulphur, 4; lampblack, 2. All these compositions should be moistened with gum water, and in No. 3 the stearine employed must be in fine powder.

Violet Stars.—Chlorate of potash, 9 parts; nitrate of strontia, 4; sulphur, 6; carbonate of copper, 1; calomel, 1; mastic, 1.

White Stars. — Saltpetre, 9 parts sulphur, 3; antimony, 2.

TO PREPARE CHERTIER'S COPPER.—Take any quantity of common sulphate of copper, or blue vitriol, and dissolve it in as little water as possible; then take an equal quantity by weight of chlorate of potash and also dissolve it in as little water as will hold it in solution. Mix these two solutions, and boil them gently over a clear fire until the moisture is nearly evaporated; then dry the green precipitate that remains by a gentle heat. When dry treat it with strong liquor ammoniæ till it changes to a deep blue colour; then let it dry very gradually in a warm place. If this operation be properly performed you will have a fine, very light blue powder, which is Chertier's copper.

TO PREPARE NITRATE OF STRONTIA.—Procure a common earthenware pipkin, or a glazed iron frying-pan of a convenient size. Into this place nitrate of strontia in rough crystals. 1 or 2 lbs. will be sufficient to prepare at a time. Place the vessel on a clear fire, but do not make it too hot. Now boil, or rather stew, the crystals in their own water of crystallization. The heat will soon cause them to run into a thick pulpy mass.

When in this state, they must be constantly stirred, or upon the evaporation of the moisture they will reassume a crystalline form. Continue then to stir it with a stick or flat piece of wood until the moisture is driven off by the heat, and the salt remains in the condition of a white dry sand. No strontia can be used for coloured stars or fires unprepared, and this operation is proper also for the preparation of the nitrate of baryta.

GOLDEN RAIN. — Golden rains are made in the following manner:—Procure a piece of brass rod, the diameter of which is $\frac{3}{16}$ of an inch, or rather less. The length of the former may be from 6 to 8 inches. Cut thin brown paper into short strips, about 2 inches wide, and long enough, when wrapped round the former, to make a case whose external diameter should be $\frac{1}{4}$ of an inch, or rather more. The former should have a small cup-shaped hollow cut in one of its ends, into which the paper may be turned, to form a closed end to the cases. Paste the strips of paper all over, and also rub some paste on the former; then roll the paper round the former, and draw it out so as to leave its cupped end $\frac{1}{4}$ of an inch inside one of the ends of the case. Pinch in the paper that projects beyond the former, and drive it down with a tap upon the pasting slab, so that the twisted end is pressed into the cup of the former. By this means a neat and secure end is obtained for the cases, which may be dipped afterwards into warm size or glue. If a little red-lead is mixed with this size, it will solidify much more rapidly. This dipping the ends of the cases into size should not be done until they are dry from the paste. For filling the cases a tin funnel is used that will exactly fit into the mouth of golden-rain cases. The composition employed for filling the cases is the following:—1. Meal-powder, 6 parts; nitre, 1; fine charcoal, 2. 2. meal-powder, 8 parts; fine charcoal, 3. 3. Saltpetre, 1 lb.; meal-powder, 4 oz.; sulphur, 4 oz.; brass dust, 1 oz.; sawdust, 2½ oz.; glass dust, 6 drs. When the case is charged, the funnel must be removed, and the space that was occupied by its nozzle filled with gunpowder or meal-powder moistened with gum water. This will prevent the composition from being shaken out of the cases and at the same time forms the best method of priming them. Take care that this paste is pressed well into the mouth of the cases, and fills them.

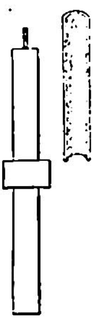
Silver Rain. — 1. Saltpetre, 4 oz.; sulphur, mealed powder, and antimony, each 2 oz.; sal prunella, ½ oz. 2. Saltpetre, 8 oz.; sulphur, 2 oz.; charcoal, 4 oz. 3. Saltpetre, 1 lb.; antimony, 6 oz.; sulphur, 4 oz. 4. Saltpetre, 4 oz.; sulphur, 1 oz.; powder, 2 oz.; steel dust, ⅜ oz. Used in similar cases and treated in the same way as *golden rain.*

PORTFIRES. — The portfires used for firing rockets and fireworks are generally made in the following manner:—The former for this purpose should be of brass, and not less than $\frac{1}{4}$ of an inch in diameter, and the wire for filling them not less than $\frac{1}{8}$ of an inch. Portfire cases are usually made very thin, but prepared in precisely the same manner as that described for golden rains, and are also primed in the same way. The following are the compositions usually employed for portfires. 1. Nitre, 6 parts; sulphur, 2; meal-powder, 1. 2. Saltpetre, 2 lbs.; sulphur, 3 lbs.; antimony, 1 lb. 3. Saltpetre, 3½ lbs.; sulphur, 2¼ lbs.; meal-powder, 1 lb.; antimony, ½ lb.; glass dust, 4 oz.; brass dust, 1 oz.

ROMAN CANDLES.—In the manufacture of these fireworks the following important points must be observed, namely, to have a composition to burn in the intervals between the stars, which will throw a jet of fire uniformly good throughout, to have stars of tolerably rapid combustion, otherwise they will not be ignited before they are blown into the air, and to have the charges of powder for blowing the stars regulated to a great nicety. The former for the cases must be $\frac{5}{8}$ of an inch in diameter, and 18 inches long. The cases require rather a large amount of paper and imperial board for their manufacture, but otherwise they are made similar to rocket cases.

Roman-candle Stars. — The brilliant stars may be made of the same composition as that given for rocket stars of that kind. If, however, a whiter star is required, use the following:—Nitre, 48 parts; sulphur, 10; regulus of antimony, 8; realgar, 6; red-lead, 4; shellac, 1. Yellow Roman-candle stars may be made from the same formula as that given for yellow-rocket stars. Green Roman-candle stars may be made from the formulas given for rocket stars; but there is also another formula, which produces a rather deeper tint, but is hardly rapid enough in combustion for rocket stars. It is the following:—Nitrate of baryta, 40 parts; chlorate of potash, 20; calomel, 12; sulphur 12; fine shellac, 4; fine charcoal, 1. The formulas for crimson, rose, blue, and purple Roman-candle stars are the same as given for rocket stars. In order to make the stars, moisten the compositions very slightly. The mould in which these stars are shaped is a brass tube, Fig. 21, of a size proportioned to the size of the Roman-candle case, and is generally about $\frac{1}{16}$ of an inch smaller in its inner diameter than the case. The drift with which the composition is pressed into the tube, is made of boxwood or metal, and fits easily into the tubular mould. At one of its ends there is a wire point. Place the end having the point in the mould as far as it will go. It will leave a space at the end of the mould unoccupied by the drift. Press this empty end of the tube into the slightly-moistened composition until it is filled by it, so that the drift, being driven down upon the composition, will compress it into a firm cylindrical mass, into the centre of which the wire point projects. When the star is thus formed in the mould the drift must be withdrawn, reversed, its long plain end inserted, and the star pushed out. The object of making the star hollow is that it may dry and harden perfectly in its centre, and also for the priming of the star, which is effected by placing a little piece of quick-match into the hole in the star, and allow it to project about $\frac{1}{4}$ of an inch above. By this means even slowly-combustible stars are ignited, and almost every chance of failure is avoided. This priming, however, should not be done until the stars are to be put into the cases—at all events, till they are perfectly dry.

FIG. 21.



Composition for Roman Candles.—1. Nitre, 18 parts; sulphur, 6; fine charcoal, 7; meal-powder, 4. 2. Nitre, 16 parts; meal-powder, 8; fine charcoal, 6; sulphur, 6. 3. Nitre, 16 parts; meal-powder, 11; sulphur, 6; antimony, 4. The next thing is to fill the case. Before filling it introduce a little clay to the bottom of the case, thus forming a better and firmer bottom. This being done properly, put in a little coarse powder, and over this a small piece of paper, to prevent the composition mixing with the powder; then ram down as much composition as will fill the case one-sixth of its height; over this put a small piece of paper covering about two-thirds of the diameter, then a little corn powder, and upon that a ball, observing that the ball is rather smaller than the diameter of the case. Over this first ball more of the composition must be put and rammed lightly down to prevent breaking the ball, till the case is one-third full; then a piece of paper, a little powder, and then another ball as before, till the case is filled with balls and composition, taking care to place composition above the highest ball. When the case is thus filled, cap it with touchpaper by pasting it round the orifice, and a little priming of powder being added the work is complete.

TOUCHPAPER. — Obtain some thin blue paper—not so thin as tissue paper, but thinner than the ordinary blue paper used by storekeepers; brush or sponge this over with or dip it into a weak solution of saltpetre, and when well saturated dry for use. Touchpaper should be cut into slips, placed once round the mouth of the firework, and twisted into a point.

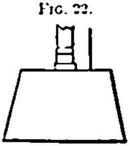
QUICK-MATCH.—Make a thick paste of gunpowder and hot water, with a small quantity of gum in it. Take about four strands of cotton, such as is sold in balls and used for making the wicks of lamps, steep this in the solution of nitre used for making touch-paper, and wring it as dry as possible; then rub it well in the gunpowder paste till it is thoroughly covered with it. One end of the cotton may be passed through a small funnel, whose mouth is not more than $\frac{1}{8}$ of an inch in width. By this means, if the whole length of the cotton is drawn through it, the superfluous paste will be removed, and the match will be of a nice round form. Hang it out of doors on a dry day, and when it is nearly dry coil it upon a tray or paper, and dust it over with meal-powder. In winter it will not be sufficiently dry for use under a week. When thoroughly dry it should be stiff and hard, and the less it is bent or doubled the better. To use this match for connecting the mouths of different fireworks, or clothing them as it is termed, make some long paper tubes round a wire former which has a diameter of not less than $\frac{3}{16}$ of an inch. These pipes are threaded on the match, and have a piece cut away at their side wherever they are inserted into the mouth of a case, in order that the match may be laid bare and convey its fire to the priming of the cases.

GERBES AND JETS OF BRILLIANT, CHINESE, AND COMMON FIRES.—These are certainly among the most beautiful and effective pieces to be met with in the whole range of pyrotechny. They have one great advantage—that there is no limit to the modes of combination or arrangement in which these pieces may be effectively employed. By means of them any such things as the following can be made:—Fountains of any size or design, cascades, brilliant suns, either fixed or revolving, bouquets of Chinese fire, spread eagle, trees of silver flowers, and a thousand other devices. Their compositions, to produce the desired effect, must be made as shortly as possible before it is intended to fire them, as iron and steel filings are a principal ingredient in their composition. Many attempts have been made to secure these metallic ingredients from corrosion. A coating of any kind is tolerably certain either to rob the spark which each particle of metal should produce of its brilliancy, or to render the composition during combustion very smoky, and so impair the intended effect. The most successful plan is the following:—A weak solution of asphalte in naphtha is made, and the filings or borings are stirred about in this. When it is thought that they are thoroughly covered with it, the solution is poured off, and the filings spread out upon paper to dry. But still the best way is to prepare the compositions as short a time as possible before they are to be fired. The cases should be made like rocket cases, and choked while wet, only it must be remembered that their aperture may be almost choked up, because when it has been reopened by the point over which they are loaded, it must not be more than $\frac{1}{4}$ of the interior diameter of the case in size.

Red Chinese Fire.—1. Meal-powder, 16 parts; nitre, 16; sulphur, 4; charcoal, 4; iron borings, 14. 2. Meal-powder, 16 parts; sulphur, 3; charcoal, 3; iron borings, 7. 3. Meal-powder, 8 parts; nitre, 16; sulphur, 3; charcoal, 3; iron borings, 8. 4. Meal-powder, 16 parts; nitre, 8; sulphur, 4; charcoal, 3; iron borings, 7.

White Chinese Fire.—1. Meal-powder, 16 parts; nitre, 6; sulphur, 3; iron borings, 10. 2. Meal-powder, 16 parts; nitre, 4; sulphur, 2; iron borings, 6. 3. Meal-powder, 16 parts; iron borings, 5. For filling the cases nipples of various sizes are employed, made preferably of metal. The case must now be pressed over the point of the nipple, Fig. 22, and by this means its aperture will be made of the proper size. It will be found very convenient to have a ring of iron fixed into your block, through which the case must be passed, which will steady it and keep it in a perpendicular position while being filled. Now drive in the composition,

FIG. 22.



a ladleful at a time, and after putting in each ladleful, give the drift twelve blows with the mallet. Fill the cases till there remains a space of 2 inches only unoccupied at the end. Into this end put a gun charge and a half of gunpowder. Then with a bradawl separate one or two of the inner folds of the paper of the case, and turn these down on the top of the powder. For filling in the ends of the cases:—Melt in an earthen pipkin a mixture of 2 parts of common resin and 1 of wax. This may be poured into the ends of the cases upon the paper that has been turned down. It will harden in a few minutes, and will be found to ensure a good report from the powder. To prime these cases:—This is an operation requiring some care, although it may be performed in a very simple manner. If the point of the nipple is not too long, all that is needed is to press into the mouth of the case some meal-powder paste; but if a cavity has been left in the composition, this must be filled up before priming, or the case will inevitably burst. It is an excellent plan to take for the first ladleful, not any of the compositions for Chinese fire, but a ladleful of some slower fire containing no iron borings, such as a mixture consisting of nitre, 6 parts; sulphur, 1; charcoal, 1. These gerbes or jets are exhibited, when finished, by being attached to strong frames of wood or metal, arranged in such a manner as the exhibitor may wish, to produce any desired effect. The mouths of the cases are connected by means of leaders or quick-match.

Brilliant Fire.—The cases employed for brilliant fire need not be so large as those employed for Chinese fire, but observe the same rules in filling these cases. 1. Meal-powder, 4 parts; bright steel filings, 1. 2. Meal-powder, 16 parts; nitre, 8; sulphur, 3; fine charcoal, 3; bright steel filings, 10. Neither of these compositions should on any account be mixed before their preparation is absolutely necessary, for their whole beauty depends upon the brightness of the filings at the time of firing.

Common and Sparkling Fires.—1. Meal-powder, 4 parts; charcoal, 1. 2. Meal-powder, 16 parts; nitre, 8; sulphur, 4; charcoal, 4. 3. Meal-powder, 16 parts; very fine glass dust, 5. 4. Meal-powder, 8 parts; very finely powdered porcelain, 3. These fires can be arranged very effectively as stars, suns, &c. For instance, provide a circular disk of hard wood, 6 inches in diameter, and 1 inch thick. Nail to this five spokes of wood at equal distances from one another, and 15 inches long. Nail also to the back of the central disk a strip of wood about 2 feet long, 2 inches wide, and ¾ of an inch thick. By means of this you can screw the whole piece conveniently to your firing post. On each of the five spokes tie a case of brilliant fire, reported at its end, and connect the mouths of these with quick-match.

LANCES.—Lances are used in making up devices, such as *names*, mottoes, wreaths, and so on. They consist of small cases, generally made about $\frac{3}{16}$ of an inch in diameter, that is, round a piece of glass or brass rod or tube of that size; tubes are always best for these small formers. The cases are about 2 or 2½ inches long, with one end pinched or turned in. Two rounds of thin demy or double-crown white paper, pasted, will give sufficient thickness and substance for the case. The cases, when dry, are to be filled with either of the following compositions in the same way as golden rain:—

Compositions for Lances. White.—1. Nitre, 16 parts; sulphur, 8; meal-powder, 6. 2. Nitre, 16 parts; sulphur, 4; meal-powder, 6. 3. Nitre, 12 parts; sulphur, 4; sulphide of antimony, 3. 4. Nitre, 72 parts; sulphur, 18; regulus of antimony, 33; realgar, 1; shellac, 1. 5. Nitre, 96 parts; sulphur, 24; regulus of antimony, 48; realgar, 6; shellac, 1. These for the most part give a bluish white flame, and when employed in cases of the size mentioned above, burn slowly, and will last as long as this species o firework is required to last.

Yellow.—1. Chlor. of potash, 72 parts; oxal. soda, 60; stearine, 6; sulphur, 6.

2. Chlor. pot., 40 parts; oxal. soda, 16; shellac, 8; stearine, 3.

Green.—1. Chlor. pot., 60 parts; nitr. baryta, 41; calomel, 49; powdered sugar, 30; shellac, 1. 2. Chlor. pot., 63 parts; nitr. baryta, 50; calomel, 50; sugar, 32; shellac, 1.

Emerald Green.—1. Chlorate of baryta, 18 parts; calomel, 7; very fine shellac, 3. 2. Chlorate of baryta, 24 parts; stearine, 3; very fine sugar, 1.

Red Lances.—1. Chlor. pot., 13 parts; nitr. strontia, 10; calomel, 8; shellac, 3; dextrine, 1; Chertier's copper, 1. 2. Chlor. pot., 12 parts; nitr. strontia, 12; calomel, 6; shellac, 4; Chertier's copper, 1; fine charcoal, 1.

Rose-coloured Lances.—Chlorate of potash, 24 parts; sulphur, 2; stearine, 3; oxalate of strontia, 4. This composition will remain good for any length of time.

Blue Lances.—1. Chlorate of potash, 12 parts; Chertier's copper, 6; sulphur, 4; calomel, 1. 2. Chlorate of potash, 32 parts; Chertier's copper, 12; calomel, 40; sugar, 25. 3. Chlorate of potash, 6 parts; Chertier's copper, 1; calomel, 5; sugar, 4.

Violet.—Chlorate of potash, 26 parts; calomel, 24; carbonate strontia, 4; Chertier's copper, 3; sugar, 14.

Lilac.—Chlorate of potash, 12 parts; prepared chalk, 4; sulphur, 5; calomel, 3; sulphide of copper, 10. Sugar for pyrotechnic compositions must be kept in a closely-corked or stoppered bottle. It should be reduced to powder in a very dry mortar, and then sifted through very fine muslin.

