

cleansing operations; — A furnace and separate pans for first dipping, old aquafortis, aquafortis and soot, compound acids for dead lustre, compound acids for bright lustre, solution of nitrate of mercury, acids to dissolve gold from old pieces, acids to dissolve silver from old pieces; with two large pans for rinsing with a constant flow of water. If the draught of the chimney is not sufficient, a small fire may be kindled under the hood. A gas-burner is often sufficient. The pot of nitrate of mercury, with two rinsing pans, may be placed near the electroplating bath.

CLEANSING SILVER. — Mechanical agents will not, like acids, act simultaneously on every part of the object, and it is impossible to entirely prevent the action of the air, steam, gases, and acid fumes. Heat the object to a dull red heat upon a slow fire. If the silver is pure, it becomes covered with a thin bluish film; but if, as is nearly always the case, the silver is alloyed with a variable proportion of copper, the latter becomes oxidized, and covers the piece with a greyish-black coating. While the piece is still hot, plunge it into a boiling pickle of water and sulphuric acid, which dissolves the oxide. If the heat has been sufficiently protracted for oxidizing all the copper on the surface, the object, when removed from the pickle, is of a perfectly dead white. It is greyish if the heating has been too short, and the operation must be repeated as many times as are needed for a perfect lustre. Or the silver may be placed in sheet-iron boxes filled with a mixture of powdered borax, lime, and charcoal dust. The borax dissolves the oxide of copper as soon as formed. If the objects to be cleansed are hollow, it is necessary, before heating, to make a small hole which will allow of the escape of the air expanded by the fire. Without this precaution, the piece will burst open. When the piece is put into the pickle, the acid liquor enters through the hole, and takes the place of the air between the shells, and is difficult to remove. In order to prevent the spotting of the piece by this liquor, it is dipped for a few minutes into a very dilute solution of ammonia or of

soda crystals, which prevents the action of the acid upon the silver. Then place the article between layers of dry and warm fir wood saw-dust, which will absorb the saline solution. Nitric, instead of sulphuric, acid may be used for the pickle bath. In this case, the water must be distilled, and the acid free from chlorine or hydrochloric acid, otherwise the silverware will be covered with a bluish-white film of chloride of silver. This method will not suit articles in which iron or zinc may be present. In such cases, employ alkalis, and polish afterwards with very fine sand or pumice-dust, with the aid of a stiff and short brush, or with a scratch-brush alone. Perfectly cleansed silver may directly receive a metallic deposit which will have the same dead lustre as the object itself, but it is customary, before introducing the articles into the electroplating bath, to scratch-brush them.

SCRATCH-BRUSHING. — Scratch-brushing is to remove the dead lustre on an object by the frequently-repeated friction of the points of many stiff and straight metallic wires, called a scratch-brush or wire-brush. Its shape varies with the articles to be operated upon. A hand scratch-brush is made of numerous wires, stiff and straight, taken from a bundle or coil of large diameter, so that the wires have little tendency to curve. For delicate objects, scratch-brushes are made of spun glass, the fibres of which are very thin and elastic. For making a good hand scratch-brush, choose a bundle or coil of brass wire of the proper thickness, and wrap a good string tightly round it for about two-thirds of the intended length of the instrument, usually about 8 inches. Then, with a cold chisel, cut the bundle of wire close to the string at one end, and at 2 inches from the other end of the string wrapping. Dip the end closed by the string into a neutral solution of chloride of zinc, and plunge into melted tin, which solders all the wires, and prevents their separation and injury to the hand of the operator. The tool is then fixed to a thin wooden handle which projects above the soldered end. Very small scratch-brushes are necessary for

reaching small holes and corners. An old scratch-brush, the wires of which have been bent in every direction, and fixed to a long handle, is useful for rubbing the insides of certain pieces, such as Etruscan vases. Scratch-brushing is seldom done dry; the tool and pieces must be constantly wetted with a stream of water, which carries away the impurities. Good metallic deposits are only polished by the friction of the scratch-brush; bad ones scale off from the defective adhesion. A large tub, with a board placed across it, on which to rest the pieces, may be used; and various solutions are employed to assist the brushing, such as water and vinegar, or sour wine, or solutions of cream of tartar or alum, when it is desired to brighten a gold deposit which is too dark; but generally a decoction of liquorice-root, horse-chestnut, marsh mallow, or bark of Panama wood, all of which allow of a gentle rubbing with the scratch-brush, with the production of an abundant scum. Every 5 or 6 days the old liquid is carefully decanted, so as not to carry away the deposits at the bottom, which always contain some of the precious metals, which are collected to be afterwards treated. For small objects and articles of jewellery, hold the scratch-brush as a writing pen, and the motion is imparted by the wrist only, the forearm resting on the edge of the tub. For larger articles of bronze, hold the fingers extended close to the fore part of the scratch-brush, so as to maintain the wires, and, with raised elbow, strike the piece repeatedly with a sliding motion at the same time. When a hollow is met which cannot be rubbed lengthways, a twisting motion is given to the tool. Circular wire-brushes, fixed on the spindle of a lathe, and the wires of which move all in the same direction, have been constructed for certain pieces of silversmith work, such as forks and spoons.

Lathe for Scratch-brush.—An ordinary lathe is used for scratch-brushing, upon the spindle of which is fixed a circular brush of brass wires. A wooden frame covers the wire brush; it is open in front; the top supports a small reservoir from

which a slender jet of water runs upon the brush. A board receives the projected water, and lets it fall into a zinc pan resting on the bottom of the box.