To exhibit lances procure a board of sufficient size for the design, or make a wooden framework of the shape that is required. Sketch the design upon one side of the board, or, larger than a board will allow, make a plain rough framework describing the letters. When this is done, decide upon the distance at which to place the lances one from another. This distance is generally about 2 inches, but no exact rule can be laid down, for much depends upon the kind of design, and upon its size. Upon the outlines of the sketch make little pencil circles wherever it is intended to place a lance; and, as far as it is possible, arrange that the lances shall be equidistant one from another. Now with a centre-bit, or, what is better, a pin-bit, bore a hole about a $\frac{1}{4}$ of an inch deep where the circles are pencilled. These holes must be of such a size that the closed ends of the lances will fit easily into them. Get either some glue or some of the mixture of size and red-lead, and when it is liquid, dip into it the closed end of each of the lances. Enough of the mixture will adhere to the lances to allow of their being secured firmly in the holes that have been bored. In a very short time all will be hard and dry, and you will then have a series of lances projecting at right angles with your board or framework, each having its mouth primed, and all being the same length. The only thing that remains now to be done is to clothe these primed mouths with quick-match. This is by no means difficult, but requires a certain amount of patience. Take a length of match in its case, and, having exposed one end of the black match itself, put a small pin through it into the priming of one of the lances. This will fasten it down, and at the same time will ensure ignition. Then lead the quick-match on to the next lance, cutting away with scissors a piece of the under side of its case, to allow the match in passing to touch its priming. Put a pin through the match into the priming of this lance also, and so on till all are clothed. If more of the casing of the match has been cut away than is necessary, it will be well to paste small strips of paper wherever this has happened, as any exposure of the black match will endanger the piece, rendering it liable to ignition from the sparks of other fireworks.

COLOURED LIGHTS.—Their preparation is exceedingly simple. They are generally made in two sizes only; these are the 2-oz. and the 1-oz. sizes. The cases are made of cartridge or foolscap paper, and are about 2 inches long for the 2-oz. size and $1\frac{3}{4}$ inch for the 1-oz. size. Used-up copy-books furnish excellent paper for making these coloured-light cases. Three or four rounds of the paper will give ample thickness for the case. The paper should be pasted all the way along the strips. When the cases are thoroughly dry, ram into the bottom of them some dry powdered clay; this will make a close end, and will also furnish an incombustible part by which the case may be tied or fastened to its place.

White Lights for Decoration. — 1. Nitre, 4 parts; sulphur, 1; sulphide of antimony, 1. 2. Nitre, 4 parts; sulphur, 1; meal-powder, 1. These will give the ordinary bluish light, and compositions made from them will remain good for any length of time.

Yellow Lights may be made from the formulas given under the head of Lances.

Green Lights.—Nitrate of baryta, 80 parts; chlorate of potash, 32; sulphur, 24; calomel, 16; fine charcoal, 3; shellac, 2.

Red Lights.—1. Chlorate of potash, 32 parts; nitrate of strontia, 48; calomel, 20; shellac, 12; Chertier's copper, 4; fine charcoal, 1. 2. Chlorate of potash, 84 parts; nitrate of strontia, 80; calomel, 51; dextrine, 22; shellac, 18; Chertier's copper, 4.

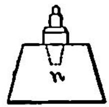
Purple.—1. Chlorate of potash, 28 parts; Chertier's copper, 28; calomel, 13; shellac, 8; stearine, 1. 2. Chlorate of potash, 40 parts; calomel, 28; Chertier's copper, 28; dextrine, 10; stearine, 3. 3. Chlorate of potash, 26 parts; Chertier's copper, 24; calomel, 14; shellac, 7.

TOURBILLONS. — The tourbillon is a species of firework very ingeniously contrived to represent a spiral column of fire. Its performance is of short duration, but while it lasts it produces a very striking effect. A tourbillon consists of a stout case filled with a strong sparkling composition, and closed very tightly at both ends. In this case are bored four holes, at which the fire is to find vent. Two of these holes are made underneath the case; from these the fire issues in a downward direction, and gives the piece the power of ascending perpendicularly. The outer two holes are made in opposite sides of the case near each end; the fire issuing from these causes the cases to revolve in a horizontal direction while it is ascending. The cases are made as for rockets, and should be about 8 inches in length, and $\frac{3}{4}$ of an inch in their bore. Their external diameter will be found to be about $1\frac{1}{8}$ inch.

Plain Tourbillons.—Nitre, 8 parts; meal-powder, 16; sulphur, 4; charcoal, 4.

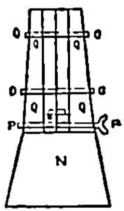
Brilliant Tourbillons. — Meal-powder, 16 parts; nitre, 8; sulphur, 3 to 4; fine charcoal, 3; steel filings, 6. Tourbillon cases are filled by means of an apparatus which consists of a block of wood, Figs. 23, 24, provided with a settle, *n*, on which one end of the tourbillon case is placed, and over which the composition is rammed. There is a wooden mould for enclosing the case and supporting it tightly and firmly while the operation of ramming is being performed.

FIG. 23.



This mould Q, Q, Fig. 24, consists of a hollow cylinder of wood pierced throughout, and of such a size in its bore as will just admit the tourbillon case. The mould is divided longitudinally in halves, and these halves are kept together by means of iron rings, O O O O, which encircle the whole. P P is a pin to pass through cylinder and settle to connect them. In order to fill the cases, squeeze one end of one of them over the projecting piece at the top of the settle. Fit on the two halves of the cylindrical mould, drive down the iron rings until they are tight, and put in the pin which secures the cylinder to the block and settle. First put into the tourbillon case as much clay as will, when rammed very hard, occupy $\frac{3}{8}$ of an inch in the length of the case. The settle projects into the case about $\frac{1}{8}$ of an inch, and thus $\frac{1}{2}$ an inch at each end of the case is left for the purpose of ensuring a very firm ending,

FIG. 24.



which cannot be blown out by the combustion of the composition. When the clay has been rammed in as tightly as possible, drive in the composition, a ladleful at a time, as uniformly as possible, until only ½ an inch at the upper end of the case is unoccupied by it. Into this vacant space drive the same quantity of clay that was put into the lower end, and be sure that it is rammed in very firmly. When this is done, open your penknife, and lay its blade on the table, back downwards and edge upwards. Place the filled tourbillon case across the edge of the knife, and find the exact central point at which it balances on it, and mark that point by making a hole there with a small bradawl. Now, having found the centre of its balance, next mark the places at which the holes are to be made, and by far the best way is to use a shape made of zinc or tin, such as is shown Fig. 26. This piece of sheet metal, when bent into the form of a trough of such a size as to fit tightly round the tourbillon case, will give the true position of the holes. In using it put the filled tourbillon case into it, and make pencil marks through the holes that correspond to those drawn in the Fig. 26, and you will then have got over the entire difficulty. In the middle of the scale is one small hole. This hole is to come exactly over the mark made with the bradawl at the balancing point, and if this be done all the rest must come right. Having thus marked the position of the holes, the next thing is to bore them. This is best effected by means of a bradawl driven by a mallet, the tourbillon during the operation being laid upon a small block of wood, M, with a groove cut in it, as *m*, Fig. 25. The holes should be as nearly as possible $\frac{3}{16}$ of an inch in size. It is easier to drive the bradawl with a mallet than to work it in with the hand. It must not be driven in farther than necessary, the object being merely to make a clear hole through. If a block is 2 inches square or rather more it will be quite large enough. The block will be found very useful afterwards. The two extreme holes, which are on opposite sides of the case, are made at the ends of the composition; the fire issuing from these gives the tourbillon a horizontal revolution round its centre of balance. The two inner holes, which are on the under side of the case, should be the same distance from one another that they are from the extreme holes; the fire issuing from these gives the tourbillon its ascending power. We have now to connect all these holes with quick-match, in order that the composition may take fire at all the four points simultaneously; and unless this is attended to with care, it will not only cause the tourbillon to fire irregularly, but entirely destroy its effect. Begin at one of the under holes, those marked F in Fig. 26, and press into it the end of a piece of uncased quick-match, taking care that the match reaches the composition. Then carry the match on to the nearest side hole, and press it into it. Carry on the quick-match over the upper side of the tourbillon to the side hole at the other end of the case, and press it in there; and,

Fig. 25.

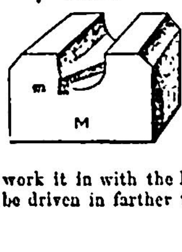


Fig. 26.

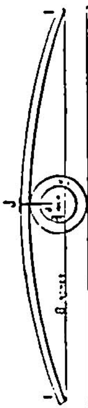
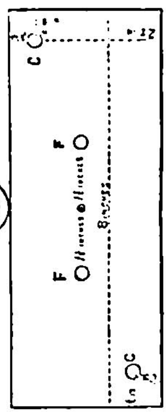


Fig. 27.



lastly, carry it on to the remaining under hole, and press it into it. Having completed this operation, cut some strips of thin paper, about 1 in. wide, paste them well over, and cover the quick-match with them, holes and all. A very little practice will enable one to adapt this pasted paper very neatly. The tourbillon, if now ignited, will be sure to go somewhere, but in order to regulate its flight we must adjust a stick to it, which shall have the effect of keeping its under side downwards, and so of compelling it to move upwards perpendicularly. This stick is usually made of beech, 8 inches long, about ⅛ inch thick, and of a curved shape, in the manner represented at II in Fig. 26. There is a small hole in their centre through which a flat-headed nail is driven into the tourbillon at its balance point. The stick must, of course, lie at right angles with the case in the manner represented at R, Fig. 28. It is a very good plan to put a drop or two of glue

FIG. 28.

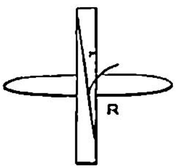


FIG. 29.

at the point where the stick touches the case, as it will then be prevented from shifting its position. In driving the nail through the stick into the tourbillon, make use of the block represented at M, having previously cut at the bottom of its rounded groove another small groove diagonally, so that when the tourbillon is lying upside down in the large groove, for the purpose of having the nail driven into it, the quick-match that extends across it may lie in the smaller groove, and may not be injured by being crushed, as would otherwise be the case. The nails used should be about ¾ of an inch long, and should have a smooth, flat head. To fire the tourbillon, place it stick downwards on a level board, and see that it spins easily and freely on the head of the nail. Then with a portfire burn through the quick-match in the middle on the upper side. The tourbillon will make a few revolutions on the board before it begins to rise.

Reference to Figs. 24 to 29.—M, block to receive the tourbillon while it is being bored. *m*, groove in it to receive the quick-match. N, block, with settle (*n*) over which tourbillons are rammed. QQQQ, wooden cylinder to enclose tourbillon case. OOOO, iron rings to tighten cylinder. PP, pin to pass through cylinder and settle to connect them. R, tourbillon complete, with stick attached. S, revolving cradle from which tourbillons are fired. *ss*, iron spike, with tubular top, in which the cradle revolves.

DRAWING-ROOM FIREWORKS.—*Lightening Paper.*—Dry 1000 grains of pure nitre at a moderate heat, place it in a dry retort, pour on it 10 drachms by measure of strong sulphuric acid, and distil until 6 drachms of nitric acid have passed over into the receiver. Dry some thin unsized paper, such as filter paper, and weigh out 60 grains of it. Mix 5 measured drachms of the nitric acid with an equal volume of strong sulphuric acid in a small glass vessel; allow the mixture to cool; immerse the paper, pressing it down with a glass rod, cover the vessel with a glass plate, and set it aside for 15 or 20 minutes. Lift the paper out with a glass rod, throw it into a bucket of water, and wash it thoroughly in a stream of water till it no longer tastes acid or reddens blue litmus paper. Dry it by exposure to the air, or at a very gentle heat.

Japanese Matches. — Lampblack, 5; sulphur, 11; gunpowder from 26 to 30 parts, this last proportion varying with the quality of the powder. Grind very fine, and make the material into a paste with alcohol; form it into dice about ¼ of an inch square, with a knife or spatula let them dry rather gradually on a warm mantelpiece, not too near a fire. When dry, fix one of the little squares into a small cleft made at the end of a lavender stalk, or, what is better, the solid straw-like material of which housemaids' carpet-brooms are made. Light the material at a candle, hold the stem downward. After the first blazing off, a ball of molten lava will form, from which the curious coruscations will soon appear.

QUICK-MATCH.—Quick-match is made of cotton lamp-wick thread, soaked for an hour or two in a mixture of gunpowder, 1½ lb., and gum water, made by dissolving 2 oz. of gum-arabic in 1 pint of water, into which the gunpowder should be beaten up till dissolved. The cotton may be 3, 4, or more strands in thickness, and should be wound off out of the mixture, passed through a funnel pipe to make it even, and dried on a frame. It must be enclosed in paper tubes for use, as it will not burn with the necessary rapidity if not covered.

Another method is by coating lamp-cotton as thickly as possible with meal-powder, rendered adhesive by mixture of thick gum-arabic, and covered by two strips of paper wound round it spirally, one over the other in opposite directions, the outer one being pasted to the inner.

FIRE BALLOONS. — The material for making a small balloon should be a fine, thin, close-textured tissue paper. Having determined that the balloon shall consist of a specific number of gores, or sections, say 34 or 16, a pattern for cutting them by should be made of pasteboard, or some tolerably hard substance. Suppose the entire height of the balloon, without its appendages, is to be 3 feet, and the number of gores 32, an elegant shape will be got by making the pattern 1 inch wide at one end, 3 inches at the other, and 8 inches at its broadest part, which should be at one-third of its length, if the balloon is intended to have a pear-like figure. Varnish the gores with the ordinary boiled oil, and hang them up singly on lines till perfectly dry. They are next to be put together, which may be done with gum water or clean thin paste. After pasting or gumming about ½ an inch of one of the gores, lay the edge of another about midway across the part pasted, and then double over about ¼ of an inch of it, dabbing it lightly from end to end with a clean cloth, to ensure its holding securely. Two of the gores being thus united, unite two others in like manner, and so on, until, if there were 32 gores in all, the number is reduced to 16. In like manner proceed till the number is eight, then four, and then two; hanging the sections up at every pasting, so that they may get thoroughly dry whilst proceeding. The two halves are last of all to be connected in the same way; and this part of the undertaking is then completed. A circle of wire, about 6 inches in diameter, should be worked into the bottom of it, to keep the fabric of the balloon at a sufficient distance from the flame of the spirit. Another wire may be fixed across this circle to hold a piece of sponge, which should be immersed in spirits of wine. A smouldering piece of brown paper held underneath the aperture will in a few minutes put the balloon in an ascending condition. Having thus inflated the balloon, ignite the piece of sponge, and let it rise.. When it is intended to inflate the balloon with hydrogen or coal gas, the latter apparatus is not needed; but a light car, or any other ornament proportioned to the ascending power of the balloon, may be appended to it, which will have the effect of maintaining it in the right position, and also of keeping it longer in sight than would otherwise be the case.

SALTPETRE FROM DAMAGED GUNPOWDER. — Dissolve the powder in warm water, filter the solution through fine linen bags, and then evaporate the water by boiling it, until the solution is of sufficient strength to crystallize.

SERPENTS, OR SQUIBS. — 1. Mealed powder, 1 lb. 8 oz.; charcoal, 4 oz.; sulphur, 1 oz.; saltpetre, 3 oz. 2. Mealed powder, 1 lb.; charcoal, 1 oz.; saltpetre, 1⅜ oz.; steel filings, 1 oz. The case is made by rolling cartridge paper in slips of 6 or 8 inches in breadth round a former, and pasting down the last fold, for serpents. The case, having been choked at one end, is filled by inserting a funnel into the case, filling the funnel with composition, and gently moving a rod or rammer up and down the funnel-pipe, the rod being introduced before the composition. A piece of touchpaper is fastened to the end. For squibs, before filling the case, ram in hard a thimbleful of coarse gunpowder.

SHOWERS OF FIRE.—*Chinese Fire.*—Mealed powder, 1 lb.; sulphur, 2 oz.; iron filings, 5 oz. *Ancient Fire.*—Mealed powder, 1 lb.; charcoal, 2 oz. To form a shower of fire, mould small paper cases on a rod, 3/16 of an inch in diameter, and 2½ inches in length. They must not be choked, as it will be sufficient to twist the end of the case, and having put the rod into it, beat it to make it assume its form. When the cases are filled, which is done by immersing them in the composition, fold down the other end, and then apply a match. They must be fixed on a frame with leaders, to be fired simultaneously.

PIN, OR CATHERINE, WHEELS.—Mealed powder, 12 oz.; saltpetre, 3 oz.; sulphur, 1½ oz. The pipe or case is made on a long wire former, about 3/16 of an inch in diameter, into which the composition is poured through a funnel, and shaken down. The case is then rolled round a small circle of wood about 1 inch in diameter, and not more than ½ an inch thick, with a hole through the centre of it for a nail, or pin. One end of the case is to be pasted round the wood, and each half turn of it secured with sealing wax, or a strip of paper pasted across the wheel. The end is then primed.

CRACKERS.—The case is made of cartridge paper, the dimensions required being 15 inches by 3½ inches. First fold down one edge, about ¾ of an inch broad, then turn down the double edge about ¼ of an inch, and bend back the single edge over the double fold, so as to form within a channel, which is to be filled with mealed powder, not ground very fine; the powder is then to be covered by the folds on each side, and the whole is to be pressed by a flat ruler; and the part containing the powder is to be folded into the remainder of the paper, every fold being pressed down. The cracker is then doubled backwards and forwards in folds about 2¼ inches, which are pressed quite close, and a piece of twine is passed twice round the middle across the folds, and the joinings secured by causing the twine to take a turn round the middle at each fold successively; one of the ends of the folds may be doubled short under, which will produce an extra report; the other must project a little beyond the rest for the purpose of being primed.

COLOURED FIRES.—In the preparation of coloured fires the utmost care should be taken to have the component parts of the mixtures well triturated apart from each other, passed through fine sieves, and kept separately in stoppered bottles. They do not improve by keeping, and therefore should be used as soon as possible after mixing. The proper amount of each ingredient being parcelled out and placed on a sheet of glass or paper, the whole is carefully mixed with a light hand by means of a bone or wooden knife, a common paper knife for instance. Chlorate of potassa must be treated with especial caution, as it is very liable to explosion from friction whilst in contact with combustible matter.

Blue Fire.—1. Sulphur, sulphate of potassa, and ammonio-sulphate of copper, of each, 15 parts; nitre, 27; chlorate of potassa, 28. For theatrical illuminations. 2. Metallic antimony, 1 part; sulphur, 2; nitre, 5. 3. Sulphate of copper, 7 parts; sulphur, 24; chlorate of potassa, 69.

Crimson Fire.—Chlorate of potassa, 4¼ parts; alder or willow charcoal, 5¾; sulphur, 22½; nitrate of strontia, 67½. For pots.

Green Fire.—1. Charcoal and sulphuret of arsenic, of each, 1¾ part; sulphur, 10½; chlorate of potassa, 23¼; nitrate of baryta, 62½. 2. Nitrate of baryta, 77 parts; chlorate of potassa, 8; fine charcoal, 3; sulphur, 13. 3. Metallic arsenic, 2 parts; charcoal, 3; chlorate of potassa, 5; sulphur, 13; nitrate of baryta, 77.

Lilac Fire.—Black oxide of copper, 6 parts; dry chalk, 20; sulphur, 25; chlorate of potassa, 49.

Purple Fire.—1. Sulphuret of antimony, 2¾ parts; black oxide of copper, 10; sulphur and nitrate of potassa, of each, 22¾; chlorate of potassa, 42. 2.

Sulphur, 12 parts; black oxide of copper, 12; chlorate of potassa, 30.

Red Fire.—1. Sulphur, sulphuret of antimony, and nitre, of each, 1 part; dried nitrate of strontia, 5. 2. Chlorate of potassa, 20 parts; sulphur, 24; nitrate of strontia, 56. 3. Coal-dust, 2 parts; gunpowder, 6; sulphur, 20; dried nitrate of strontia, 72. 4. Nitrate of strontia, 37½ parts; flowers of sulphur, 10; charcoal, 1¼; powdered chlorate of potash, 5; black sulphur of antimony, 2½.

Violet Fire.—Charcoal, 8 parts; sulphur, 10; metallic copper, 15; chlorate of potassa, 30.

White Fire.—1. Nitre, 60 parts; sulphur, 20; black antimony, 10; meal-powder, 6; powdered camphor, 4. 2. Gunpowder, 12½ parts; zinc filings, 18; sulphur, 23; nitre, 46½. 3. Charcoal, 1 part; sulphur, 24; nitre, 75.

Yellow Fire.—1. Sulphur, 16 parts; dried carbonate of soda, 23; chlorate of potassa, 61. 2. Charcoal, 6 parts; sulphur, 19½. For pans.

PYROTECHNIC MIXTURES:—

White Light.—Saltpetre, 8 parts; sulphur, 2; antimony, 2.

Red Light.—Nitrate of strontia, 20 parts; chlorate of potash, 5; sulphur, 6½; charcoal, 1.

Blue Light.—Chloride of potash, 9 parts; sulphur, 3; carbonate of copper, 3.

Yellow Light.—Nitrate of soda, 24 parts; antimony, 8; sulphur, 6; charcoal, 1.

Green Light.—Nitrate of baryta, 20 parts; chlorate of potash, 18; sulphur, 10.

Violet Light.—Nitrate of strontia, 4 parts; chlorate of potash, 9; sulphur, 5; carbonate of copper, 1; calomel, 1.

MATCHES. — Ordinary matches are small slips of wood which have been dipped in sulphur, and afterwards tipped with a paste capable of ignition by friction. This paste contains—1. Common phosphorus, 4 parts; nitre, 10; red-lead, 8; strong lead, 6. 2. Ordinary phosphorus, 9 parts; nitre, 14; binoxide of manganese, 14; gum or glue, 16. Melt the glue at 212° F., gradually add the phosphorus, which must be well stirred into the liquid; then add the nitre and colouring matter. Keep the paste at a regular temperature of about 97° F. by means of hot water under the marble or cast-iron slab on which it is spread whilst the matches are being dipped. If gum is used, all the operations may be more easily performed, as the materials can be mixed cold; but the matches made with gum are easily spoilt by damp.

MATCHES WITHOUT SULPHUR.—Char the ends of the splints with red-hot iron, dip them into a thin layer of stearic acid, or wax, melted in a flat-bottomed tinned copper pan. The dipping paste for these matches is ordinary phosphorus, 3 parts; strong glue, 3·5; water, 3; fine sand, 2·0; colouring matter, ·1 to ·5; chlorate of potash, 3. These matches burn readily, with a bright flame, and have no unpleasant smell. Amorphous phosphorus not being poisonous, or liable to accidental ignition, is preferable to ordinary phosphorus. The paste used is amorphous phosphorus, 3 parts; chlorate of potash, 4; glue, 2·5; water, 5; pounded glass, 2.

SAFETY MATCHES.—Dip the splints in a paste composed of chlorate of potash, 6 parts; sulphide of antimony, 2 to 3; glue, weighed dry, 1. The paste for the rubbing surface is amorphous phosphorus, 10 parts; oxide of manganese, or sulphide of antimony, 8; glue, 3 to 6, weighed dry. The ingredients must be thoroughly mixed, and care must be taken not to mix the chlorate of potash in the dry state with the other materials; it should be mixed first with glue dissolved in warm water. The paste for the rubbing surface may be spread with a brush or spatula on the side of the box.

MATCHES WITHOUT PHOSPHORUS.—1. For the production of these lucifers a mixture of from 4 to 6 parts of chlorate of potash, and 2 parts each of bichromate of potash, and of oxide of iron or of lead, with 3 parts strong glue is used. For the igniting surface, a mixture of 29 parts sulphate of antimony, 2 to 4 parts bichromate of potash, 4 to 6 parts oxide of either iron, lead, or manganese, 2 parts of glass powder, and from 2 to 3 parts strong glue or gum. These matches will ignite only on the friction surface thus prepared. 2. For the match-heads a mixture of chlorate of potash and a compound of hyposulphurous acid with soda, ammonia, and oxide and sub-oxide of copper. This compound is formed by dividing a solution of copper into two equal parts, supersaturating one of them with ammonia, and the other with hyposulphate of soda; then mixing the two solutions, and stirring the mixture well, a violet powder precipitates. One part of it is to be mixed with 2 parts of the chlorate of potash, and a small quantity of pounded glass. Lucifers made in this way are, however, objectionable, from the fact that they will ignite on any rough surface, even more easily than the common kind.

Gun-Cotton. — There are several varieties of gun-cotton — the explosive, soluble only in acetic ether; pyroxiline, soluble in sulphuric ether and alcohol; and xyloidine. All these are formed by the action of nitric acid on cotton or lignine in some form. The difference between them consists mainly in the strength and temperature of the acids employed in their preparation. The most explosive is prepared with the strong acids, sulphuric and nitric, mixed, the object of the sulphuric being to take water from the nitric, and so leave the latter in its full strength to combine with the lignine or cotton. The first thing to be done is to thoroughly cleanse the raw material. This is effected by boiling it in an alkaline solution, then drying it in a current of air, and then again boiling it in clean water. After the second boiling it must be very *thoroughly* dried at about 120° F. The cotton must be *very* thoroughly dried, as any moisture which might remain in it would, by combining with the acid, generate heat, and set up a destructive action. The cotton, in charges of 1 lb., is placed separately in a bath containing the mixed acids, the mixture in which the cotton is submerged consisting of 3 parts by weight of Nordhausen sulphuric acid, specific gravity 1·84, and 1 part of nitric acid, specific gravity 1·5; this mixture allowed to cool down—a process which occupies two or three days —before the cotton is placed in it. After immersion, the charges of cotton are strained until each contains only about 10 times its weight of acids, and each charge is then placed in an earthenware jar and covered down. In order to prevent any heating from taking place, the jars should be placed in a current of *cold* water. The cotton after being exposed to the acid for 48 hours, in order to ensure its thorough conversion, is removed from the jars and squeezed nearly dry. It is then to be *suddenly* plunged into a *strong* fall of cold water, and left for a short time. The object of placing the gun-cotton in the fall of water is to ensure the sudden and complete submersion of the material, and thus avoid the heating and decomposition of the cotton, which would take place at the surface of the water if the cotton were immersed gradually. On its removal from the fall of water, the gun-cotton is wrung dry, and placed in a stream of water for 48 hours. After being washed and partly dried several times more, the cotton should be thoroughly dried at the temperature of no more than 140° F. It is now so explosive that great care is required in its arrangement, being about three times as explosive as gunpowder. As thus prepared gun-cotton scarcely differs from unchanged cotton in appearance; it is white and fibrous, and rather harsh to the touch. If only a small quantity is required—1. Mix 4½ oz. of pure, dry, nitrate of potash with 30 fluid drachms of sulphuric acid, sp. gr. 1·845, and stir into this mixture carefully 120 grs. of best carded cotton. As soon as saturation is complete, in about one minute, if proper care has been used, throw the cotton into a large pan of clean rain water, and change the water repeatedly until litmus ceases to show the presence of acid, then squeeze it in a cloth, and, after being well pulled out, dry it at a temperature of about 180°. 2. Take of cotton 1 oz., sulphuric acid, 5 fl. oz., nitric acid, 5 fl. oz.; mix the acids in a porcelain mortar, immerse the cotton in the mixture, and stir it for three minutes with a glass rod, decant the liquid, pour more water on the mass, and repeat the process until the washing ceases to give a precipitate with chloride of barium. Drain the product on filtering paper and dry in a water bath.

Nitro-Glycerine. — Nitro-glycerine is made in the following manner:—. Fuming nitric acid (sp. gr. about 1·52) is mixed with twice its weight of the strongest sulphuric acid, in a vessel kept cool by being surrounded with cold water. When this acid mixture is properly cooled, there is slowly poured into it rather more than ⅕ of its weight of syrupy glycerine; constant stirring is kept up during the addition of the glycerine, and the vessel containing the mixture is maintained at as low a temperature as possible by means of a surrounding of cold water, ice, or some freezing mixture. It is necessary to avoid any sensible heating of the mixture, otherwise the glycerine, which is the sweet principle of oil, would be, to a considerable extent, transformed into oxalic acid. When the action ceases, nitro-glycerine is produced. It forms on the surface as an oily-looking fluid, the undecomposed sulphuric acid forming the subjacent layer, owing to its greater specific gravity. The whole mixture is then poured, with constant stirring, into a large quantity of cold water, when the relative specific gravities become so altered that the nitro-glycerine subsides and the diluted acid rises to the surface. After the separation in this manner into two layers is effected, the upper layer may be removed by the process of decantation or by means of a siphon, and the remaining nitro-glycerine is washed and re-washed with fresh water till not a trace of acid reaction is indicated by blue litmus paper. The final purifying process is to crystallize the nitro-glycerine from its solution in wood naphtha. The final process is not necessary when the compound is to be used at once. As prepared in this manner, nitro-glycerine is an oily-looking liquid, of a faint yellow colour, perfectly inodorous, and possessed of a sweet, aromatic, and somewhat piquant taste. It is poisonous, small doses of it producing headache, which may also be produced if the substance is absorbed into the blood through the skin, and hence it is not desirable to allow it to remain long in contact with the skin, but rather to wash it off as soon as possible with soap and water. Glycerine has a specific gravity of 1·25–1·26, but the nitro-glycerine has a specific gravity of almost 1·6, so that it is a heavy liquid. It is practically insoluble in water, but it readily dissolves in ether, in ordinary vinic alcohol, and in methylic alcohol or wood spirit. If it is simply exposed to contact with fire it does not explode, although it is so powerful as an explosive. A burning match may be introduced into it without producing any explosion; the match may be made to ignite the liquid, but combustion will cease as soon as the match ceases to burn. Nitro-glycerine may even be burned by means of a cotton wick or a strip of bibulous paper, as oil from a lamp, and as harmlessly. It remains fixed and perfectly unchanged at 212° F.; if heated to about 360°, however, it explodes. It detonates when struck by the blow of a hammer, but only the part struck by the hammer explodes; the surrounding liquid remains unchanged. As the carriage of nitro-glycerine is dangerous, many trials have been made to render it inexplosive, and to restore its explosiveness with equal readiness. Nobel's method of making it inexplosive is at once simple and effective. It is to mix with it from 5 to 10 per cent. of wood spirit, when all attempts at exploding it are rendered utterly futile. Five per cent. of methyl-alcohol is said to be amply sufficient to transform the nitro-glycerine into the inexplosive or protected state, but 10 per cent. is generally added before sending any liquid into the market. The transformation of protected into ordinary nitro-glycerine is effected by thoroughly agitating it with water, and allowing the mixture to settle for a short time. By this means the water dissolves out the methyl-alcohol, and the mixture of spirit and water readily rises to the surface, in virtue of its low specific gravity, and can be removed by means of a siphon, or by simply pouring it off. As a blasting liquid it is now ready for use. If protected blasting liquid be kept in a closed vessel, it will remain in that state for an indefinite period of time, and ready at any moment to be reduced or rendered fit for action; if, however, it be exposed in an open vessel, it will regain its explosiveness, in periods of time proportionate to the amount or degree of exposure. For blasting purposes, the chief advantage which nitro-glycerine possesses is that it requires a much smaller hole or chamber than gunpowder does, the strength of the latter being scarcely $\frac{1}{10}$ that of the former. A chamber, 34 millimètres in diameter, was made perpendicularly in a dolomitic rock, 60 ft. in length, and at a distance of 14 ft. from its extremity, which was nearly vertical. At a depth of 8 ft., a vault filled with clay was found, in consequence of which the bottom of the hole was tamped, leaving a depth of 7 ft. One litre and a half of nitro-glycerine was then poured in; it occupied 5 ft. A match and stopper were then applied as stated, and the mine sprung. The effect was so enormous as to produce a fissure 50 ft. in length, and another of 20 ft. Nitro-glycerine has, however, one disadvantage. It freezes at a temperature very probably above 92° F., and it is said that even at a temperature of 43° to 46° F. the oil solidifies to an icy mass, which mere friction will cause to explode. It is probable, however, that the freezing-point of the oil lies somewhat lower than is here stated, though as yet no exact determination of the freezing-point of the oil has been made. Great care must be exercised whilst it is in a frozen state, as otherwise it will cause most dreadful accidents.

Dynamite is made by mixing 75 per cent. of nitro-glycerine with 25 per cent. of powdered sand. Dynamite retains all the properties of nitro-glycerine for blasting, but is not so dangerous, as it may be handled freely. Explosion is produced by means of a percussion cap in the same manner as with nitro-glycerine.

Fulminates.—*Fulminate of Mercury.*— 1. This highly-explosive compound consists of protoxide of mercury united with an acid; fulminic acid, formed of cyanogen and oxygen. Fulminate of mercury is prepared by causing alcohol to react on the acid protonitrate. A quantity of mercury is dissolved in 12 parts of nitric acid of 35° or 40° of Baumé, and 11 parts of alcohol at ·86 are gradually added to the solution; while the temperature is slowly elevated, a lively reaction, accompanied by a copious evolution of reddish vapours, soon ensues, when the liquid, on cooling, deposits small crystals of a yellowish white colour. Fulminate of mercury is one of the most explosive compounds known, and should be handled with great care, especially when it is dry, and it detonates when rubbed against a hard body. It dissolves readily in boiling water, but the greater portion is again deposited in crystals during cooling. The fulminating material of percussion caps is made of fulminate of mercury prepared as just stated, after having been washed in cold water. The substance is allowed to drain until it contains only about 20 per cent. of water, and is then mixed with $\frac{2}{3}$ of its weight of nitre, which mixture is ground on a marble table with a muller of guiacum-wood. A small quantity of the paste is then placed in each copper cap and allowed to dry, the fulminating powder in the cap being often covered with a thin coat of varnish to preserve it from moisture. 2. Weigh out 25 grains of mercury in a watch-glass, transfer it to a half-pint pipkin, add a measured $\frac{1}{2}$ oz. of ordinary concentrated nitric acid, sp. gr. 1·42, and apply a gentle heat. As soon as the mercury is completely dissolved, place the pipkin upon the table away from any flame, and pour quickly into it, at arm's length, 5 measured drachms of alcohol, sp. gr. 0·87. A brisk action will ensue, and heavy white clouds will arise. When this action has subsided, fill the pipkin with water, allow the fulminate to settle, and then pour off the liquid acid. Collect the fulminate on a filter, and wash with water as long as the washing tastes acid, then dry by exposure to the air. This explodes at a temperature of 360° F., or by being touched by a glass rod which has been dipped in concentrated nitric or sulphuric acid. An electric spark also explodes it.

Fulminate of Silver. — Dissolve 10 grains of pure silver, at a gentle heat, in 70 minims of ordinary concentrated nitric acid, sp. gr. 1·42, and 50 minims of water. As soon as the silver is dissolved the heat is removed, and 200 minims of alcohol, sp. gr. 0·87, are added. If the nitric acid and alcohol are not of the exact strength here given it may be difficult to start the action, in which case add two or three drops of red nitric acid, which contains nitrous acid. Standard silver, containing copper, may be used for the preparation of the fulminate. If the action does not commence after a short time, a very gentle heat may be applied until effervescence begins, when the fulminate of silver will be deposited in minute needles, and may be further treated as in the case of fulminate of mercury. As the fulminate of silver is exploded much more readily than the fulminate of mercury, it must be handled with the greatest caution when dry. It should be separated into small quantities, each portion wrapped in paper, and kept in a cardboard box, nothing harder than this should be brought in contact with it. This mixture is of no use for percussion caps, being too violent in its action.

Throw-down Detonating Cracker. — Screw up a particle of fulminate of silver in a piece of thin paper, with some fragments of a crushed quartz pebble.

Double Fulminate of Silver and Ammonia.—Dissolve fulminate of silver in warm ammonia: the solution, on cooling, will deposit crystals of the double fulminate. This is very violent in its explosion, and is dangerous whilst still moist.

Fulminating Platinum.—Dissolve binoxide of platinum in diluted sulphuric acid, mix the solution with excess of ammonia, a black precipitate is obtained, which detonates violently at about 400° F.

Fulminating Gold.—Add ammonia to a solution of terchloride of gold; the buff precipitate which it deposits is violently explosive at a gentle heat.

Terchloride of Gold.—Dissolve gold in hydrochloric acid, with one-fourth of its volume of nitric acid. Evaporate on a water bath to a small bulk; when cool, yellow prismatic crystals of a compound of the terchloride, with hydrochloric acid are deposited, from which the hydrochloric acid may be expelled by a gentle heat, not exceeding 250° F. The terchloride forms a red brown deliquescent mass, which dissolves very readily in water.

Gunpowder. — The component parts of gunpower are saltpetre, sulphur, and charcoal, used in the following proportions:—1. English war powder.—Saltpetre, 75 parts; sulphur, 10; charcoal, 15. 2. French war powder.—Saltpetre, 75 parts; sulphur, 12·5; charcoal, 12·5. 3. French sporting powder.—Saltpetre, 76·9 parts; sulphur, 9·6; charcoal, 13·5. 4. French blasting powder.—Saltpetre, 62 parts; sulphur, 20; charcoal, 18. There are a number of variations of the above receipts; but the difference, which is purely a matter of opinion, consists principally in varying the quantity of sulphur or charcoal employed.

Saltpetre.—Crude saltpetre cannot be used for making gunpowder. The crystalline flour, quite free from chloride, is the best for the purpose. The washing process is carried so far that nitrate of silver produces no precipitate in the purified saltpetre. The general rule is to use the saltpetre whilst slightly damp, allowing for the proportion of moisture when mixing with the other ingredients. This saves the processes of drying and grinding the saltpetre before mixing with the sulphur and charcoal.

SULPHUR.—Refined sulphur in rolls is used. This must be reduced to an impalpable powder, which is usually effected by placing the sulphur in hollow wooden drums, having projections, or brackets inside. A number of small brass balls are put into the drum with the sulphur, and the drum is made to revolve for six hours, when the action of the balls and projections reduces the sulphur to very fine powder, which is then extracted through wire gauze. Any small particles of sand, or unequally pulverized sulphur, are then separated by a bolting machine.