Scratch-brushes.—The brass wire used for the manufacture of hand or circular scratch-brushes is of various strengths. Thick wires are employed for bronzes, and thinner wires for lighter articles. The wires must be preserved stiff and straight. When a hand scratch-brush becomes too short, cut the twisted ends with a cold chisel, and a new portion of wire is uncovered by removing part of the string wrapping. To remove the twisted wire ends, rest the scratch-brush upon a lead block, and cut them with a sharp cold chisel, with one stroke of a hammer if possible. When they begin to curl, they are now and then beaten with a mallet of boxwood, upon a small block kept between the knees, so as not to produce a dead stroke. Scratch-brushes if kept too long in water become hard; when greasy, they are cleansed in caustic potash; oxide is removed by the compound acids. This last operation, and even dipping in aquafortis, are sometimes resorted to for diminishing the size of the wires, and making them smoother. The circular brush is occasionally resorted to for diminishing the size of the wires, and making them smoother. The circular brush is occasionally reversed, in order to change the direction of the wires.

Bright Lustre for small Articles.—Very small articles, which cannot be scratch-brushed, receive a bright lustre by mutual friction. The operation is generally performed with the hands. The articles to be brightened are introduced, together with boxwood saw-dust, bran, or sand, into a bag; the ends of the bag being gathered into the hands with the thumbs inwards, the bag is shaken to and fro. As this operation becomes very fatiguing, mechanical means may be employed to effect the shaking.

CLEANSING ZINC.—Zinc is cleansed by being passed through a boiling solution of caustic lye, without remaining too long in it, because it may be corroded, and even dissolved; after rinsing, it is plunged for a few minutes into water contain-

ing from one-tenth to one-twentieth of sulphuric acid, then rinsed in plenty of warm water, and, when necessary, brushed with a stiff brush and pumice-stone dust, or scratch-brushed. This last operation is especially useful when parts have been united with tin solder, which becomes black and dull by the alkaline and acid baths. Another method is to dip the articles rapidly into a cold mixture of sulphuric acid, 100 parts; nitric acid, 100; common salt, 1 per cent.; and quickly rinse in cold water perfectly free from copper salt, which will blacken the zinc. If, instead of quickly cleansing the zinc, it is allowed to remain a little longer in the mixture, it acquires a dead lustre which may be utilized for producing contrasts between the various parts of the same ornament. The dead lustre will become a bright one, if the object is quickly plunged in several times, and rinsed as often, in the same compound acids. It often happens that the lines of tin or lead solder are black after being dipped into the acid bath; it is then sufficient to scratch-brush before placing the object in the electroplating solution. Zinc may be slightly amalgamated with the solution of nitrate of binoxide of mercury; this increases the adherence of the electro deposits. It is often necessary, from some defect in cleansing, or in electroplating, which impairs the adherence of the deposits, to do the work over again. In such a case, remove the copper entirely by plunging the object into aquafortis and soot, until it appears black. Another dipping into the compound acids will render it perfectly clean and white, and ready to receive a new deposit.

CLEANSING LEAD AND TIN.—Tin, lead, and the alloys of these metals, are much more difficult to cleanse than zinc. A rapid scouring with potash lye, and a rubbing with a hard substance are the only means of effecting this. The objects are sometimes plunged into diluted hydrochloric acid; but the first operation is nearly always necessary. Notwithstanding the greatest care, the direct deposit of the precious metals is difficult, and does not adhere well. The results are much better if a coat of pure copper

or brass is interposed between the low metal, and the gold or silver.

CLEANSING CAST IRON.—Cast iron is cleansed by being immersed for 2 or 3 hours in water containing one-hundredth part of sulphuric acid; the metal is afterwards rinsed in cold water, and scoured with sharp sand and a fibre brush, or a coarse rag; then put again in the acid pickle, rinsed, and plunged into the electro bath. If more than 1 per cent. of sulphuric acid is added to the water, the length of the immersion must be shortened, otherwise the cast iron will be deeply corroded, and the carbon of the metal, which is insoluble in the pickle, will with great difficulty be removed by the friction of the sand. Cast iron does not gild or silver well, by a direct deposit of the precious metals. Copper or brass deposits are better, although far from perfect; but if cast iron is tinned, the coat is adherent, and will afterwards receive copper, brass, gold, or silver, if desired. If it is desired to keep cast iron already cleansed for some time before electroplating it, it is necessary to preserve it in a liquor rendered alkaline by caustic lime, potash, or soda, or their carbonates; but caustic lime-water is the cheapest and most easy method, and cast iron which has remained in it for a few hours will not rust after a long exposure to a damp atmosphere.

CLEANSING WROUGHT IRON.—The cleansing of wrought iron is effected in the same manner as cast iron, but will bear a stronger pickle and a longer immersion. We refer in this place to ordinary wrought iron covered with a film of black magnetic scale or of red rust. Whitened, filed, or polished iron must be treated like steel.

CLEANSING STEEL.—Polished articles of steel, or iron, must be first cleansed in a boiling solution of caustic lye, and rubbed with pumice-stone dust, which scratches the polish slightly, and thus produces a better hold for the metals afterwards to be deposited. They are then rapidly passed through a bath composed of water, 1 quart; hydrochloric acid, 12 oz.; or sulphuric acid, 4 oz.; rinsed in cold water, and plunged into

the electroplating solution. Carefully avoid substituting nitric acid for the hydrochloric or sulphuric acid, of the above acid bath. Iron and steel may be well gilt, without an intermediary coat, in hot gilding baths. Silvering directly upon steel or iron is always imperfect and without adherence; it is therefore customary to interpose a coat of copper or brass, which renders the further operation of silver plating easy.