CHARCOAL.—The quality of the charcoal depends greatly upon the material from which it is obtained, and the manner in which it is prepared. The soft, woody parts of plants, which yield a friable, porous charcoal, leaving very little ash, are preferred. Black alder, and spindle tree, poplar, chestnut, vine-stalks and willow, are most esteemed. Hemp-stalks, fibres of flax, and old linen also yield a very good charcoal. Remove the bark, leaves, and smaller branches, selecting branches from 1 to 2 inches in thickness. These are to be cut into lengths of 5 or 6 feet, and tied in bundles, weighing about 30 lbs. The wood will not be injured by exposure to the rain, as that tends to remove extractive matter. The carbonization is effected either in pits, or in cast-iron cylinders. The yield of charcoal is 18 to 20 per cent., when prepared in pits; and from 35 to 40 per cent. when prepared in the cast-iron cylinders. The process of manufacture is similar to that adopted for ordinary charcoal, the pits or cylinders, however, replacing the ordinary kiln. If the charcoal is intended for sporting powder, it may be withdrawn whilst of a brown colour, when it is called *red charcoal*. This would make a powder too explosive for war purposes; this must be prepared from the *black* or *distilled charcoal*, which is more completely calcined, and is used by all English makers. The best quality has a bluish black colour, is light, firm, and slightly flexible, and should be used immediately it is made, as it rapidly deteriorates by keeping. Charcoal that has been too highly burned for war powder is used in the manufacture of blasting powder, as that need not be so inflammable.

Pulverizing.—The required quantities of sulphur and charcoal are thoroughly pulverized, and intimately mixed, by being rolled for about four hours in a cast-iron drum, with numerous small brass balls, at a speed of about 28 revolutions a minute. When the mixture is complete, the powdered sulphur and charcoal is removed from the drum, and a proportionate quantity of saltpetre is added. Great care must be used in weighing out the various ingredients, according to the quality of the powder required, as upon that, and the complete mixing of the materials, the success of the manufacture depends.

Mixing.—The powder is put in a mixing machine, which is a leather drum, in which are placed numerous small bronze balls. The machine revolves at from 25 to 30 revolutions a minute, and in about 4 hours' time the mixing is complete.

Granulating.—The powder having been damped and pressed into cakes, must then be crushed to the required size of grain. It is first roughly broken into lumps by small mallets; it is then fed into the granulating machine, which is caused to revolve for 35 or 40 minutes, at about 10 revolutions a minute. A small stream of water enters the granulator; the movement of the machine rolling the damp grains constantly among the dry meal powder, causes the latter to adhere to their surface, and each grain is thus increased by concentric layers. When the small meal powder is all absorbed by the action of the granulator, the material is placed in a barrel ready for *equalization*.

Equalizing.—The grains as they come from the granulator are of various sizes, they are therefore sifted over two leather or parchment sieves, one of which is pierced to separate the grains which are too large, whilst the other allows all the dust to pass through, retaining only the grains which are of the desired size.

The small refuse powder which has passed through the sieve, is again placed in the granulator, and acted upon as before described.

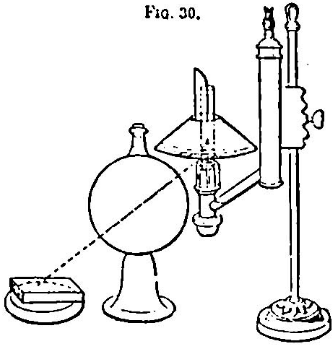
Glazing.—The powder is placed in a cask, or barrel, which revolves on its axis at about 40 revolutions a minute; by the friction of the grains against each other they become round, smooth, and polished, in which state the powder will bear the shaking and friction of carriage without injury, and is less likely to absorb moisture than when in rough and angular grains.

Drying.—The powder must not be too rapidly dried, a temperature commencing at about 66° F., and gradually increased to 130° or 140° F., is a safe one; the operation requires from 3 to 4 hours, and is best performed in a room warmed by steam pipes or hot-air flues. The powder is then fit for use, and may be packed in sacks, to be afterwards placed in casks, or in double casks; sporting powder is usually packed in tin canisters.

Pharaoh's Serpents.—Fuse in a crucible equal parts by weight of yellow prussiate of potash and flower of sulphur, frequently it is advisable, if the heat cannot be well regulated, to include a little carbonate of potash; lixiviate the mass with water and filter; the filtrate will be sulphocyanide of potassium, which, upon being added to a solution of mercury dissolved in nitric acid, gives a copious precipitate of sulphocyanide of mercury; collect this; wash well with water, and dry; roll into a small pyramid, cover with tin-foil, and when dry it is ready to be lit.

Engraving on Wood. — *Engraver's Lamp.* — A clear and steady light, directed immediately upon the block to be cut, is a most important point, and in working by lamplight it is necessary to protect the eyes from its heat and glare. The lamp shown in Fig. 30 can be raised or lowered at pleasure by sliding the bracket up or down the standard, it being fixed in the desired position by means of the small set screw. A large globe of transparent glass, filled with clean water, placed between the lamp and the block, causes the light to fall directly upon the block.

FIG. 30.

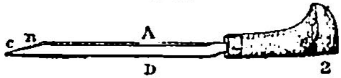


The dotted line shows the direction of the light; by lowering the lamp this light would take a more horizontal direction, thus enabling the engraver to work farther from the lamp. A shade over the eyes is occasionally used as a protection from the light of the lamp.

TOOLS.—These consist of gravers, tint-tools, gouges or scoopers, flat tools or chisels, and a sharp-edged scraper, something like a copper-plate engraver's burnisher, which is used for lowering the block. Of each of these tools several sizes are required.

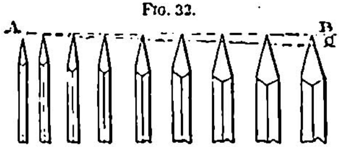
Gravers.—The outline tool, Fig. 31, is chiefly used for separating one figure

FIG. 31



from another, and for outlines. A is the back of the tool; B, the face; C, the point; D is technically termed the belly. The horizontal line, 2, shows the surface of the block. All the handles when received from the turner's are circular, but as soon as the tool has been inserted a segment is cut away from the lower part, so that the tool may clear the block. The blade should be very fine at the point, so that the line it cuts may not be visible when the block is printed, its chief duty being to form a termination to a number of lines running in another direction. Although the point should be fine, the blade must not be too thin, for it would then only make a small opening, which would probably close up when the block was put in the press. When the tool becomes too thin at the point, the lower part must be rubbed on a hone to enable it to cut out the wood instead of sinking into it. Nine gravers of different sizes, starting from the outline tool, are sufficient for ordinary work. The blades as made are very similar to those used in copperplate engraving; the necessary shape for wood engraving is obtained by rubbing the points on a Turkey stone. The faces, and part of the backs, of nine gravers of different sizes, are shown on Fig. 32;

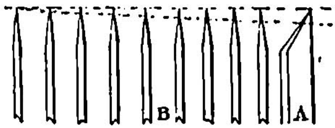
FIG. 32.



the dotted line, A C, shows the extent to which the tool is sometimes ground down to broaden the point. This grinding rounds the point of the tool, instead of leaving it straight, as shown at A B. Except for the parallel lines, called *tints*, these gravers are used for nearly all kinds of work. The width of the line cut out is regulated by the thickness of the graver near the point, and the pressure of the engraver's hand.

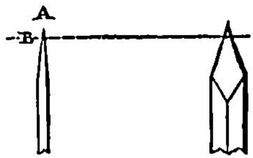
Tint-tools.—The parallel lines forming an even and uniform tint, as in the representation of a clear sky, are obtained by what is called the tint-tool, which is thinner at the back, but deeper at the side, than the graver, and the angle of the face at the point is much more acute, as shown on Fig. 33: A is a side view of the blade; B shows the faces of nine tint-tools of varying fineness. The handle is of the same form as that used for the graver. The graver should not be used in place of the tint-tool, as from the greater width of its point a very slight inclination of the hand will cause a perceptible irregu-

FIG. 33.



larity in the distance of the lines, besides tending to undercut the line left, which must be carefully avoided. Fig. 34 shows the points and faces of the

FIG. 34.



two tools, from a comparison of which this statement will be readily understood. As the width of the tint-tool at B is little more than at A, it causes only a very slight difference in the distance of the lines cut, if inclined to the right or the left, as compared with the use of the graver. Tint-tools that are strong in the back are to be preferred as less likely to bend, and giving greater freedom of execution than weak ones. A tint-tool that is thicker at the back than at the lower part, leaves the black raised lines solid at their base, as in Fig. 35,

FIG. 35.

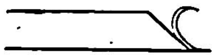
FIG. 36.

the block being less liable to damage than in the case of Fig. 36, in which the lines are no thicker at their base than at the surface. The face of both gravers and tint-tools should be kept rather long than short; though if the point be ground too fine it will be very liable to break. When, as in Fig. 37, the face is long,—or, strictly speaking, when the angle formed by the plane of the face and the lower line of the blade is comparatively acute,—a line is cut with

FIG. 37.

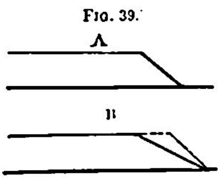
much greater clearness than when the face is comparatively obtuse, and the small shaving cut out turns gently over towards the hand. When, however, the face of the tool approaches to the shape seen in Fig. 38, the reverse happens; the

FIG. 38.



small shaving is rather ploughed out than cleanly cut out; and the force necessary to push the tool forward frequently causes small pieces to fly out at each side of the hollowed line, more especially if the wood is dry. The shaving, also, instead of turning aside over the face of the tool, turns over before the point, as in Fig. 38, and hinders the engraver from seeing that part of the pencilled line which is directly under it. A short-faced tool of itself prevents the engraver from distinctly seeing the point. When the face of a tool has become obtuse it ought to be ground to a proper form; for instance, from the shape of the figure A to that of B, Fig. 39.

FIG. 39.



Preparing Gravers and Tint-tools.—Gravers and tint-tools, when first received from the makers, are generally too hard—a defect that is soon discovered by the point breaking off short as soon as it enters the wood. To remedy this, the blade of the tool must be tempered to a straw colour, and either dipped in sweet oil, or allowed to cool gradually. If removed from the iron while it is still of a straw colour, it will have been softened no more than sufficient; but should it have acquired a purple tinge, it will have been softened too much, and instead of breaking at the point, as before, it will bend. A small grindstone is of great service in grinding down the faces of tools that have become obtuse. A Turkey stone is a very good substitute, as, besides reducing the face, the tool receives a point at the same time; but this requires more time. Some engravers use only a Turkey stone for sharpening their tools; a hone in addition is of great service. A graver that has received a final polish on a hone cuts a clearer line than one which has only been sharpened on a Turkey stone; it also cuts more pleasantly, gliding smoothly through the wood, if it be of good quality, without stirring a particle on either side of the line. The gravers and tint-tools used for engraving on a plane surface are straight at the point, as are here represented, Figs. 40 and 41; but for engrav-

FIG. 40.

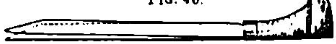
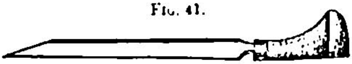


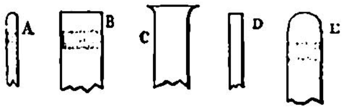
FIG. 41.



ing on a block rendered concave in certain parts by lowering, it is necessary that the point should incline slightly upwards, as in Fig. 40. The dotted line shows the direction of the point used for plane surface engraving. There is no difficulty in getting a tool to descend on one side of a part hollowed out or lowered; but unless the point is slightly inclined upwards, as is here shown, it is extremely difficult to make it ascend on the side opposite without getting too much hold, and thus producing a wider white line than intended.

Gouges and Chisels, A to E, Fig. 42.—Gouges of different sizes are used for scooping out the wood towards the centre of the block; whilst flat tools, or chisels, are chiefly employed in cutting away the wood towards the edges, about one-eighth of an inch below the subject. The gouge

FIG. 42.



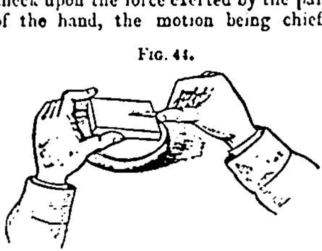
is similar to an ordinary carpenter's gouge, except that it is solid, being a round bar, with the end ground off at an angle. The other articles required are, a sand-bag, on which to rest the block whilst engraving it; an agate burnisher, and a dabber, which are used for taking proof-impressions of the wood-cut; an oil stone, and eye-glass with shade.

Holding the Graver.—Engravers on copper and steel, who have much harder substances than wood to cut, hold the graver with the forefinger extended on the blade beyond the thumb, Fig. 43, so

FIG. 43.

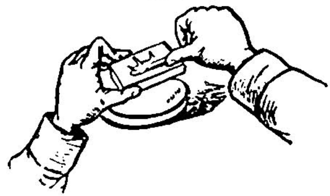
that by its pressure the point may be pressed into the plate. As boxwood, however, is much softer than these metals, and as it is seldom of perfectly equal hardness throughout, it is necessary to hold the graver in a different manner, and employ the thumb at once as a stay or rest for the blade, and as a check upon the force exerted by the palm of the hand, the motion being chiefly

FIG. 44.



guided by the forefinger, as is shown in Fig. 44. The thumb, with the end resting against the side of the block, in the manner just represented, allows the blade to move backwards and forwards with a slight degree of pressure against it, and in case of a slip, it is ever ready to check the graver's progress. This mode of resting the thumb against the edge of the block is, however, only applicable when the cuts are so small as to allow the graver, when thus guided and controlled, to reach every part of the subject. When the cut is too large to admit of this, the thumb then rests upon the surface of the block, as in Fig. 45,

FIG. 45.



still forming a stay to the blade of the graver, and checking at once any accidental slip.

Wood.—For large coarse cuts, such as are often used for trade purposes, sycamore and pear tree may be employed, but are too soft and irregular in the grain to bear fine work. Boxwood, either English, American, or from the Levant, is the favourite material; it should be of a light straw yellow colour, free from black or white spots or red streaks, as these indicate a soft wood, which crumbles away under the graver. The small wood is generally tolerably free from blemishes. When a large cut is wanted, if a block of the required size is not at hand, several smaller blocks are sometimes bolted together. The blocks are cut a trifle thicker than the height of type, about an inch; they are then planed, brought to a very smooth surface, and gauged to the exact height of type. These blocks should be kept for some months until they are properly seasoned.

Drawing on the Block.—The polished boxwood will not take the pencil without a slight wash is first laid on it. A thin wash of Chinese white mixed with water, some very fine Bath brick dust, or the white scrapings of glazed cardboard, mixed with water, and gently rubbed off when dry with the palm of the hand, gives a capital surface for the black-lead pencil. Make a tracing of the outline of the subject, place a sheet of transfer paper on the block, lay the tracing over it, and go carefully over every line with a sharp point. It must be remembered that the woodcut will be reversed when printed. The outlines must be corrected, and completed, by a hard sharp-pointed H H H H pencil; the tints may afterwards be filled in by a softer pencil, or thin washes of Indian ink, to show the effect of light and shade. Caution must be taken to use these washes sparingly, so as not to affect the wood. All parts of the block, not being cut, must be kept covered up, so as to preserve the drawing from injury, and the fine lines of the cut from being blunted or broken. Smooth blue glazed paper is very good for this purpose, as it reduces the glare from the lamp.

Proofs. — When the engraving is finished, a proof may be taken in the following manner before blocking out the cut, that is, before the superfluous wood is cleared away; — rub down a little printer's ink on a slab till it is fine and smooth; take a little of this on a silk dabber, and carefully dab the block until sufficient ink is left upon the surface, without allowing any to sink below it. Lay a piece of India paper on the block with about two inches margin all round; on this place a thin smooth card; rub this over with the burnisher, taking care not to shift the card or paper.

Plugging.—If a slip, or mistake, occurs in a woodcut, it may be remedied by the insertion of a plug. A hole must be drilled in the block; if the error is a small one the hole need not be deep, but if a large piece has to be inserted it must be deeper in proportion. A plug is cut, of a round, taper shape; the small end is inserted in the hole, and the plug is driven down, without, however, using too much force. The top of the plug must then be cut off, and carefully brought to a smooth surface, level with the rest of the block; if this is not done the plug will be visible on the print. If the error to be remedied happens to be in a long line, a hole must be drilled at each end, and the wood between the two holes removed by small chisels, the hollow space being filled up in a similar way to that already described.

Lithography.—The following are the principles on which the art of lithography depends; — the facility with which calcareous stones imbibe water; the great disposition they have to adhere to resinous and oily substances; and the affinity between each other of oily and resinous substances, and the power they possess of repelling water, or a body moistened with water. Hence, when drawings are made on a polished surface of calcareous stone, with a resinous or oily medium, they are so adhesive that nothing short of mechanical means can effect their separation from it; and whilst the other parts of the stone take up the water poured upon them, the resinous, or oily parts, repel it. When, therefore, over a stone prepared in this manner, a coloured oily or resinous substance is passed, it will adhere to the drawings made as above, and not to those parts of the stone which have been watered. The ink and chalk used in lithography are of a saponaceous quality; the former is prepared in Germany from a compound of curd or common soap, pure white wax, a small quantity of tallow and shellac, and a portion of lampblack, all boiled together, and, when cool, dissolved in distilled water. The chalk for the crayons used in drawing on the stone is a composition consisting of the ingredients above mentioned. After the drawing on the stone has been executed, and is perfectly dry, a very weak solution of nitric acid is poured upon the stone, which not only takes up the alkali from the chalk or ink, as the case may be, leaving an insoluble substance behind it, but lowers, to a small extent, that part of the surface of the stone not drawn upon, thus preparing it to absorb water with greater freedom. Weak gum water is then applied to the stone, to close its pores and keep it moist. The stone is now washed with water, and the printing ink applied with rollers, as in letterpress printing; after which it is passed, in the usual way, through the press, the processes of watering and inking being repeated for every impression. If the work is inclined to get smutty a little vinegar or stale beer should be put into the water that is used to damp the stone.

There is a mode of transferring drawings made with the chemical ink on paper prepared with a composition of paste, isinglass, and gamboge, which, being damped, laid on the stone and passed through the press, leaves the drawing on the stone, and the process above described for preparing the stone and taking the impressions is carried into effect.

Lithographic Stones, to Prepare.—Stones are prepared for chalk drawings by rubbing two together, with a little silver sand and water between them, taking care to sift the sand to prevent any large grains from getting in, by which the surface would be scratched. The upper stone is moved in small circles over the under one till the surface of each is sufficiently even, when they are washed, and common yellow sand substituted for the silver sand, by which means is procured a finer grain. They are then again washed clean, and wiped dry. It will be found that the upper stone is always of a finer grain than the under one. To prepare stones for writing or ink drawings, they are rubbed with brown sand, washed, and powdered pumice-stone used instead; the stones are again washed, and each polished separately with a fine piece of pumice-stone, or water Ayr-stone. Chalk can never be used on the stones prepared in this manner. The same process is followed in order to clean a stone that has already been used.

Lithographic Ink.—Tallow, 2 oz.; virgin wax, 2 oz.; shellac, 2 oz.; common soap, 2 oz.; lampblack, ½ oz. The wax and tallow are first put in an iron saucepan with a cover, and heated till they ignite; whilst they are burning the soap must be thrown in in small pieces, one at a time, taking care that the first is melted before a second is put in. When all the soap is melted the ingredients are allowed to continue burning till they are reduced one-third in volume. The shellac is now added, and as soon as it is melted the flame must be extinguished. It is often necessary in the course of the operation to extinguish the flame and take the saucepan from the fire, to prevent the contents from boiling over; but if any parts are not completely melted, they must be dissolved over the fire without being again ignited. The black is now to be added. When it is completely mixed the whole mass should be poured out on a marble slab, and a heavy weight laid upon it to render its texture fine. The utmost care and experience are required in the making both the ink and chalk, and even those who have had the greatest practice often fail. Sometimes it is not sufficiently burned, and when mixed with water appears slimy: it must then be remelted and burned a little more. Sometimes it is too much burned, by which the greasy particles are more or less destroyed; in this case it must be remelted, and a little more soap and wax added. This ink is for writing or pen-drawing on the stone. The ink for transfers should have a little more wax in it.

Lithographic Chalk.—Common soap, 1½ oz.; tallow, 2 oz.; virgin wax, 2½ oz.; shellac, 1 oz.; lampblack, ¼ oz. Mix as for *lithographic ink*.

Lithographic Transfer Paper.—Dissolve in water ½ oz. gum tragacanth. Strain and add 1 oz. of glue and ½ oz. of gamboge. Then take 4 oz. French chalk, ½ oz. old plaster of Paris, 1 oz. starch; powder, and sift through a fine sieve; grind up, with the gum, glue, and gamboge; then add sufficient water to give it the consistence of oil, and apply with a brush to thin sized paper.

Transferring.—The drawing or writing made on the prepared side of the transfer paper is wetted on the back, and placed, face downwards, on the stone, which must previously be very slightly warmed, say to about 125° F. Pass the stone through the press four or five times, then damp the paper, and carefully remove it.

Drawing on Stone.—The subject should first be traced on the stone in red, great care being taken not to touch the stone with the fingers. Or the drawing may be done by means of a black-lead pencil; but this is objectionable, as it is difficult to distinguish the line from that made by the chalk or ink. Then, having a rest to steady the hand, go over the drawing with the chalk, pressing it with sufficient firmness to make it adhere to the stone. For flat tints, considerable practice is necessary to secure an even appearance, which is only to be obtained by making a great many faint strokes over the required ground. Lights may either be left, or, if very fine, can be scraped through the chalk with a scraper. If any part is made too dark, the chalk must be picked off with a needle down to the required strength.

Etching-in, for Printing on Stone.—Dilute one part of aquafortis with one hundred parts of water. Place the stone in a sloping position, then pour the solution over it, letting it run to and fro until it produces a slight effervescence. Then wash the stone with water, and afterwards pour weak gum water over it. The acid, by destroying the alkali on the lithographic chalk, causes the stone to refuse the printing ink except where touched by the chalk; the gum water fills up the pores of the stone, and thus prevents the lines of the drawing from spreading. When the stone is drawn on with ink, there must be a little more acid used with the water than when the drawing is made with chalk. The roller charged with printing ink is then passed over the stone, which must not be too wet, and the impression is taken as before described.

Engraving on Stone.—The stone must be highly polished; pour the solution of aquafortis and water over it, washing it off at once. When dry, cover with gum water and lampblack; let this dry, then etch with a needle, as on copper. It is necessary to cut the surface of the stone through the gum, the distinction of light and dark lines being obtained by the use of fine or broad-pointed needles. Rub all over with linseed oil, and wash the gum off with water. The lines on the stone will appear thicker than they will print.

To Imitate Woodcuts on Stone.—Cover with ink those parts meant to be black; scratch out the lights with an etching needle; the lines which come against a white background are best laid on with a very fine brush and lithographic ink.

Inking Roller.—Fasten a smooth piece of leather round a wooden roller of the required length.

Removing the Transfer.—The existing transfer is ground away by rubbing it with another piece of stone, putting sand between, like grinding flour between the millstones, using finer sand as it gradually wears away; then it is ground with rotten-stone till of the requisite fineness for the next transfer.

Transferring from Copper to Stone.—In transferring from copper to stone use prepared paper, that is, ordinary unsized paper, coated with a paste of starch, gum-arabic, and alum. Take about 60 parts of starch, and mix with water to a thinnish consistency over a fire; have twenty parts of gum ready dissolved, and also ten parts of alum dissolved; when the starch is well mixed, put in the gum and alum. While still hot, coat the paper with it in very even layers, dry, and smooth out. Take an impression from the copper with the transfer ink; lay the paper on the stone, damp the back thoroughly with a sponge and water, and pass through the litho-press. If all is right, the impression will be found transferred to the stone, but it will of course require preparing in the usual manner. The great advantage gained is, that very many more impressions may be printed from stone than from a copper plate, and very much quicker.

Engraving on Steel is the same as copper-plate engraving, except in certain modifications in the use of the acids; therefore, so far as the process is concerned, no particular description is necessary; but the means employed for decarbonizing and recarbonizing first the steel plate, so as to reduce it to a proper state for being acted upon by the graving tool, must be explained. In order to decarbonate the surfaces of cast-steel plates, by which they are rendered much softer and fitter for receiving either transferred or engraved designs, pure iron filings, divested of all foreign matters, are used. The stratum of decarbonated steel should not be too thick for transferring fine and delicate engravings; for instance, not more than three times the depth of the engraving; but for other purposes the surface of the steel may be decarbonated to any required thickness. To decarbonate it to a proper thickness for a fine engraving, it is to be exposed for four hours in a white heat, enclosed in a cast-iron box with a well-closed lid. The sides of the box must be at least three-quarters of an inch in thickness, and at least a thickness of half an inch of pure iron filings should cover or surround the cast-steel surface to be decarbonated. The box is allowed to cool very slowly, by shutting off all access of air to the furnace, and covering it with a layer of six or seven inches of fine cinders. Each side of the steel plate must be equally decarbonated, to prevent it from springing or warping in hardening. The safest way to heat the plates is to place them in a vertical position. The best steel is preferred to any other sort of steel for the purpose of making plates, and more especially when such plates are intended to be decarbonated. The steel is decarbonated to render it sufficiently soft for receiving any impression intended to be made thereon; it is, therefore, necessary that, after any piece of steel has been so decarbonated, it should, previously to being printed from, be again carbonated, or reconverted into steel capable of being hardened. In order to effect this recarbonization or reconversion into steel, the following process is employed; a suitable quantity of leather is to be converted into charcoal, by exposing it to a red heat in an iron retort until most of the evaporable matter is off the leather. The charcoal is reduced to a very fine powder; then take a box made of cast iron of sufficient dimension to receive the plate which is to be reconverted into steel, so as that the intermediate space between the sides of the box and the plate may be about an inch. Fill the box with the powdered charcoal, and, having covered it with a well-fitted lid, let it be placed in a furnace similar to those used for melting brass, when the heat must be gradually increased until the box is somewhat above a red heat; it must be allowed to remain in that state till all the evaporable matter is driven off from the charcoal; remove the lid from the box, and immerse the plate in the powdered charcoal, taking care to place it so that it may be surrounded on all sides by a stratum of the powder of nearly a uniform thickness. The lid being replaced, the box, with the plate, must remain in the degree of heat before described for from 3 to 4 hours, according to the thickness of the plate so exposed; 3 hours are sufficient for a plate of ½ an inch in thickness, and 5 hours when the steel is 1½ inch in thickness. After the plate has been exposed to the fire for a sufficient length of time, take it from the box and immediately plunge it into cold water. Here it is found by experience that the plates, when plunged into cold water, are least liable to be warped or bent when they are held in a vertical position, and made to enter the water in the direction of their length. If a piece of steel, heated to a proper degree for hardening, be plunged into water, and suffered to remain there until it becomes cold, it is found by experience to be very liable to crack or break, and in many cases it would be found too hard for the operations it was intended to perform. If the steel cracks it is spoiled. Therefore, to fit it for use, should it not be broken in hardening, it is the common practice to heat the steel again, in order to reduce or lower its temper. The degree of heat to which it is now exposed determines the future degree of hardness, or temper, and this is indicated by a change of colour upon the surface of the steel. During this heating a succession of shades is produced, from a very pale straw colour to a very deep blue. It is found that, on plunging the steel into cold water, and allowing it to remain there no longer than is sufficient to lower the temperature of the steel to the same degree as that to which a hard piece of steel must be raised to temper it in the common way, it not only produces the same degree of hardness in the steel, but, what is of much more importance, almost entirely does away with the risk of its cracking. The proper degree of temperature arrived at, after being plunged into cold water, can only be learned by actual observation, as the workman must be guided entirely by the kind of hissing noise which the heated steel produces in the water while cooling. From the moment of its first being plunged into the water the varying sound will be observed; and it is at a certain tone, before the noise ceases, that the effect to be produced is known. As a guide, take a piece of steel which has already been hardened by remaining in the water till cold, and by the common method of again heating it, let it be brought to the pale yellow or straw colour, which indicates the desired temper of the steel plate to be hardened. By the above process, as soon as the workman discovers this colour to be produced, to dip the steel into water and attend carefully to the hissing which it occasions, he will then be able, with fewer experiments, to judge of the precise time at which the steel should be taken out. Immediately on withdrawing it from the water, the steel plate must be laid upon or held over a fire, and heated uniformly until its temperature is raised to that degree at which a smoke is perceived to arise from the surface of the steel plate after having been rubbed with tallow; the steel plate must then be again plunged into water, and kept there until the sound becomes somewhat weaker than before. It is to be taken out, and heated a second time to the same degree as before, and the third time plunged into water till the sound becomes again weaker than the last; exposed the third time to the fire as before; and for the last time returned into the water and cooled. After it is cooled clean the surface of the steel plate by heating it over the fire. The temper must be finally reduced by bringing on a brown or such colour as may suit the purpose required. The above is an old process and not generally used. Engraving on steel is effected nowadays by graving and etching like copper; using for biting-in a mixture of 1 part pyroligneous acid, 1 nitric acid, 3 water; run off from the plate in less than a minute, rinse in running water, and dry quickly. Use stronger acid when a deeper tint is required.

Engraving Steel Cylinders.—A cylinder of very soft or decarbonized steel is made to roll, under a great pressure, backward and forward on the hardened engraved plate till the entire impression from the engraving is seen on the cylinder in alto-relievo. The cylinder is then hardened and made to roll again backward and forward on a copper or soft steel plate, whereby a perfect facsimile of the original is produced of equal sharpness.

Etching.—The apparatus consists of copper plates, etching needles, hand-rest, etching-ground dabber, oil-rubber, rottenstone, smoking taper, engraver's shade, bordering wax, stopping-out varnish, tracing paper, and aquafortis.

Ground.—The ground is composed of equal parts of asphaltum, Burgundy-pitch, and beeswax; place them in an earthen pipkin in an oven, and melt. The mass must be kept stirred until well incorporated. Pour the mixture into a basin of cold water, and, when nearly cold, it should be pressed, and rolled with the hand until all the water is discharged, then make into a ball. Procure a piece of worn silk, without holes; double it; place the ball therein, and tie up the ends with packthread, taking care that the double silk reaches well and tightly over the ball; cut off the surplus silk, and let the knot remain for a hand-hold.

Dabber.—Take a piece of silk, twice the size of that for the ground ball; double it; place in it a ball of coarse wool well picked out, about the size of a small apple; tie it up in the same way as the ball for the ground, and it is ready for use.

Oil-Rubber.—An oil-rubber is made from a strip of woollen cloth, about 2 inches wide, rolled up tightly, and bound over with packthread or thin tape. With a sharp knife cut off one end, avoiding the string, so that the surface may be quite flat. This is used for taking out stains, or polishing the plate, as in Fig. 46.

Fig. 46.

Rotten-stone.—Take a piece of fine flannel, rather less than the silk which covers the etching-ground ball; double it; place on it a small quantity of rotten-stone, in powder, which tie up in a bag. A small portion of fine whiting in the lump should be also kept at hand.

Smoking Taper, or Lamp.—For small plates, procure a wax taper; uncoil it by degrees before the fire until it is all equally pliant; double it up in about six lengths; give it one twist while warm, and turn it a few times before the fire, that the pieces of taper may adhere to each other; melt the wax at one end, so that the wick is exposed; see that all the cotton ends will light freely; care should be taken to extinguish the cotton, or it will revive with the least draught, and may become dangerous. For large plates it is preferable to use an ordinary oil lamp mounted on gimbals; this obviates the inconvenience occasioned by the dripping of the tapers.

Bordering Wax.— 3 oz. of resin, 2 oz. of beeswax, and such a quantity of sweet oil as will soften the mixture to fancy. Procure an earthen pipkin; place in the bottom ½ oz. or more of sweet oil; add the resin and beeswax, broken in small pieces; when melted work the ingredients well together with a stick until thoroughly incorporated; then pour into a basin of cold water; as it gets cold, work it well with the hands by pulling out into lengths and doubling it together again; the more it is worked the better it will be for use. Should it turn out brittle, return it broken to the pipkin, and add more oil; work it well together as before, pour it into water, and work it again with the hands.

Engraver's Shade.—Bend a piece of wire into a half circle; bind it together with waxed string; lay it on tissue paper; cut away all but ½ an inch round the wire: cover that ½ inch with paste, and turn it over the wire; when dry the shade is complete. Fasten a light string to the centre of the half-circle, and suspend it from the window-latch when in use. This shade must be placed in a forward position, sloping before the plate, and the white light it produces will enable the engraver to see the lines made by the etching needle. An equally effective shade may be made by covering a light square wire frame with tissue paper, and supporting it with two struts. This frame can be made to rest at any angle, upon the table immediately in front of the work.

Hand-Rest.—Any flat and thin piece of wood will answer the purpose, which is to keep the hand clear of the plate whilst at work. A good hand-rest may be made of a thin board raised above the work upon side pieces of such a height as to allow the plate to be freely moved underneath the board. The front edge of the board may be faced with a strip of steel planed true when it serves as a straight-edge. This arrangement will be found extremely handy.

Stopping-out Varnish.—Turpentine varnish is superior, for several reasons, to Brunswick black.

Turpentine Varnish.—Break small pieces of resin into a phial; pour over spirits of turpentine to about twice the height of the resin. Place the bottle in a small saucepan of water on the hob, near enough to the fire to make and keep the water hot; place a cork lightly in the mouth of the bottle, as the mixture will require to be shaken occasionally. Pour a small portion of this mixture into a small pot, with a little lampblack added to give it a colour, and well mixed. This last is necessary to prevent lumps; it may be done by working the mixture well together with the camel-hair pencil. This is a good stopping-out varnish. With this varnish go over the border or margin of your plate; do this when about to put it away, and the varnish will become hard by being left a night to set. When biting-in again, go over the margin, using the same brush and mixture. It can always be worked up by adding a little turpentine. When it is set so hard that the finger may be placed on it without sticking, it is time to make up the wall or border of wax to hold the aquafortis.

Aquafortis.—Procure three half-pint bottles with glass stoppers, and two pint earthen jugs with spouts. Place ½ lb. of nitric acid in bottle No. 1. Pour into bottle No. 2 rather less than the fourth of the nitre; fill the bottle three-parts full of water; slowly pass it into one of your pint jugs, and back again to the bottle, to mix it well. In bottle No. 3 put one-half of the remaining nitric acid; water it as before; see that the nitric acid in bottle No. 1 is well stoppered, and cover it with a piece of old glove.

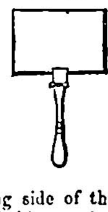
Tracing and Tracing Paper.—Tracing can be conveniently effected by using sheets of transparent gelatine, similar to that made for Heliotype purposes, and placing it over the drawing, which can be seen clearly through the gelatine. Trace with a sharp etching-needle, taking care to remove the burr from the lines with the thumb-nail as the work proceeds. When finished, fill in with fine powdered Brunswick black, entirely free from grease, or powdered red chalk, reverse on to the plate, and rub the lines with a burnisher. Tracing paper of various qualities may be readily purchased. But in case of necessity, very good tracing paper may be made by saturating, with a camel-hair pencil, the finest tissue paper with the following mixture;—⅓ oz. of balsam of Canada, to ¼ oz. of spirits of turpentine; shake well together in a 2-oz. bottle. When covered with the mixture, hang the paper on a line to dry; then wash in like manner the other side. Place your drawing on a tracing board, a piece of soft planed deal; lay the tracing paper over it; fasten down with brass-headed points, not through the drawing, but close to it, so that the pressure of the brass head secures both the drawing and tracing paper from moving. Go carefully over all the lines of your drawing with an H pencil, occasionally placing a piece of white paper between the drawing and the tracing paper to ascertain that no lines on the drawing have escaped attention.

Transferring Paper.—This is made as follows;—Take half a sheet of very fine bank-post paper; lay it on a clean place, and rub it well with the scrapings of red chalk with a small piece of sponge. Apply the chalk until the paper is all of one colour; then, with a piece of clean old muslin, rub the greater part of the colour from the surface. The colour may be renewed occasionally as the markings become faint.

Testing the Ground.—Heat one corner of your plate and rub over it the ground in a thin and even surface. Next apply your dabber, to make a yet more equal distribution of the ground. When cold, mark over it with rather a blunt needle (No. 3). Should the ground be brittle, and crack with the passage of the needle, add to it more beeswax; should it drag with the needle, add more asphaltum; the ground will easily melt again. When a ball is satisfactorily made it will last a long time. The weather has considerable effect on the mixture, and the quality of the ingredients is very important, so that it is advisable to get the ground as perfect as possible while the melting pot is in use.

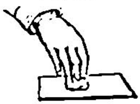
Heating the Plate for Ground.—Have a small hand-vice, Fig. 47, with a haft of wood to resist the passage of heat to the hand. If the plate is stained or discoloured, the mark must be removed with the oil-rubber with a little rotten-stone and oil, polished off with a bit of old muslin powdered with whiting, care being taken that no dust remains on the plate.