GALVANIC BATTERIES.—There are two kinds of batteries used for electro-deposition; those which act under the action of physical agents; but these, on account of their feeble intensity, are rarely used. Others act under the influence of chemical reactions, of decompositions and recompositions, or of greater or less affinities. The varieties of these instruments are, at the present time, very numerous. But the best battery is that which, under the smallest volume, is the most energetic, constant, regular, and economical.

Daniell's Battery.—This battery develops a constant and lasting current, but is wanting in intensity. It is especially adapted to slow deposits, which must be thick and of uniform texture. A great advantage of this battery is, that it will work without acids, and therefore without the production of gases or smell, and can be used in a private apartment without inconvenience. The vase for the battery is a flat vessel of pure copper, which is half filled with a saturated solution of sulphate of copper, into which is placed a bag of canvas or a cell of porous porcelain or earthenware, which causes the solution of sulphate of copper to rise to about 1 in. from the top of the copper vessel. The bag or cell is filled with a saturated solution of common salt, in which a well-cleansed zinc plate is placed. It is necessary that the levels of the two solutions should be nearly the same. If there is any difference, the solution of chloride of sodium should be slightly above the other, because if the solution of sulphate of copper passes into the porous cell, the zinc is immediately corroded, and blackened, and the battery may cease to work. When one of

Daniell's elements only is used, which seldom happens, on account of the feeble intensity of the current, the conducting wire which supports the article to be galvanized is connected with the zinc plate by a binding screw of brass, and the other wire supporting the anode is connected with the copper of the exterior vase. The solution of sulphate of copper must be kept constantly saturated with crystals of this salt, enclosed in a bag of linen or hair cloth. A similar process may be employed to keep the solution of common salt in a state of saturation. A battery thus arranged may be kept in operation for three weeks, or a month. When this battery is working, the copper of the decomposed sulphate is deposited upon the copper of the vessel, which thus increases in weight and in value. The zinc is slowly dissolved in the solution of common salt, and forms a double chloride of sodium and zinc. When a number of the elements of a Daniell's battery are to be joined together, the zinc of the first element is connected with the copper of the second by means of a well-cleansed metallic ribbon, then the zinc of the second with the copper of the third, and so on, until the whole apparatus presents at one end a copper vase, and at the other a zinc plate, unconnected. A metallic wire connects the anode with the copper end, and a similar wire is bound to the zinc end, and supports the object to be electroplated. Another battery used by the electro-gilders of watch parts and by telegraphers, is composed of a cylindrical vase of stoneware, glass, or porcelain; a cylinder of zinc to which is soldered a ribbon of pure copper; a porous clay cell, and a glass balloon with a short neck, and filled with crystals of sulphate of copper. It is closed with a cork perforated with two holes, or having two notches cut along its sides. The rolled zinc plate is put into the stoneware pot, and the porous cell inside the zinc. The copper ribbon of the zinc of the first element dips on to the bottom of the cell of the next element, in such a manner that, when several elements are connected together,

there is at one end the ribbon of a zinc plate, and at the other end a copper ribbon put into the cell. Then the porous cell and the stoneware pot are filled to the same level with water. The balloon containing the crystallized sulphate of copper receives as much water as it can hold, and the notched cork being put in place, the balloon is quickly inverted with its neck in the water of the porous cell. The battery is ready to work 24 hours after. The ribbon of the zinc end is connected with the objects to be electroplated, and that of the other cell end, with the soluble anode. The sulphate of copper contained in the balloon is dissolved in the water around it, and as this solution is denser than water it falls into the porous cells through one of the notches of the cork, while an equal quantity of purer and lighter water ascends through the other notch, and so on, producing a circuit of denser liquor falling by one notch, and of lighter liquor rising by the other. The solution of sulphate of copper is decomposed in the porous cell; the sulphuric acid passes through the cell by outward pressure and acts upon the zinc, and at the same time the copper becomes deposited upon the copper ribbon connected with the zinc of the former element. In order that this battery may work regularly for 6 or 7 months, it is sufficient to replace the evaporated water. The balloon ought to contain at least 2 lbs. of sulphate of copper, and the zinc to be about 7 in. in height, and from 4 to 4½ in. in diameter. The zinc may be amalgamated, in which case the action is a little slow at the start, but more regular afterwards. The copper ribbon receives all the metal of the decomposed sulphate, and it sometimes happens that part of the copper becomes deposited upon the porous cell, which must then be cleaned in aquafortis. When all the sulphate of copper is used up, the balloons are filled with a fresh quantity of crystals and new copper ribbons inserted to take the place of those rendered too voluminous. If it be desired to start the battery with a balloon immediately, add a small quantity of sulphuric acid, or of common

salt, to the water in which the zinc is placed.

Bunsen's Battery.—Each element is composed of a glass vessel which is half filled with nitric acid at 36° or 40° Baumé, and which receives a hollow cylinder of pulverized coke, moulded and cemented at a high temperature, by sugar, gum, or tar. At the upper part of this cylinder, where it does not dip into the acid, a copper collar is fixed, which may be tightened at will by means of a screw. A copper band or ribbon is fixed to the collar, and may be connected with the zinc of another element. A porous porcelain cell is placed inside the coke cylinder, and contains a diluted solution of sulphuric acid, 1 part acid and 9 parts water, into which is put a bar or cylinder of zinc strongly amalgamated, or covered with mercury. When a battery of several elements is to be formed, the coke of the first element is connected with the zinc of the second, and so on, and the apparatus is completed, at one end, by coke communicating with the anode, and at the other, by a zinc connected with the cathode, or object to be electroplated. In this apparatus the surface of the carbon is much greater than that of the zinc; this is a wrong disposition, since, generally, the intensity of the current is in direct ratio with the surface of the zinc corroded, provided that this surface be opposite and parallel to that of the carbon.

Bunsen's Battery modified by Archaureau.—This battery is preferred by gold and silver electroplaters. Each element is composed of an exterior vessel or pot, most generally of stoneware; a cylinder of zinc, covered with mercury, provided with a binding screw, or with a copper band, whether for a single element, or for the end of a combination of elements in a battery, or to connect the zinc with the carbon of another element. A porous cell of earthenware pipe or porcelain. A cylinder of graphite, made from the residue found in old gas retorts. The graphite is bound by a copper band fixed to it by means of a wire of the same metal, all the binding being afterwards covered with a

thick varnish to protect it from the acid fumes of the battery; notwithstanding the varnish, the acid may rise by capillary attraction and corrode the copper band between the carbon and the wire; therefore binding screws of various shapes and sizes should be used to connect the carbon or zinc by means of ribbons, or wires. Use conducting wires of pure copper, covered with cotton, silk, india-rubber or gutta-percha, and presenting the metal at their extremities in order to effect the connections.

Charge of the Battery.—Taking as a standard an element 10 in. in height, and 6 in. in diameter, half fill the stoneware pot with water; add 7 oz. of sulphuric acid at 66°; and 1 oz. of amalgamating salt, or the zinc may be amalgamated with metallic mercury, after it has been cleansed in diluted sulphuric acid, by being dipped into mercury, or rubbed over with this metal by means of a scratch-brush of brass wire. Put the zinc cylinder into the stoneware pot; then introduce the cylinder of carbon into the porous cell; fill the empty space between the carbon and the sides of the cell with nitric acid at from 36° to 40° Baumé; place the porous cell thus filled into the centre of the zinc cylinder. The surfaces of the two liquids should be level.

Reunion of Several Elements.—When several elements are to be connected, they are placed near each other, without touching, and the first carbon or graphite is left free for the attachment of the anode. The ribbon or band of the first zinc is pinched between the jaws of the brass binding screw, and the carbon of the second element, and so forth, until the last zinc is ready to be connected with the object to be electroplated.

Bringing Batteries into Action.—Batteries will furnish electricity when the circuit is closed, that is to say, when the conducting wires starting, one from the carbon, and the other from the zinc, are put into communication, whether by direct contact or through the medium of a conducting liquid. It sometimes happens that batteries, which appear to

be in good order, do not work. This is generally due to some foreign substance preventing the conductivity at the points of contact, or to the copper band of one zinc resting upon another zinc. Before using a battery, try if the current escapes well from both extremities. For this purpose present the point of the negative wire to the carbon of the other end, and a spark should immediately ensue. The same experiment being made with the positive wire, against the last zinc, another spark should be produced; or it is still more easy to have the two ends of the wires made to rest at a short distance from each other upon a piece of carbon, or upon a file, and then rubbing with one wire while the other remains in contact. Numerous sparks will immediately appear. When one element of a battery is wrongly put up, discover the defect by successively presenting the end of one of the wires to the carbon of each element, and that which does not produce any spark belongs to the defective element. Too much porosity in the cells is another cause of stoppage in the current, because the solution of zinc which penetrates deposits upon the carbon a whitish coat preventing further action. Change the cell and scrape off the coat entirely from the carbon. This generally takes place when the battery has been working several days without the addition of fresh liquor, or when there is too much acid. The battery will also cease working from too great an accumulation of sulphate of zinc, which, not having sufficient water to remain in solution, crystallizes upon the zinc, and prevents any further action. Remove the acid solution, substitute a fresh one, and clean the zinc. Laminated zinc is preferable to that cast in a mould, because the latter is not so homogeneous, and is more rapidly corroded, and even perforated.

Keeping Batteries in Order.—Every 24 hours, or oftener, the losses of batteries must be made good by adding, without taking the elements apart, about two teaspoonfuls of amalgamating salt, and as much of sulphuric acid, to the liquor of the zinc plates, and stirring

with a glass rod. Nitric acid, to replace that evaporated, is put into the porous cell. This manner of operating may be sufficient for 5 or 6 days; but after this lapse of time, all the old liquors must be removed, and fresh ones added. Although amalgamated zinc is scarcely corroded, even in a very acid solution, when the two poles are not in connection by direct contact, or through a conducting liquid, it is preferable to take the batteries apart every evening, in the following manner;—All the binding screws are let loose, and cleaned; the cylinders of carbon are removed, and, without washing, deposited in a vessel especially for their use; the porous cells are removed, and their acid poured into a special vessel. The cells are not washed; the zincs are removed from the acid liquor, and placed in an inclined position upon the edges of the store-ware pots; the batteries are made ready to work by a converse manipulation.

Important Observations on Batteries.

—Batteries must be kept in a place where the temperature does not greatly vary. A frost arrests their action, and great heat increases it too much. A good place for them is a box, and they are put at such a height that they may easily be manipulated. This box should have means of ventilation, in such a way that the air coming in at the lower part, will escape at the top through a flue and carry away with it the acid fumes constantly disengaged. It is best to keep the batteries in a room different from that where the baths and the metals are to be operated upon, as these are easily injured by acid vapours. The galvanic current may be conducted into the work-room by wires passing through holes in the wall, and covered with gutta-percha.