FIG. 47.



Screw the vice on the long side of the copper plate with a slight hold, covering the part grasped by the jaws of the vice with a small piece of paper to prevent injury to the surface. Heating may be performed by burning paper under the back of the plate; but a stove or clear fire is preferable, and a couple of spirit lamps with rests for the corners of the plate, the best plan of all. Be careful not to overheat the plate. If the surface becomes discoloured the plate is over hot; as a test, turn it over and spit on the back; if the moisture jumps off, the plate is sufficiently hot; should it hiss and remain on the plate, more heat must be obtained. A piece of canvas, rather larger than the plate, should be warmed by laying it before the fire during the heating process; place it on the table, and lay upon it the plate retained in the vice. Now pass the ball of ground, Fig. 48, over it backwards and forwards until the plate is covered, spreading the ground as evenly and thinly as possible. Use the dabber with a quick action, pressing it down and plucking it up. If the ground does not distribute itself easily, burn paper under the plate as before until it shines all over, being cautious that the ashes of the paper do not settle on the surface; dab on again, decreasing the pressure, but not the speed of action, until the surface is all over alike.

FIG. 48.



Smoking the Plate.—Have the taper ready, and a single taper or candle to take the light from; the surface of the plate being perfectly covered, it may be as well to renew the heat in the plate, by a paper burnt under the back until the surface shines, taking the same precautions as before. Hold the plate in the left hand, with the face downward; light the smoking taper, Fig. 49, at the same time, having all the wicks burning; pass it rather quickly round the margin, and by degrees towards the centre, using a fluttering action with the hand, Fig. 50; smoke on until the whole surface is of a dark colour, keeping the taper at such a distance from the plate that the burning cotton may have no chance of touching it, although the flame spreads over it. Another way is to suspend the plate, if of large size, overhead, and smoke with the oil lamp. When the surface is all black alike, and no sooty marks are to be seen on the working part of the plate, the ground is fit for use. Take the plate, face downwards, to some convenient place, and pour cold water over the back, Fig. 51, holding the plate in a sloping position, the vice up. This last process produces a stronger and harder surface than could be obtained if the plate were left gradually to cool. Now place the plate face downwards, supported on one side by the screw of the vice, Fig. 52. Clean the smoke from the back, and let it remain until quite cold. Some difficulty may be found in laying the first ground with success, but with a little practice this is surmounted.

FIG. 49.

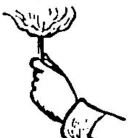


FIG. 50.

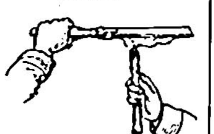
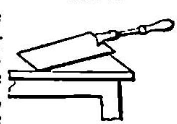


FIG. 51.

FIG. 52.



Transferring.—In the absence of an etching board, place the copper plate on a thick piece of brown paper larger than the plate; make two ribs of the same paper, doubled four or more times, and about an inch wide; place them at each end of the plate on the brown paper, and fasten them with sealing wax; these ribs serve as shoulders for the rest to lay on, which will prevent the hand from touching the work. Now cut the tracing paper to the size of the plate, having ruled the margin line if one is required. Place the tracing reversed; that is, with the pencil side to the plate. Fix it with pieces of soft wax round the border, leaving open the bottom to admit the transfer paper, which introduce with the chalk side next to the plate; the upper side of the paper must be kept clean, that the pencil-lines on the tracing paper may be seen. With an H H pencil, cut sharp and short, go over all the lines of the tracing with rather an upright hand and a strong pressure; the upper side of the tracing paper will show whether all the lines have been traced; look sideways at the work, and the black-lead marks will be perceptible. Before advancing far in the transfer, lift up the bottom of the tracing to ascertain if the lines are of sufficient strength; if not, apply more red chalk to the transfer paper. When the transfer is nearly completed, do not take off the whole of the paper, but let the top part remain fixed. Then lift up the tracing, and if any part of it has been neglected, it can again be fixed down, and the omission rectified.

Etching. — Commence with a fine-pointed needle, No. 1, and go carefully over the outline, not making much impression on the copper, but sufficient to remove the ground; with the same point go over all the lighter parts, increasing the pressure, so as to make a slight indentation on the plate. No. 2 point may now be used to go over the lighter shade, with an increased weight of hand. No. 3 point will answer for the darker shades by making the lines nearer together and increasing the pressure. Interline parts that require extra colour with No. 1 point; the etching may be worked at for a considerable time by interlining and dotting. If there are any marks to expunge, dip a pointed camel-hair pencil into the turpentine bottle, and with its point work up some of the ground on the margin of the plate, and therewith stop out the objectionable marks. When set it will resist the aquafortis.

Bordering the Plate.—In cold weather the wax will be too hard to roll out with the hand; in that case it must be placed in moderately warm water until it becomes pliable; then pull and roll it out, Fig. 53, to about the thickness of a small walking-stick; slightly grease the point of the thumb and two forefingers with deer or mutton fat; press the roll of wax flat, and place it on the border of the plate with the edge to the varnish, taking great care that the bordering wax does not go off the varnish. At the parts intended to be the darkest corner of the plate pinch out the wax border, that the height of the wall may be increased at that corner where the spout is to be formed with the wax to prevent spilling the aquafortis in pouring it off.

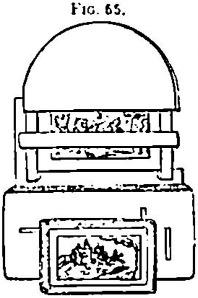
FIG. 53.

Biting-in.—Lay the plate flat on a piece of canvas larger than the plate as a protection from any splashings that may be made. Place the spout of the plate in front for the convenience of pouring off. Pour a little water over the plate to see if there are any leaks in your border; if there are any, pour off the water; let the plate dry, particularly in the defective part; then press down the outer edge of the wax with a piece of wood. Leaks can also be found without using water by holding the plate up to the light and looking at the edge, when the smallest pin-hole will be immediately detected. Have two or three small wedges, to be used for tilting the plate should the acid not lay even. When the border is sound pour off the water; then cover the surface of the plate with the aquafortis from No. 2 bottle. If, in the course of half a minute, the etching on the plate should assume a light-grey coating, the mixture is good; but if it should throw up bubbles, it is over strong, and more water must be added, but not on the plate. The mixture must be placed in the jug, then in the bottle, and afterwards returned to the plate. Should the lines on the plate remain as bright copper after the acid has been on half a minute, it is not strong enough, and some aquafortis out of bottle No. 3 must be added. When the mixture on the lines does not produce a foam, but the plate continues of a grey, frosty appearance, the process is going on well. The power of biting-in correctly depends on the experience in using the acid. With a soft camel-hair pencil lightly remove the frosty appearance, taking care that the quill does not touch the ground. Should any part of the ground break up by the lines becoming united, pour off the acid carefully into the jug. Lay the plate again on the flat, and cover it with water from the other jug, moving it gently with the camel-hair pencil, which place at once in a water-jug when taken from the acid, or it will soon be destroyed. Throw away the wash-water from the plate. When the first biting is completed set the plate up endways to dry, Fig. 54.

Fig. 54.

Second Biting.—When the plate is perfectly dry, take off with a blunt point covered with silk and dipped in turps a spot of ground in the lighter part to ascertain if the acid has made sufficient indentation. If it has, work up the stopping-out varnish with a camel-hair pencil, and with it cover all the parts intended to remain light; elevate the rest, Fig. 55, so as not to press the border wax. When the stopping-out varnish is dry, which may be ascertained by placing the finger on it; if it does not stick, it is dry; put on the same aquafortis (bottle No. 2), and let it remain until you observe the ground giving way; then pour off the acid, and wash well as before. Put the plate to drain. Should it be required, more biting may be done; the process is the same.

Fig. 55.



Cleaning Off. — Great care must be taken that the plate is perfectly dry; if it is not it may be placed before the fire, but not close enough to melt the wax. Having carefully wiped the canvas, lay the plate a little more than half-way upon it, so that the balance remains upon the table. Apply a lighted taper, or a folded paper match, progressively under the wax; pull up the wax, Fig. 56, as the warmth proceeds; a very slight warmth answers the purpose. By removing the wax with a knife you are liable to injure the margin, which is difficult to remedy. Should any of the wax adhere to the plate, remove it by using a piece of wood cut in the shape of a chisel. Fix the vice on the same place as when laying on the ground. Rub the plate over with turps, taking care to go over every part; hold the plate up by the vice; heat the back with burning paper as before, until the ground varnish and tallow are melted. Rub off with a soft rag. Should any smut remain, apply a little turpentine; withdraw the vice, and wash the spot it covered with turpentine. Rub the plate front, back, and sides with the rag. Dab the plate with the bag of rotten-stone; pour on it a little sweet oil; and polish the plate with oil-rubber, using considerable up-and-down pressure; wipe the plate quite clean, and polish with fine whiting. Should the biting-in have succeeded, the plate is ready for the printer.

Fig. 56.

Dry Point.—The dry point may next be used. For this purpose the needle No. 3, well pointed, may be employed, as indenture must be made by pressure of the hand. For interlining the parts which are too weak, and uniting lines neglected in the etching, the dry point will be sufficient; but the pressure will leave a projection or burr on the plate, which must be carefully removed by the sharp scraper; should the plate require more than the dry point can accomplish, recourse must be had to re-biting.

Re-biting.—Heat the plate as before, but make one corner, the one with the least work in it, hotter than the other part. Prior to laying the ground the plate should be polished with whiting, or with methylated spirit and aquafortis, using a piece of old muslin folded in the shape of a dabber, which will fill the etched lines, and prevent the new-laid ground from entering. Rub the ground on the hot corner, and with the dabber take the ground therefrom, and dab quickly over the other part until the whole surface is covered. All the parts but those wanting more colour may be stopped out as before; the border wax must again be used. Next follow the same process with the acid.

Re-etching.—This is the most certain method of finishing the plate. The ground must be laid as in the first instance, but using a greater body, and with the dabber, Fig. 57 rubbing it well into the lines, taking care that no whiting remains in the etching marks; for this process the plate should be merely washed with turpentine; a slight extra warmth and good dabbing will render the ground acid proof. The smoking is here dispensed with. Set up the ground, and work at the plate as in the first instance. Now use No. 3 sharp point, and interline the parts that should be darker and where greater strength is wanted, crossing the lines, not at right angles, but lozenge-ways. The plate cleaned off as before directed, receiving a light oil rubbing with a little rotten-stone, and washed off with turpentine, may now be sent to the printer's, and a proof obtained. By repeating the re-etching the plate may be worked up to the colour of a line engraving. In some of the darker parts a graver or lozenge-tool may be used; but it is rather dangerous in the hands of the uninitiated; as it is apt to slip, and make deep lines where none are wanted. Re-biting will produce any extra colour that may be wanted with little more trouble and with greater safety.

FIG. 57.

ETCHING.—PROCESS AVOIDING STOPPING-OUT.—For the first biting, ground and smoke the plate in the ordinary manner, then etch those parts only which are to be darkest, such as vigorous foreground in landscapes, and other deep work. Use no delicate lines at this stage; japan the back of the plate and the spot where the hand-vice was placed; use a photographer's tray as an acid bath, in which immerse the plate in nitric acid until the very black lines are bitten-in. Clean the plate, and take a proof. For the second biting, ground the plate again, and smoke it; the first lines will still clearly show. Draw all the work of a medium darkness, with a sharper point than that used for the first biting-in. Place the plate in the acid bath, and let it remain until the lines are of a moderate depth. Remove and clean the plate, and take a second proof. For the third biting, ground with transparent ground, and do not smoke it. Etch all the delicate work, keeping the lines close to each other, and using a sharper needle than before. This operation requires more care than the two previous ones, as the lines will not show very distinctly. This process is of great service for intricate work, in consequence of the ease it gives of introducing pale lines amongst the darker work, and a delicate background beyond the vigorous lines of the subject; whilst, by taking proofs after each biting, the progress of the work may be seen, and its correctness ensured. By covering the back and edges of the plate with japan varnish, the old and tedious process of banking up the sides with wax is avoided, and the plate may be plunged into the acid bath without any further risk or trouble.

ETCHING.—GENERAL INSTRUCTIONS.—The following directions will relieve beginners from much trouble, and enable them to avoid many accidents to which engravers are liable;—when using the acid, slightly grease that part of the hand likely to come in contact with it, as a preventive to its making stains, which are not easily eradicated. When your border wax has done its duty, have it well washed in cold water, then warmed before the fire, pulled out and pressed together again, as the more frequently that is done the more pliable the wax will be for future use. As your aquafortis will become reduced in strength by exposure to the air, it becomes necessary to add a portion of No. 3 bottle to that of No. 2, and a small quantity of

No. 1 bottle to No. 3, No. 1 bottle containing the undilute acid. When making a point to an etching needle, work the point round, as, should there be any flat side to the point, it will bite the copper, and prevent the freedom of hand required to give spirit to the etching. The burnisher will soften down any part of the etching that appears harsh or crude, by gently passing it over the parts to be reduced in colour. The shade must be between the plate and the light, in order to be able to see the marks of the burnisher; fine charcoal and oil will remove these marks, and the oil-rubber will clear away the charcoal marks. The charcoal can be obtained at a coppersmith's or plate-printer's. If a burnisher is good at first, it never requires alteration. The scraper must be occasionally sharpened.

Soft Ground.—Take half a ball of hard ground, mixed as described under the head *Etching Ground;* to that add a piece of mutton suet. Melt them well together, observing that the ingredients must be thoroughly incorporated; then pour into cold water, and use it as before directed.

Laying the Ground.—The process is exactly the same as in laying the etching ground, with this difference, that the plate does not require so great a heat. Smoke the plate the same as in laying etching ground. The ground must be spread as thinly as possible, to cover the plate and bear smoking. The surface of the plate must be alike all over, and quite bright or shining. If any part but the edges appears sooty, it must be cleared off and the plate polished, as described for etching, and laid again. A good ground may be made at the first melting, but that can scarcely be expected. It may be as well to test the quality of the mixture before laying a whole ground. To this end, heat a small portion of the plate; lay on the ground; smoke it; and let it get quite cold. Obtain some of the finest tissue paper, of very even texture. Place a piece of the paper on the patch of ground laid, and, with a fine-pointed H pencil, make a slight sketch;—a bit of foliage, for instance; the paper should slightly stick to the plate; when carefully raised by the two bottom corners, the back of it should clearly show every line made on its surface, only darker. Should the sketch on the copper look as if it was dotted all over, the mixture of ground will do. Should the ground adhere to the paper, like marks with pen and ink, the ground must be melted, with an addition of hard ground; and if even the softest marks of the pencil do not pull the ground from the plate, the ground must be remelted and remixed until it is fit for work. As the temperature has great effect on this ground, that which will answer for summer will not do for winter, so it may be as well to make two or three mixtures, and number them according to their several degrees of hardness. Having succeeded in mixing the ground, take a piece of tissue paper twice the size of the plate. Place the plate in the centre, and with a black-lead pencil draw a line all round it. Make the same mark on the other side; then lay the ground as described. When cold, wipe the back and edges before taking off the hand-vice. This ground being very tender, care must be taken not to touch the face of the plate.

Drawing.—The drawing is to be made upon the square marked on the paper. If it is intended to copy a subject, the same process as in transferring for the hard-ground etching is used; only, instead of transferring the red lines on to the plate, they must be made within the square marked on the paper. Take care that the tracing is reversed. If it is intended to draw on the plate without copy, lightly make the design on the square marked with fine-pointed red chalk. Should the subject be figures, everything must be drawn to the left hand, or reversed. Fold a silk handkerchief in four; lay it flat and smooth on the table; place on it the paper, with the chalk sketch downwards. Then, with great care, lay the plate, face down, exactly on the square mark of the paper; fold over the back the surplus paper, and fix the sides with four thin spots of sealing wax near the corners; be sure not to move the plate on the silk. Take up the plate carefully, and place it for work. Use a hand-rest, as in etching, and a hard-pencil, H H, on the places you wish to be dark. In soft-ground engraving, the drawing must be finished the day it is commenced; the mechanical part of the work may be delayed. When the drawing is finished, pull up the paper by the two bottom corners. Varnish the border down the same as in etching. The acid used must be much stronger; the border wax higher and broader in the spout, as you may perhaps have to pour off suddenly.

Biting-in.—In biting-in, pour off the acid when the ground begins to break up; that is, coming up in patches. During the biting-in the soft camel-hair pencil may be used, but very tenderly. Wash well off with cold water, and place the plate to dry. For cleaning, see *Etching*. Should the plate require more finishing, have recourse to the hard ground without smoking.

AQUA-TINTA ENGRAVING.—This was formerly resorted to where the object was to produce a plate, the impressions from which were to be coloured. It is recognized by its similarity to Indian ink or sepia drawing; for, in working the plate at press, black and brown inks are used indifferently, as the artist or publisher may direct. Resin forms the ground in this method of engraving.

Aqua-tint Ground.—Break some of the best white resin into pieces, and put into a bottle with spirits of wine, and shake occasionally until the resin is dissolved. The bottles must have corks, not glass stoppers. Have two other bottles ready; mark the bottles 1, 2, 3. No. 1 is the bottle into which the resin is placed. Pour a third of No. 1 into No. 2, and nearly fill it with spirits of wine. Pour into No. 3 rather less of the mixture from No. 1, and nearly fill it with spirits of wine. These bottles must be occasionally shaken, and their contents allowed to settle well before use. The contents of the three bottles must be so mixed that they are one under the other in strength, as the size of the grain to be laid on the plate depends on the quantity of resin each mixture contains. The more of resin the larger the grain. The spirits should be entirely free from water.

To Test the Spirits.—Place a small quantity of gunpowder in a silver spoon; pour over it some of the spirit; light the spirit, and let it burn to the powder. If the powder takes fire and explodes, the spirit is good, and fit for use. Should it remain in the bottom of the spoon, black and wet, the spirit has been adulterated with water, and is not fit for the purpose.

Trial of Aqua-tinta Ground.—Have a tin trough about 2 inches wide, and rather longer than the plate, with a convenient spout at one end; the trough is to act as a receiver of the spirit when poured over the plate; the spout to return it to the bottle.