Grove's Battery.—This battery is like the preceding one, except that it has a platinum foil which plunges into the nitric acid, and replaces the prism of carbon. This foil is supported by a small brass stand, fixed itself to a round band resting upon a rim on top of the exterior vase. A binding screw is soldered to the stand when connection is to be made with the copper ribbon of the preceding

zinc. The several elements of batteries are united together in the manner already mentioned, the zinc to the platinum of the next element, and so on. The disadvantage of this battery is its great cost, due to the platinum employed; it has been proposed to substitute aluminium, but still the battery is an expensive one.

Grenet's Battery.—A solution of 100 parts of water, 10 of bichromate of potash, and 10 of sulphuric acid in the porous cell, replaces the nitric acid employed by Grove and Bunsen. This battery does not emit acid fumes, but the carbon is rapidly incrustated with oxide of chromium, which arrests the galvanic current.

Murié-Davy Battery.—Slightly damp sulphate of mercury replaces the nitric acid in the porous cell. The working expenses of this battery are very high, and it is used only in the telegraphic service, where the Daniell battery with balloons is preferred.

Smees's Battery.—This battery is very simple in construction. It is composed of a thick wooden frame open at the top, with three internal parallel grooves which run the height of the two opposite sides. The middle groove receives a movable plate of silver, platinum, gold, or copper which has been strongly gilt, silvered, or platinized; its surfaces must be rough or with a dead lustre. Two plates of strongly amalgamated zinc are run down the other two grooves. The plates of zinc must be near to, but not in contact with, the central one, and are connected by a wire or metallic band. The positive wire starts from the middle plate, and the negative from the zinc, and the whole apparatus is immersed in a solution containing common salt or one-tenth of sulphuric acid. Several elements may be united together by connecting the zinc of the first with the middle plate of the second. Or the cell may be made of gutta-percha, with a plate of carbon to replace the plate of silver, or of platinized copper. The two other grooves receive two plates of amalgamated zinc with one of the upper corners cut away. A double binding screw, for the positive

wire, is fixed upon the plate of carbon where the two zinc corners have been cut off, and another large binding screw unites the two zinc plates, and carries the negative wire. Fill the cell with water saturated with common salt, or acidulated with one-tenth of sulphuric acid.

Watt's Battery.—In a stoneware jar holding about 4 galls. place a cylinder of thin sheet copper, dipping into water acidulated with 2 lbs. of sulphuric acid and 1 oz. of nitric acid. A solid zinc cylinder is put into the porous cell, which is filled with a concentrated solution of common salt, to which a few drops of hydrochloric acid have been added.

Various Kinds of Metallic Deposits.—An intense current, for brass and hard deposits will be obtained by joining alternately the zinc of one element to the copper or carbon of the next one. For silver plating a smooth and not too hard deposit is desired, the current should be feeble in intensity, but considerable in quantity, and may be obtained by connecting together all of the zincs on the one side, and all of the coppers or carbons on the other.

Porous Cells.—The porous cells are absolutely necessary in batteries working with two exciting solutions, like the Bunsen battery. But the trouble arising from the clogging of the pores of the cell, and from the difficulty of preventing the diffusion between the two liquids of the porous cell and of the jar, the specific gravity of which is constantly varying, makes it desirable that the cell should be dispensed with in batteries worked with but one exciting fluid.

Callaud Battery.—The Callaud battery is a modification of that of Daniell, doing away with the porous cell. A jar is filled with water acidulated with sulphuric acid, only for starting the solution of the zinc, as the sulphuric acid will be furnished afterwards by the sulphate of copper. The zinc and copper plates are both placed horizontally in the jar; the zinc in the upper part, and the copper lying on the bottom. To start this battery, throw into the jar a

few crystals of sulphate of copper. These go to the bottom, dissolve, and form a saturated solution around the negative plate of copper. The electrode or conducting wire from the copper plate may be made to pass through a glass tube reaching down to the bottom of the jar, and large enough to contain a supply of crystals of sulphate of copper necessary to keep a saturated solution in the lower part of the cell. This avoids disturbing the upper part of the liquid in which the zinc dips, and its mixture with the solution of sulphate of copper. The deposits from the zinc and other impurities are prevented from falling upon the copper plate, and thus interfering with the current, by covering the copper plate with a layer of clean quartz sand, which serves also as an obstacle to the effusion upward of the sulphate of copper, because the interstices between the grains act as a series of narrow tubes, but the force of the current diminishes by reason of the increased resistance.

COPPER DEPOSITS.—*By Dipping.*—Copper deposits are obtained either by simple dipping or galvanic methods. Copper deposits by dipping are seldom practised except upon iron, and are generally wanting in lasting qualities, since, from the thinness of the deposit, the iron is not protected against atmospheric influences. If the iron is steeped in a solution of sulphate of copper, $3\frac{1}{2}$ oz.; sulphuric acid, $3\frac{1}{2}$ oz.; water, 1 to 2 galls., for a short time, it becomes covered with a coating of pure copper, having a certain adhesion; but should it remain there for a few minutes, the deposit of copper is thicker and muddy, and does not stand any rubbing. In this case, compress it by means of rollers or a draw plate, in order to impart a certain cohesion to the particles of copper. Small articles, such as hooks, pins, or nails, are coppered by jerking them about for a certain time in sand, bran, or saw-dust impregnated with the above solution, diluted with three or four times its volume of water.

By Battery.—Electro-deposits of copper are obtained by decomposing a double

salt of copper with another base, such as the double cyanide of potassium and copper. This process is equally well adapted to all metals, and the deposits are fine, lasting, and their thickness is entirely regulated by the will of the operator. Dissolve about 16 oz. of sulphate of copper in 2 galls. of water, and add a solution of carbonate of soda until no more precipitate is formed; collect the green precipitate, carbonate of copper, thus obtained upon a cloth filter, and wash it several times with water; then stir the washed carbonate of copper in water, to which cyanide of potassium is added until the carbonate is entirely dissolved, and the solution is colourless. It is well to add a small excess of cyanide, which will increase the conducting power of the liquor. This bath may be employed hot or cold, and requires an intense electric current for its decomposition. A copper plate or foil forms the anode, and as it slowly dissolves, nearly makes up for the loss of copper in the bath which has deposited on the negative pole. This anode must be removed when the bath does not work, because it will be dissolved even without an electric current, and the bath having been overcharged with copper, which is indicated by a blue or green colour, will require a fresh addition of cyanide to be in good order. This bath is neither economical nor very reliable. The following formula is preferable;—Water, 2 galls.; acetate of copper, crystallized; carbonate of soda, crystals; bisulphite of soda; cyanide of potassium, pure, per cent., 7 oz. of each. For this bath the acetate of copper is put first into the vessel, and moistened with sufficient water to make a homogeneous paste. This salt, like flour, is wetted with difficulty, and will float on the surface of too great a body of water. The carbonate of soda and some water are added to this paste, and, after stirring, a light green precipitate is formed. Three pints more water are then added with the bisulphite of soda, and the mixture becomes of a dirty yellow colour. Lastly, add the remainder of the water and the cyanide of potassium. The electro-copper

bath must be colourless. If, after the complete solution of the cyanide, the liquor is not entirely colourless, add more cyanide. If a perfectly limpid bath is desired, pass it through filtering paper, or decant it after settling. This bath requires an electric current of moderate intensity for its decomposition. The copper anode should have a surface nearly equal to that of the immersed objects. Large pieces are generally kept hanging and motionless in the bath, whilst small articles are moved as much as possible, which is always to be preferred, especially with warm baths. If it were always possible to obtain a pure cyanide of potassium, this formula would be satisfactory in every case. But it is very difficult to find a perfectly satisfactory cyanide of potassium; the following formulae require a cyanide containing from 70 to 75 per cent. of the real article.

Cold Bath for Iron and Steel.—Bisulphite of soda and cyanide of potassium, 18 oz. of each; carbonate of soda, 36 oz.; acetate of copper, 17 oz.; aqua ammonia, 12½ oz.; water, 5½ gallons.

Warm Bath.—Bisulphite of soda, 7 oz.; cyanide of potassium, 25 oz.; carbonate of soda and acetate of copper, 18 oz. of each; aqua ammonia, 10 oz.; water, 5½ gallons.

Hot or Cold Bath for Tin, Cast Iron, or Large Pieces of Zinc.—Bisulphite of soda, 10 oz.; cyanide of potassium, 18 oz.; acetate of copper, 12½ oz.; aqua ammonia, 7 oz.; water, 5½ gallons. For small articles of zinc which are coppered in a perforated ladle, and in nearly boiling baths;—Cyanide of potassium, 25 oz.; bisulphite of soda, 3½ oz.; acetate of copper, 16 oz.; aqua ammonia, 5½ oz.; water, 4 to 5½ gallons. To prepare these different baths, dissolve all the salts in about 4 gallons of rain or distilled water, except the acetate of copper and the ammonia, which are dissolved apart in the remaining gallon. These two solutions are mixed, and that of copper and ammonia, which was of a magnificent blue, must become entirely colourless. When the liquors are not colourless there is a de-

deficiency of cyanide of potassium, which must be added until entire decolourization takes place. The bath is ready to work when subjected to the action of the electric current. The cold baths are put into well-joined tanks of oak or fir wood, lined inside with gutta-percha. The vertical sides are also covered with sheets of copper, which act as the soluble anode, and reach to just below the top edge of the tank. This anode is connected by the clean extremities of a conducting wire to the last copper or carbon,—that is to say, to the positive pole. Fix a stout brass wire upon the top of the tank, without any point of contact with the soluble anode, and connect by a second wire with the last zinc or negative pole of the same battery. The objects to be coppered are suspended in the bath by copper wires, supported, themselves upon a stout, clean, brass rod, the two extremities of which rest upon the brass conducting wire fixed upon the tank. Several of such rods are placed parallel to each other, and great care must be taken to prevent any contact with the anode, because the working of the bath would then be immediately stopped. When the thickness of the deposited copper is very small, the coat is sufficiently bright to be considered finished after drying. But if the operation is more protracted, the deposit has a more or less dead lustre on account of its thickness, and, if a bright lustre is desired, we must use the scratch-brush. The hot baths are put into stoneware vessels heated in a water or steam bath, or into an enamelled cast-iron kettle placed directly over a fire. The insides are also lined with an anode of copper connected with the positive pole of the battery, and the edges of the vessels are varnished, or support a wooden ring upon which rests a brass circle communicating with the negative pole. The objects to be electroplated hang from this circle. The hot process is much more rapid than the cold, and is especially adapted to those articles which are difficult to cleanse, because any remaining greasy substance is dissolved by the alkaline bath. Parcels of

small articles, metallic pens, for instance, are not suspended in the bath; they should be connected with the negative wire in the hand of the operator, and stirred about in every direction in the bath. This agitation permits of the employment of an intense current, without danger to the beauty of the deposit. Small articles of zinc are placed in a stoneware perforated ladle, at the bottom of which is attached a zinc or copper wire, which is wound up around the handle, and is connected with the negative pole of the battery. It is sufficient that one of the small articles touches the wire for all of the others to be affected by the current, as they are in contact with each other. If the bottom of the vessel is metallic, the ladle is made to rest upon a porcelain or stoneware ring. During the operation the articles are often jerked in the ladle; this agitation changes the position and the points of contact of the objects. When the deposit is being made too slowly bring up the bath by the addition of equal weights of acetate of copper and cyanide of potassium.