Laying the Ground.—Polish the plate well, as before directed. Place it at a slight slope, the tin trough under the lower edge to receive the spare mixture. As a trial of the ground, pour the liquid from each bottle, and make a small patch in different places at the bottom of the plate. When the liquid has run off into the tin trough, lay the plate flat, and with a piece of rag wipe the lower edge. Take a magnifying glass, and look at the grains deposited on the copper. Having poured the spirit from the trough to bottle No. 1, make choice of the grain most likely to suit the work; if neither of the three should, mix the large grain and the small together until it does, letting the mixture settle well before it is used. Remove the trial spots; polish the plate well, and place it as directed for trial with the side intended for the foreground next to the tin trough. Pour the mixture along the top of the plate, from one end to the other, until the whole of the surface is covered. As soon as the spirit has run into the tin, lay the plate flat; the sooner it is laid flat the rounder will be the setting of the grain; the longer the plate remains on the slope the more elongated the deposit of resin will become, which for some sort of work will answer better than round; such as broken rock, waterfalls. In most cases it is advisable to make a very fine etching of the subject intended to be placed on the plate prior to laying the aqua-tinta ground; in the end it will save time. The etching must be very light, otherwise the aqua-tinta ground will hang round the lines, and form a ray of light. Should the etching be strong, it will require to be filled up with wax, and polished off before laying the ground. Engravers send the plate to the printer's to have it filled up with ink, which is the best method. If obliged to use wax, heat the plate rather above what is required for the etching ground, the surface wiped off, and polished with the soft part of the hand slightly rubbed with whiting.

Stopping-out the Lights.—Place on the left side a small looking-glass in a leaning-forward position; lay before it the drawing intended to be worked from, with the base or foreground towards the bottom of the glass; you will then see the subject reversed in the glass. Go over the margin as directed in the head Etching. For this a camel-hair pencil and the same pot of varnish, with a little more lampblack added, and well worked together, should be used. Stop out all the white lights seen in the drawing. By the time this is done the varnish on the margin will be dry or set; if not, the plate must remain until it is. Go over the margin again with the same varnish, and let that set hard. Place your border wax as before directed, making the spout rather larger, that you may be enabled to pour off the acid quickly if necessary. Use the same aquafortis as for etching, but the strength somewhat increased, as it must remain on the plate a much shorter time. Lay the plate an inch or so over the front of the table, with a piece of canvas underneath, having small wedges of wood ready to be used should the acid not float evenly.

First Lights.—Pour on the acid rather quickly, running it from the bottle to the jug, then on to the plate; another jug, having been filled with cold water, should be kept ready for washing off. When the acid has entirely covered the plate, the surface should immediately assume a frosty appearance, but not come up in bladders. Little more than a minute may be enough for the acid to remain on the plate; pour it into the jug as quickly as you can without spilling it; immediately wash off with cold water; have a receiver for the wash-water, as it must be thrown away.

Second Lights.—Dry the surface of the plate, and, should any spots of moisture remain on the surface, carefully take them up with blotting paper. Now, with the same varnish, stop out all the second lights. To prevent injury to the border, place two blocks or old books under the ends of your rest.

Third Lights.—When the second stopping-out is set, put the plate through the same process with the same acid. Again dry the plate, and stop out the third light parts; when set, apply the acid, but let it remain on rather longer; wash as before directed. As all the flat tints are now laid, it only requires the very dark ones. Ascertain, with a magnifying glass, if the spots of resin remain on the plate; if so, it will bear biting again. Should the ground remain sound enough to stand another application of the nitre, you must prepare a mixture called touching stuff.

Touching Stuff.—Burn a good-sized cork to ashes; take some treacle and add as much ivory black as will make the mixture a dark colour by the addition of a small quantity of sheep's or ox gall; it works almost as free as the varnish. Make the composition into a ball, a small quantity to be used with water when required. Again lay the plate for work. Paint over all parts that are required to be very dark, such as projecting foliage, and all sharp shadows, with the touching stuff, loading all the touches with as much of the mixture as can be placed on them. When the touching stuff is dry, mix some turpentine varnish, slightly coloured with lampblack, and with a larger brush go over the whole of the plate. When this last varnish is set, pour on some very weak acid and water; the former washings of the plate will do. With the soft camel-hair pencil used for the acid, work up the touching stuff until the whole comes off; then wash the plate clean with cold water, and again apply the acid. For this last biting the acid may remain on the plate as long as the ground will stand. This may be ascertained by clearing the plate with the camel-hair pencil, and using the magnifying glass. The plate must now be cleaned, and remove the border wax as before described. On this tint the oil-rubber should be very carefully used. The plate being quite clean, and placed under the shade, it will be found that the tints or bitings are rather sharper against each other than is required. The burnisher will remove this by rubbing the parts which are to be reduced in colour. The parts to be burnished should be slightly touched with the oil-rubber. The use of the burnisher requires some skill, which can only be acquired by practice. The scraper is useful for bringing out sharp lights, and modulating the darker parts. If the first ground is not satisfactory, the plate must be polished, and another ground laid. The second ground must contain more resin than the first; bordering, biting, and stopping-out as before. The plate should be sent for proof before the second ground is laid. The proof will show where increase and where reduction of colour is required. The burnisher will reduce; the increase can only be had by laying another ground.

Ground to Etch on.—Mix a small quantity of turpentine varnish with turpentine slightly coloured with black, but only sufficiently so as to render the lines made by the needle perceptible. With this thin varnish, and a good-sized camel-hair brush, go over the plate lengthways; when that is set, repeat the coating crossways; let it set, and lay it by for a night if convenient. The etching finished, border and bite as before directed, but with stronger acid.

AQUA-TINT ENGRAVING. — GENERAL INSTRUCTIONS. — Great care must be taken while laying the ground that there is not much dust floating in the air; for, should the slightest particle of flock lodge on the plate whilst wet, it will cause what is called an accident. Wherever the speck falls the resin will corrode around it, forming a white spot on the ground where the acid has been applied. These accidents are of little consequence, unless they should happen on the sky. To do away with these light places, the chalk tool, or dotter, must be used; this is simply a bent graver. From pouring the ground mixture backwards and forwards, it is likely to become foul; it should then be passed through a double piece of clean muslin, and put away in a bottle to settle. The burnisher acts as principal in forming a good sky and background. As the action of the acid will leave all the tints with a sharp edge, they must be softened down with the burnisher. Every fresh aqua-tinta ground laid should be increased in the size of the grain, or the ground will become murky. To enrich and darken the foreground and foliage, etching over the parts with the etching ground above described is much the easiest method.

Resin-ground Engraving.—This is well adapted to ornamental work, as great depth of colour can be obtained. The process is extremely simple. The best white resin should be reduced to powder by pestle and mortar, then placed in fine doubled flannel, and tied up in a bag. The plate must be heated as in laying etching ground, and the resin then powdered on the surface; lay the plate on a table, so as to leave both hands free. Take the bag of resin in the right hand, and strike it against the left, the bag must be held some distance from the plate, which will force the powdered resin to escape from the flannel bag, and, falling on the hot plate, will there fix itself in small spots, something similar to the aqua-tint deposit, but much more enduring. This produces very imperfect results and causes dry ground engravings to be looked on with disfavour. The stopping-out process is the same as in the aqua-tint. By repeating the process with the flannel bag, a positive black ground may be procured, as dark and more enduring than a mezzo-tinto ground, and it may be scraped on much in the same way.

HAMERTON'S BRUSH PROCESS.—This process consists in the employment of a pigment which is strongly attacked by acid. Clean the plate thoroughly with whiting and turpentine. Remove the whiting by rubbing the plate with bread; after removing which do not allow the hands to touch the plate. Crush a soft pastel into fine powder; mix with a strong solution of white sugar. Add a solution of ox-gall, about equal in quantity to half the sugar solution. The pigment must be so mixed as to work rather freely, and draw a thin line with ease and precision. With a small, fine-pointed sable-hair brush, make the drawing on the plate, depending mainly upon lines, as with a pen; when this is completed, be careful not to let anything touch the plate, as the pigment dries slowly. Dissolve some ordinary etching ground in ether; hold the plate with a pneumatic holder, and pour the solution upon the plate till it makes a pool reaching the sides of the plate; move the plate gently from side to side, then pour the superfluous solution back into the bottle. Heat the plate gently over a spirit lamp, holding it about 12 inches above the flame, and taking care to evaporate the ether gradually, and not to allow it to catch fire. The ground will become transparent. Place the plate in a bath consisting of hydrochloric acid, 100 grammes; chlorate of potash, 20 grammes; water, 880 grammes. The hydrochloric acid used should not be of a deep yellow colour; should not give off fumes, and, when mixed with water, should have but a slight odour. Leave the plate in this bath a quarter of an hour, then brush the surface of the plate very gently with a feather. This will remove the pigment and the ether varnish over it, leaving the lines exposed to the acid. The copper between them will be perfectly protected. Leave the plate in the bath until bitten-in to the required depth, stopping-out when necessary. The finer portions of the work may either be finished with the dry point, or in point etching; in the latter case using a transparent ground. If any erasing is necessary, it must be done with a scraper. If the pigment does not take on the plate, the copper may be slightly roughened by a short immersion in a weak nitric bath. Let the ether ground remain a night on the copper before heating it, which must be very carefully done.

Hamerton's Negative Process.—This process avoids stopping-out altogether, and the progress of the work may be judged of with tolerable certainty. The ground is a solution of beeswax in turpentine. Decant the solution till no sediment remains; it should be perfectly fluid, and of a bright yellow colour. Add about one-sixth of its volume of japan varnish; this quantity will vary slightly according to the heat of the weather. If there is too much japan, the ground will be hard and brittle; if there is too little, it will not be strong enough to take smoke with safety. Clean the plate with engravers' emery paper, and place it in a bath of hydrochloric acid, 100 grammes; chlorate of potash, 20 grammes; water, 880 grammes. When the plate darkens all over, it is a sign that there is no grease on it, and it is then ready to receive the ground. Pour on the ground as photographers pour collodion, and let it dry for 12 hours; apply a second coat of ground in the same manner, and smoke the plate immediately without waiting for it to dry. The ground should then be even and smooth, and ought to be used a few days after it is laid, as it hardens in time. If in haste to use the plate, the first coat of ground may be dried over a spirit lamp until it becomes transparent; cool the plate, and proceed as before described. The use of the two coats of ground is to prevent the smoke penetrating to the plate, and causing the ground to become detached in the acid bath. Should the ground be too hard, increase the proportion of the wax solution. Draw all the dark parts first; plunge the plate into a bath of nitric acid for half the time necessary to complete the biting. In temperate weather this would be half an hour; the first biting would, therefore, take about 15 minutes. Remove the plate, dry on blotting paper, draw the next darkest lines where required, and replace the plate in the bath for a quarter of the total time. This process is repeated, and the plate, with the paler work, is replaced in the bath for one-eighth of the total time. The palest work of all is last drawn, and the plate is plunged into the bath for an eighth of the total time. Thus the plate will have had the darkest lines in acid the whole time required, the darker lines half the time, the pale lines a quarter, and the palest lines one-eighth of the times, as each biting-in has the advantage of those which preceded it. Finish with the dry point where required.

HAMERTON'S POSITIVE PROCESS.—By this process the work is distinctly seen during operation; black on a white or silvered ground, without any deceptive glitter, and exactly as it is to be seen in the print. Clean the copper plate, and rub it with a clean rag and a little of Levi's *crême d'argent*, cyanide of silver. Remove the superfluous cream with a clean rag, and the plate will be properly silvered. If the cream is too thick, add a little spirits of wine. If it is wished to make the silver of a dead white, slightly roughen the surface of the copper before silvering with fine emery paper, rubbed from right to left, or from left to right, of the way it is intended to work the plate. Use a white ground, made by dissolving white wax in ether—a saturated solution. Let it settle a few days; the clear part only is required, the milky portion at the bottom, being undissolved particles, are probably insoluble and useless. To apply this ground, hold the plate underneath with a pneumatic holder; pour the solution on the silvered side; move the plate gently but firmly from side to side, so that the solution may run to and fro; then pour all the superfluous ground back into the bottle. In finishing, move the plate more rapidly. Let the ground dry for 3 days. Apply a second coat in the same manner, and let it dry for 4 days in a quiet room, where it will not catch any dust. If the plate is dried by the heat of a spirit lamp, the ground will be transparent, but not of the dead white colour which is desirable. Paint the back and edges of the plate with japan varnish to protect them in the bath, which must be composed as follows;—Chlorate of potash, 20 grammes; pure hydrochloric acid, 100 grammes; water, 880 grammes; or the same proportions in English weights. Warm the water, dissolve the chlorate of potash in it, then add the acid. Sketch the subject with some pale but decided water colour, red or yellow for example, using the point of a small camel-hair brush. This will remain visible whilst the plate is being etched, which must be done whilst it is in the bath; the acid will, of course, attack the needle, but this action keeps the needles sharp, and they are not costly tools. The bath should be formed in an oblong square piece of light wood, about 1½ inch thick, and larger than the well, which must be a square hole, a little larger than the plate, and about an inch deep. Cover the board and well with about six coats of japan, which protects the wood from the action of the acid, and the dark colour makes the plate look whiter from the contrast. A thin piece of wood, stained black, must be used as a hand-rest. Before using a new bath or well dissolve a small piece each of copper and of zinc in it with acid. Lay the plate in the desired position, and fix it by pressing small pieces of modelling wax at the corners against the plate and the board. Etch with an ordinary strong sewing needle inserted in a holder. It must be sharp enough to scratch well through the silver, otherwise the line will not blacken at once. The wax ground permits the lines to enlarge slowly; thus there is a constant gradation in thickness from the first to the last lines; as the time of exposure diminishes, this property must be carefully attended to. Thus, if the subject requires only about 2 hours' work in etching, this must be spread over 5 hours' exposure in the bath, which is the time necessary to produce the darkest lines; other work can be carried on simultaneously, but this process cannot be hurried. If, however, the subject is elaborate, and requires more etching than can be finished in 5 hours, select for the first sitting various parts over the whole plate; clean and re-ground the plate; at the second sitting add work to that previously done, and so on until the plate is finished, so arranging the times as to work always at the same period of the operation on tones intended to be of the same depth. This process is acquired with a little practice. If necessary to efface, it may be done in the usual manner with scraper and charcoal; always re-silver before retouching, if retouching is required. For cleaning the plates turpentine is usually employed, but schist-oil or petroleum are better cleansers, and remove the japan varnish very rapidly, whereas turpentine dissolves it slowly.

ETCHING FROM NATURE.—Etching is the only kind of engraving which can conveniently be done directly from nature. The choice of subjects is the most important point, as, although etching is admirably adapted for trees and vegetation in all its forms, and for picturesque buildings and animals, it is not so well suited for the representation of figures, or for other subjects, which require delicate gradations of tones. For anything that can be expressed by lines, etching is very successful, but it is not easy of application to tones. In working from nature, the shading, in addition to giving the light and dark tints, should also be used to indicate the form and texture of the surface, the lines being drawn in a direction to indicate form as well as tint. Several plates, ready grounded, may be carried in a small grooved box to keep them apart; if only one plate is intended to be used, it can be carried between two light boards, but must not be allowed to touch them. This can be avoided by fixing small pieces of modelling wax at the corners of the plate. If intended to be etched on Hamerton's positive process, the drawing board, with the well in it, must be taken, and the necessary hydrochloric acid and chlorate of potash in two stoppered bottles. These can be mixed with water when required. Dry point is frequently used in the finishing of etched plates. The dry point is an ordinary steel etching needle, sharpened in a peculiar manner with a sharp rounded cutting edge, and used without either etching ground or acid bath. By using this tool on the bare copper, a burr is raised, which catches the ink, and in printing gives the desired effect of a line with a delicate gradation. The more perpendicular the needle is held the less burr there will be raised; by inclining the hand to the right the burr will be increased, if the pressure on the tool remains the same. Practice enables an etcher to regulate the pressure on the tool; but if the pressure used has raised too strong a burr, it can be partially or entirely removed by using a sharp scraper worked at right angles to the line. If it is desired to see the progress of the work rub a mixture of tallow and lampblack over the plate; remove what is superfluous with a soft rag; the effect of the etching can then be fairly judged of. Dry point etching can now be made to give a large number of impressions, by having the plate protected with a coating of steel applied by galvanism. To efface faulty work use sand-papers of several degrees of coarseness; the coarsest first, then the scraper; finally, rub over with willow charcoal and olive oil. This leaves the plate fit to be etched upon; if, however, it should be hollowed out by this process, mark the spot on the back of the plate by means of callipers. Lay the face of the plate on a block of polished steel, and give it two or three blows on the back with a rounded hammer. The engravers' copper planers will do this work with more precision and skill than can easily be acquired by ordinary etchers. A passage that has been over-bitten may be easily reduced by being rubbed with willow charcoal and olive oil, which merely reduces the copper without injuring the lines, except the very pale one; these must be etched over again. It is better to have the plate over-bitten than not enough, as the former is more easily remedied than the latter.

Stippling is also executed on the etching ground by dots instead of lines made with the etching needle, which, according to the intensity of the shadow to be represented, are made thicker and closer. The work is then bit-in.

Etching on Steel is executed much in the same way as in the process on copper. The plate is bedded on common glaziers' putty, and a ground of Brunswick black, or wax, is laid in the usual way, through which the needle scratches. It is then bitten-in in the way above described.

Etching on Cast Iron.—Use a solution of common salt and sulphate of copper for the biting-in.

Etching on Steel or Iron.—Take sulphate of copper, sulphate of alum, and muriate of soda, of each 2 drachms, and strong acetic acid 1½ oz., mixed together. First smear the part intended to be etched with yellow soap, and write with a quill pen without a *split*.

ETCHING GLASS.—Glass is etched by hydrofluoric acid gas, or by liquid hydrofluoric acid. The acid for this purpose is obtained by treating fluoride of calcium, Derbyshire spar, with sulphuric acid, in a leaden vessel, as we shall presently describe. The gaseous hydrofluoric acid has the property of producing a surface which represents ground glass in its appearance; but the liquid acid produces just the contrary effect, and dissolves away the glass, leaving the surface polished and clear. Etching glass, therefore, consists of two operations;—etching by the gas, and producing a dull opaque surface, and etching by the liquid, and producing a surface which is bright and clear. 1. Gaseous hydrofluoric acid is the product of the action of sulphuric acid and fluoride of calcium. Take powdered fluoride of calcium, 2 parts; sulphuric acid, 3 parts. The powdered fluoride is placed in a leaden dish or shallow box, the sulphuric acid poured upon it. By means of a stick, the acid is made into a paste with the powdered fluoride; the mixture only requires to be warmed to evolve considerable fumes of gaseous hydrofluoric acid. These fumes are disagreeable; the experiment should, therefore, be conducted in the open air or under a chimney. The glass plate to be etched is covered with wax, by gently warming the glass sufficient to melt wax, and rubbing it with a piece of white wax until it is covered by a thin layer; it is then allowed to cool, and the waxed surface is etched with a graver. The sheet of glass thus prepared is used as a cover for the leaden vessel containing the materials, with the waxed side presented to the escaping fumes. These fumes will attack the glass where the wax has been removed only, and produce the dull appearance desired. The entire surface of the glass can be rendered ground in its appearance by exposing it to the fumes of the acid gas in its ordinary condition, unprotected by the wax. The production of the gas is accelerated by the warmth of a hob or of a spirit lamp applied to the bottom of the leaden vessel for a few moments. 2. To obtain the liquid acid, place the mixture named above in a leaden retort, and conduct the gas from the retort into a leaden bottle containing some water, so long as the water absorbs the fumes. The water becomes thus highly charged with hydrofluoric acid, and this liquid is to be used in the second process. The glass plates are to be prepared as before, with the addition of a small wall of wax or putty, which is to be formed round its edges; the liquid acid is poured upon the etched waxed surface, and allowed to remain until a sufficient depth of etching is produced. 3. To produce a colourless pattern on a coloured glass ground, you proceed as for etching an ordinary pane of glass, but the operation is conducted upon the surface of flashed glass; that is, glass which is simply covered on one of its sides with a colour, and which is not stained throughout. This flashed glass is a cheap imitation of stained glass; the thin coating of coloured material is soon dissolved by the acid, so as to leave a transparent or ground-glass pattern on a coloured glass ground, according as the process is conducted by means of gaseous or liquid hydrofluoric acid. The acid must be carefully handled, as it attacks the skin and produces stubborn sores, which are not easily healed, and it must be kept in india-rubber bottles, as it will dissolve glass.

Engraving on Copper is performed by cutting lines representing the subject on a copper plate by means of a steel instrument, called a graver, or burin, ending in an unequal-sided pyramidal point. Besides the graver, the other instruments used in the process are a scraper, a burnisher, an oil-stone, and a cushion for supporting the plate. In cutting the lines on the copper, the graver is pushed forward in the direction required, being held at a small inclination to the plane of the copper. The use of the burnisher is to soften down the lines that are cut too deeply, and for burnishing out scratches in the copper; it is about 3 inches long. The scraper, like the burnisher, is of steel, with three sharp edges to it; it is about 6 inches long, tapering towards the end. Its use is to scrape off the burr raised by the action of the graver. To show the appearance of the work during its progress, and to polish off the burr, engravers use a roll of woollen, or felt, called a rubber, which is used with a little olive-oil. The cushion, which is a leather bag about 9 inches diameter filled with sand, for laying the plate upon, is now rarely used except by writing engravers. For architectural subjects, or for skies, where a series of parallel lines are wanted, a ruling machine is used, which is exceedingly accurate. This is made to act on an etching ground by a point or knife connected with the apparatus, and bit-in with aquafortis in the ordinary way.

Copper Plate.—The plate must be perfectly polished, very level, and free from any imperfection; to this must be transferred an exact copy of the outlines of the drawing. To do this the plate is uniformly heated in an oven or otherwise till it is sufficiently hot to melt white wax, a piece of which is then rubbed over it and allowed to spread, so as to form a thin coat over the whole surface, after which it is left in a horizontal position till the wax and plate are cold. A tracing having been taken of the original design with a black-lead pencil on a piece of thin tracing paper, it is spread over the face of the prepared plate, with the lead lines downwards, and, being secured from slipping, a strong pressure is applied, by which operation the lead lines are nearly removed from the paper, being transferred to the white wax on the plate. The pencil marks on the wax are now traced with a fine steel point, so as just to touch the copper; the wax is then melted off, and a perfect outline will be found on the copper, on which the engraver proceeds to execute his work.

Engraving on Silver or Gold.—1. The engraving is first exposed to the vapour of iodine, which deposits upon the black parts only. The iodized engraving is then applied, with slight pressure, to a plate of silver, or silvered copper, polished in the same manner as daguerreotype plates. The black parts of the engraving which have taken up the iodine part with it to the silver, which is converted into an iodide at those parts opposite to the black parts of the design. The plate is then put in communication with the negative pole of a small battery, and immersed in a saturated solution of sulphate of copper, connected with the positive pole by means of a rod of platinum. Copper will be deposited on the non-iodized parts, corresponding to the white parts of the engraving, of which a perfect representation will thus be obtained; the copper representing the white parts, and the iodized silver the black parts. The plate must be allowed to remain in the bath for only a very short time, for, if left too long, the whole plate would become covered with copper The plate, after having received the deposit of copper, must be carefully washed, and afterwards immersed in a solution of hyposulphite of soda to dissolve the iodide of silver, which represents the black parts; it is then well washed in distilled water, and dried. 2. Heat a silver plate, previously coated with copper, to a temperature sufficient to oxidize the surface on the copper, which successively assumes different tints, the heating being stopped when a dark-brown colour is obtained. It is then allowed to cool, and the exposed silver is amalgamated—the plate being slightly heated, to facilitate the operation. As the mercury will not combine with the oxide of copper, a design is produced, of which the amalgamated parts represent the black, and the parts of the plate covered with oxide of copper represent the white parts. The amalgamation being complete, the plate is to be covered with three or four thicknesses of gold leaf, and the mercury is evaporated by heat, the gold only adhering to the black parts. The superfluous gold must then be cleared off with the scratch-brush; after which the oxide of copper is dissolved by a solution of nitrate of silver; and the silver and copper underneath are attacked with dilute nitric acid. Those parts of the design which are protected by the gold, not being attacked, correspond to the black parts of the plate; the other parts, corresponding to the white parts of the engraving, may be sunk to any required depth. When this operation is completed the plate is finished, and may be printed from in the ordinary method of printing from woodcuts.

Line Engraving on Gold.—To obtain from the same prints plates with sunk lines, similar to the ordinary engraved copper-plates, a plate of copper, covered with gold, is operated upon. On immersion in the sulphate of copper solution, the parts corresponding to the white parts of the engraving will become covered with copper. The iodine, or compound of iodine, formed, is then to be removed by the hyposulphite; the layer of deposited copper is oxidized, and the gold amalgamated, which may be removed by means of nitric acid, the oxide of copper being dissolved at the same time. In this instance the original surface of the plate corresponds to the white parts of the print, and the sunk, or engraved, portions to the black parts, as in ordinary copper-plate engravings.

Electro-metallurgy.—The first and most important operation in all branches of the electro-deposition of one metal upon another, is to effect a thorough and chemical cleansing of the surface of the metal upon which the coating is to be deposited.

' Cleansing Copper and its Alloys.—This is done in six operations. 1. Cleansing by fire, or by alkalies. 2. Dipping. 3. Dipping in old aquafortis. 4. Dipping in new aquafortis and soot. 5. Dipping in compound acids for a bright or dead lustre. 6. Dipping in nitrate of binoxide of mercury.

Cleansing by Fire, or by Alkalies.—This is to remove any foreign substances, especially those of a fatty nature, which are destroyed by heating the pieces in every direction over a gentle fire of charcoal, breeze, or spent tan. A muffle furnace, heated up to a dull red heat, is preferred; but small articles may be cleansed in a hot revolving cylinder. This operation is not adapted to very delicate articles, or for table-forks and spoons, which must keep their toughness, or to those pieces in which the different parts are united by soft solders. Boil such articles in a solution of potash or soda, which renders the fatty substances soluble in water. This is done in a cast-iron kettle, provided with a cover, where there is a boiling concentrated solution of carbonate of potash, or soda, or of American potash. The caustic potash or soda must be dissolved in ten times its weight of water. This solution lasts a long time; when it has lost part of its power, it may be revived by a few fragments of caustic alkali. At the boiling point it will cleanse copper in a few seconds. If the articles to be scoured are joined with tin solder, they must not be allowed to remain too long in the caustic liquor, which would dissolve the solder and blacken the copper.

Dipping.—The pieces are then dipped in a mixture of from 5 to 20 parts in weight of sulphuric acid at 66° Baume for 100 parts of water. Most of the pieces to be cleansed may be dipped hot in this mixture; but certain alloys, in which tin, zinc, or antimony predominate, such as cast bronze, must not be so treated, as the sudden cooling will occasion cracks and flaws. Copper articles may remain any length of time in the dipping bath; they should not be removed before the black coat of binoxide of copper, caused by the heating, is entirely dissolved. The remaining coat of red protoxide of copper is unacted upon by the sulphuric acid. Articles having parts made of iron or zinc must not be submitted to the action of dilute sulphuric acid, or they will be entirely dissolved; therefore avoid the use of implements or wires of iron, zinc, or steel. A dipping bath which contains copper in solution from previous operations will not suit for articles which may contain iron, tin, tin solder, antimony, bismuth, or lead. In such a case, use a newly-made dipping bath and a small proportion of acid. Articles which have been cleansed by alkalies must be washed before being put into the dipping bath, or pickle. Thoroughly and rapidly rinsing in fresh water all the articles, before and after each of the following operations, must be strictly attended to. The various manipulations which complete the cleansing succeed each other without interruption; and the articles must be stirred as well as possible in the acid baths, and in the rinsing water. After dipping and rinsing, the various pieces are fixed to a brass wire, or hooked upon brass or copper hooks. Small articles of jewellery are suspended to a stout copper wire. These hooks are better if made of pure copper than of brass, and it is still better to use glass nooks, which are cheap and are not corroded by the acids. Such nooks or supports can be made by bending glass rods, by the heat of a charcoal fire, or of a gas burner, to the desired shape. Those objects which cannot be suspended or attached to hooks, are put into perforated ladles of porcelain or stoneware. It is less economical, but sometimes absolutely necessary, to use baskets of brass or copper wire cloth. Those who frequently have to cleanse very small articles will find it advantageous to employ a basket of platinum wire cloth, which, although expensive in the first cost, will be found cheaper in the end, as it is almost indestructible.

Dipping in old Aquafortis.—If there is any aquafortis, nitric acid, already weakened by preceding dippings, plunge into it the articles which have passed through the sulphuric acid pickle bath, and have been rinsed. They may remain there until the red coat of protoxide of copper has entirely disappeared, leaving, after rinsing, a uniform metallic lustre. The dipping in old aquafortis, though not absolutely necessary, is recommended for two reasons; it economizes the cost of fresh acids; and, as its action is slow, it prevents the too rapid corrosion of the cleansed copper during the time of the solution of the protoxide.

Dipping in Aquafortis and Soot.—After rinsing in fresh water, the articles are well shaken and drained, and then plunged into a bath composed of nitric acid at 36° Baumé, 100 parts; common salt, 1 part; calcined soot, 1 part. This mixture attacks the metal with the greatest energy, and the pieces should therefore not remain in it more than a few seconds. The volume of acid should be about 30 times that of the articles to be cleaned, in order to prevent too great an elevation of temperature due to the chemical reaction, which would result in the rapid weakening of the acid. After this bath, and rapid rinsing, in order to prevent the production of nitrous vapours the pieces present a fine red lustre, gold yellow or greenish yellow, according to the alloy employed, and such as to make one believe that they are entirely cleansed of foreign matter; yet if the pieces in this state are plunged into a gilding or silvering bath, they become entirely black, and without any metallic lustre. If the pieces are put aside without rinsing, there rises on their surface a green froth and nitrous vapour, which indicate the decomposition of the acid with which they are contaminated. When the vapours have disappeared, the pieces, even after washing, remain of a dull black, on account of the formation of a basic copper salt which is not soluble in water. This last mode of operating, called blacking by aquafortis, is preferred by a few gilders, varnishers, and colour fixers, who find it economical to allow the production of nitrous vapours while the pieces are draining on top of the vessel which contains the acids. Any subsequent operation is to be prefaced by a rinsing in fresh water. When small objects, such as pins, caps, or eyelets, are to be dipped, they are put into a stoneware pot, with a small quantity of aquafortis, and then rapidly shaken and stirred. In this case the acid is entirely used up with the production of abundant vapours, and the objects remain blackened, and ready for a further cleansing. Care must be taken in the choice of aquafortis. Three kinds of nitric acid at 36° are to be found in the trade;—One is perfectly white, another is straw yellow, and another which is of a more or less dark-red colour. The white acid, without nitrous gas, does not cleanse well, especially when freshly used. The red acid acts too powerfully and pits the copper. The straw-yellow acid is preferred to the others. Nitric acid at 40° is too energetic and costly; however, certain operators who have to cleanse large quantities of copper wares prefer it on account of the rapidity of the operation. The acid is spent when its action on copper goods becomes too slow, and when the objects removed from the bath are covered with a kind of bluish-white film. Such acid is preserved for the preceding operation, namely, dipping in old aquafortis; or for dipping in the whitening bath. Very good aquafortis may cleanse imperfectly when the temperature is too low or too high. This accounts for the difficulty of cleansing in frosty weather, or during the great heat of summer.

Aquafortis for Bright Lustre.—There is an excellent way of obtaining a bright lustre for any pieces, the surfaces of which have been dulled or slightly pitted by a defective cleansing, or by their passage through the acids for removing gold or silver. Place them for a few minutes in a bath composed of old aquafortis, nearly spent, 1 part; hydrochloric acid, 6 parts; water, 2 parts. The pieces, when removed from the bath, are entirely black, and must be thoroughly rinsed in water to remove the kind of black mud which covers them. They are then cleansed and dipped again. This bath will be found useful by electro-gilders. It is also convenient for removing the sand adhering to the castings of copper alloys. Large pieces may remain in the bath for 20 or 30 minutes, as this mixture acts very slowly on copper and its alloys.

Dipping in Compound Acids for a Bright Lustre.—These acids are of two kinds, according to the object in view. If the pieces are to have a bright lustre, they are stirred for 1 or 2 seconds in a liquid, prepared the day before, and cold, made of nitric acid at 36°, 100 parts; sulphuric acid at 66°, 100 parts; common salt, 1 part. In preparing this bath, nitric acid is first put into the vessel, and then sulphuric acid, which is much denser, and would not mix readily if it were put in first. At the time of mixing, especially when the salt is added, considerable heat and a quantity of acid and injurious fumes are produced, so that it is prudent to operate in the open air, or under a good chimney-hood with a movable glass sash. As these acids must be employed cold, it is necessary to prepare them in advance. Copper articles, after this dipping, are lighter coloured and much brighter than after the passage through aquafortis. They may then be considered as completely cleansed, and must be immediately rinsed in plenty of clean water. The above acids are too energetic for small articles, such as pins or hooks, which are generally cleansed in stoneware colanders. As the number of small articles stop up the perforations, the acid cannot run out so quickly as desired, and begins to heat and give off fumes, and the pieces blacken before they can be rinsed. Therefore, for small pieces, add to the above mixture one-eighth of its volume of water. Place the articles in a stoneware pot; stir rapidly with a small quantity of bitters, as the last mixture is termed, and then the whole is plunged into a quantity of fresh water as soon as the acid has sufficiently acted. This method is not economical, as the acid is lost; but the dipping liquors do not become heated.

Whitening Bath consists of old aquafortis, sulphuric acid, common salt, and uncalcined soot. Pour into a large stoneware vessel a certain quantity of old aquafortis from previous dippings, and then add twice the volume of sulphuric acid at 66°. The mixture is allowed to cool off until the next day. The nitrate of copper of the old aquafortis becomes converted into sulphate of copper, which, by cooling, crystallizes against the sides of the vessel. Decant the liquid portion into another vessel, and then add 2 or 3 per cent. of common salt, and as much of calcined soot. This mixture is much less energetic than the compound acids for a bright lustre, and often replaces them advantageously. The crystallized sulphate of copper is collected and sold. This bath is strengthened, when necessary, by the addition of stronger aquafortis and oil of vitriol. To replace the portion used up during the day, equal quantities of old aquafortis and oil of vitriol are added at the end of the day. The next morning the liquors are decanted, and the sulphate of copper is gathered. Soot and common salt in sufficient proportions are then added. In this manner a perpetual and cheap whitening bath is prepared.

Compound Acids for a Dead Lustre.—If it is desired to give the objects a dead lustre, they are, after dipping in aquafortis and rinsing, plunged into a bath, prepared previously, composed of nitric acid at 36°, 200 parts; sulphuric acid at 66°, 100 parts; common salt, 1 part; sulphate of zinc, 1 to 5 parts. Copper articles may remain from 5 to 20 minutes in the cold bath, and the dead lustre will be the more apparent, the longer the immersion has been. From this bath, after a long rinsing, the objects have an earthy appearance. This dulness is removed by a rapid passage of the pieces through the compound acids for a bright lustre, and by an immediate rinsing. If they remain too long in the latter acids, the dead lustre will disappear, and the operation for dead lustre will have to be repeated. If a bath for the bright lustre is not at hand, the objects, after rinsing, may be rapidly passed through the dead-lustre bath, which will remove the dulness of the lustre caused by too long immersion. After long use, the compound acids for a bright lustre may be employed in a certain measure for a dead-lustre bath. The mode of operation remains the same. For large embossings for furniture, or for some clocks, a hot bath for dead lustre is used, composed as follows;—Old aquafortis, about 4 to 5 parts; sulphuric acid, 1 part; sulphate of zinc, 8 to 10 per cent. The sulphate of zinc is gradually added when required, for increasing the deadness of the lustre. The lustre thus obtained appears dull and yellowish; after a thorough rinsing, a passage through the same bath for 1 or 2 seconds, and a last rinsing, it becomes clear enough.

Dipping in Nitrate of Binoxide of Mercury.—This operation consists in plunging the cleansed articles for 1 or 2 seconds into a solution of water, 2½ gallons; nitrate of binoxide of mercury, a third of an ounce; nitric acid or, preferably, sulphuric acid, two-thirds of an ounce. When nitrate of binoxide of mercury is poured into the water, a thick cloud is formed, of a yellowish-white colour, which subsequently disappears. Stir the mixture before using it. The proportion of mercury salt above-named must be modified, according to the size of the pieces, and the nature of the alloy. Thus less mercury will be used for light pieces of jewellery which need a very thin deposit. On the other hand, more mercury is required for heavy objects, such as table ornaments, which should receive a thick deposit of gold or silver. The latter must come from the mercurial solution with a perfectly white and bright appearance, looking like silver, whilst the colour of the light articles is scarcely changed. After a perfect cleansing, the pieces will, after passing through a strong mercurial solution, be perfectly white and bright. But there will be a cloudy appearance, or various shades of colour, if the cleansing has not been properly done. The amalgamating bath becomes spent by use; it may be revived by the addition of a few drops of nitrate of mercury; but it is better to prepare a fresh one. No intervals must be allowed between the various operations of cleansing. The dipping baths are ordinarily held in vessels of glass, stoneware, porcelain, or of any other material which resists the corrosion of acids. Common earthenware and that with a lead glaze must be carefully avoided. The dipping pots must be rather high, and be furnished with a cover, in order to prevent evaporation. Those with ground edges may be covered with a pane of glass. Wide open-mouthed earthen pans are very good for rinsing. A large hood, communicating with a chimney, and closed with a sliding glass sash, should contain the following apparatus for complete