To Copper Silver.—Large pieces of silverware may be coppered in these baths. Very small articles are simply threaded upon a zinc or iron wire, or placed in a perforated ladle with granules or cuttings of either of these metals. Place the whole for a few minutes in a diluted but very acid solution of sulphate of copper, the zinc or the iron is dissolved, and the copper is deposited upon the silver. When the article is intended to be gilded or silvered, it is immediately passed through the solution of nitrate of biniodide of mercury, rinsed in cold water, and placed in the electro-baths, without drying or scratch-brushing.

BRASS DEPOSITS.—All the manufactures of bronze composition made of zinc or cheap alloys, have a brass deposit placed on before the bronze lustre is given, as the bronzing operation is more easy and satisfactory upon brass deposits. The preliminary and finishing operations and the disposition of the baths are the same for brass as for copper deposits. Heat is

employed for brass deposits by those who electroplate coils of iron or zinc wire with this alloy. The proper temperature varies from 130° to 140° F., and the coils of wire dip only one-half or two-thirds of their diameter into the bath. The bath is put into an oblong open iron boiler heated by fire, steam, or hot water. The inside is lined with brass sheets connected with the positive pole of a battery. A stout copper or brass rod, in the direction of the length of the boiler, rests upon the edges, and the contact of the two metals is prevented by pieces of india-rubber tubing. The rod is connected with the negative pole by a binding screw. Remove the binding wire from the coils, and loosen the wires, bending the ends together into a loop. Dip the wire in a pickle of diluted sulphuric acid, and hang it on a strong round peg held in the wall, so that the coil may be made to rotate easily. After a scrubbing with wet, sharp sand and a hard brush, give the coil a primary deposit of pure copper. It is then suspended to the horizontal rod over the brass bath, where only a part of the coil at a time dips into the solution and receives the deposit; the coil must be turned now and then one-half or one-fourth of its circumference: by dipping the coil entirely into the liquid, the operation is not so successful. The wires are washed, dried in saw-dust, and then in a stove, and lastly passed through a draw-plate, to give them the fine polish of true brass wire. Copper and brass wires are also covered with brass electro-deposits, in order to give them various shades.

Solutions for Brass Baths.—The ordinary cyanide of potassium is often preferred to the pure article, on account of its lower price; but the real value and dissolving property of ordinary cyanide are very variable. The following is a general method by which a bath of brass may be prepared with any kind of cyanide;—1. Dissolve together, in 2 gallons of water, 8 oz. of sulphate of copper, and 8 to 10 oz. of sulphate of zinc. 2. 4 oz. of acetate of copper, with 4 to 5 oz. of fused protochloride of zinc; and add a solution of 30 oz. of carbonate of soda, which produces

a precipitate of the carbonates of copper and zinc; allow this to settle; then decant the supernatant liquor, and replace it by fresh water two or three times, after as many settlings. Then pour on 2 gallons of water containing, in solution, 30 oz. of carbonate of soda, and 15 oz. of bisulphite of soda; while stirring with a glass or wooden rod, add ordinary cyanide of potassium until the liquor is perfectly clear, or until nothing but the greyish-black iron, found in the cyanide, or the brown-red oxide of iron in the sulphate of zinc, remains in suspension. An additional quantity of about an ounce of ordinary cyanide improves the conducting power of the liquor. With pure cyanide of potassium, or the ordinary cyanides with a constant and known composition, use the following mixtures. *Cold Brass Bath for all Metals;* Carbonate of copper, recently prepared, and carbonate of zinc, recently prepared, each 4 oz.; carbonate of soda, in crystals, bisulphite of soda, and cyanide of potassium, pure, each 8 oz.; and $\frac{1}{5}$ of an ounce of white arsenic; water, about 2 gallons. This bath is prepared as follows; Dissolve, in 3 pints of water, 5 oz. of sulphate of copper, and 5 oz. of crystallized sulphate of zinc, and add a solution of 14 oz. of carbonate of soda in a quart of water. A greenish precipitate of mixed carbonates of copper and zinc is formed, stir well, and allow to deposit for several hours. The supernatant liquid, holding the useless sulphate of soda, is thrown away, and replaced by nearly 2 gallons of water, in which are dissolved the bisulphite and carbonate; dissolve together in the remaining warm water the cyanide of potassium and the arsenious acid, and pour this liquor into the former one, which is rapidly decolorized, and forms the brass bath. Filter if necessary. Arsenious acid causes the deposit to be bright, but if in too great a proportion may give a white or steel-grey colour to the metal. This inconvenience is slight, as the yellow colour soon predominates. The arsenious acid may be replaced by soluble arsenites of potash, soda, or ammonia, but the proportions must be doubled. The baths

for cold electroplating are generally placed in wooden tanks lined inside with gutta-percha, which resists their action for a long time. The sides of the tank are also lined with one or more brass sheets joined together, connected with the last carbon or copper of the same battery, the intensity of which is regulated by the surface of the articles to be electroplated. The articles are suspended by copper or brass hooks to stout rods of the same metal, all connected with the last zinc of the battery.

Correcting the Brass Bath.—The losses of the solution are to be repaired by additions of copper and zinc salts, and arsenious acid, dissolved in cyanide of potassium. The operator will determine the needed substances from the rapidity of the deposit, its colour, and so on. If the deposit is too slow, try whether the bath will absorb the salts of copper and zinc, without the addition of cyanide. If the coat of brass has an earthy and ochreous appearance, and especially if the liquor is blue or green, add cyanide of potassium until perfect decolorization takes place. If the deposit is dull and unequal, add a small quantity of arsenious acid dissolved in cyanide. If the deposit is too red, add the salt of zinc, alone, or dissolved in cyanide. If the deposit is too white, or of a greenish-white colour, add the salt of copper alone, or dissolved in cyanide. When the bath after long use has become overloaded with salts, the specific gravity is too great for the easy passage of the electric current, the liquor must be diluted with water until it works satisfactorily. The specific gravity of a brass bath may vary from 5° to 12° Baumé. The pieces, before brass electroplating, must be perfectly cleansed in the same manner as zinc or iron; if the brass deposit is irregular, remove the objects from the bath, rinse, scratch-brush, and put again into the bath until the colour and the thickness of the deposit are satisfactory. Scratch-brush again, and, if necessary, rinse in hot water, dry in warm saw-dust of white wood, and put in the stove-room. The last three operations are indispensable for hollow-pieces.

Brass Bath for Steel, Wrought and Cast Iron, and Tin; using ordinary Cyanide of Potassium.—Dissolve together in 14 pints of pure or rain water;—Bisulphite of soda, 7 oz.; cyanide of potassium, No. 2, 17 oz.; carbonate of soda, 34 oz. To this solution add the following, made in 3½ pints of water;—Acetate of copper, 4½ oz.; neutral protochloride of zinc, 3½ oz. The two liquors become colourless when mixed. Ammonia must not be used for brass electroplating baths for iron, especially for solutions worked in the cold.

Brass Bath for Zinc.—Pure or rain water, 4½ gallons; bisulphite of soda, 24½ oz.; cyanide of potassium, No. 2, 35 oz. Add the following solution;—Water, 9 pints; acetate of copper and protochloride of zinc, each 12½ oz.; ammonia, 14 oz. The filtered bath is colourless, and gives, under the action of the battery, a brass deposit of a very fine shade, varying from red to green, by increasing the proportion of copper, or that of zinc. The anode is of brass.

Colour of Brass Deposit.—The difficulty in brass electroplating, especially with small baths, is in keeping the uniformity of the colour of the deposit, as the galvanic current, having simultaneously to decompose two salts each offering a different resistance, must, according to its intensity, vary the composition and the colour of the deposited alloy. It will be found that a feeble current principally decomposes the copper salt, and results in a red deposit; whilst too great intensity in the current decomposes the solution of zinc too rapidly, and the deposit is a white or bluish-white alloy. This is the case more especially with newly-prepared baths, and is an indication of irregularity in the conducting power of the bath, which, however, becomes more regular after being used for some time. The inconvenience of a red deposit may be remedied by increasing the number of the elements of the battery, or employing stronger acids, or decreasing the number and the surfaces of the objects to be plated; the other inconvenience of white deposits will disappear by diminishing the number of elements, or

by increasing the surfaces to be covered. The deposit may also be modified by substituting for the brass anode, either a sheet of pure copper, or one of zinc, or by simply hooking one of these sheets to the brass anode. A bath of pure copper will be transformed into one of brass by the use of a zinc anode; and an electro-bath of brass will become one of copper by the aid of a copper anode.

Arrangement of the Brass Bath.—In the disposition of the baths for brass plating it is always necessary to have all the articles suspended at about equal distances from the anodes; the bath may be subdivided by several anodes forming partitions, so that each loaded rod is between two anodes, or smaller separate baths employed. The anodes should be removed when the bath is not at work. In order that the brass electroplating of zinc and copper may be lasting, the deposit must not be too thin, and must be scratch-brushed, rinsed in water rendered slightly alkaline by quicklime, and thoroughly dried in a stove. But generally the articles are brass electroplated by remaining in the bath for from 10 to 25 minutes. Cast and wrought iron, lead and its alloys, require brass solutions richer in the metals than when depositing brass upon zinc or its alloys. The battery power should also be greater.

Brass Plating by simple Dipping.—A colour resembling brass is given to small articles of iron or steel by a long stirring in a suspended tub, containing water, 1 quart; sulphate of copper and protochloride of tin crystallized, about $\frac{1}{2}$ of an ounce each. The shades are modified by varying the proportions of the two salts.

Brassing Lead and Pewter.—Lead and pewter should be cleansed in a solution of about 4 oz. of nitric acid to the gallon of water, in which they remain for half an hour. Pewter is more easily coated with brass than lead, but the same bath may be used for either. They are then rinsed, scoured with sand, and rinsed again. A good battery power and a large surface of anode are necessary, especially at the beginning of the

deposit. The proper temperature of the bath for brassing lead, pewter, and tin is about 90° F. Stirring articles in a brass bath has a tendency to cause the deposition of copper alone.

TINNING.—Tinning Bath, by Exchange, for Iron.—This process is of little importance as a protection for iron as the layer of tin is a mere film, but it may be useful when thicker coats of tin are to be applied by other processes. For the bath, dissolve with the aid of heat, in an enamelled cast-iron kettle, ammoniacal alum, 11 oz., and fused protochloride of tin, $\frac{1}{2}$ oz., in $4\frac{1}{2}$ gallons of soft water. The pieces of iron, previously cleansed and rinsed in cold water, are steeped in the solution as soon as it boils. They are immediately covered with a film of tin of a fine white dead lustre, which may be rendered bright by friction. The bath is maintained at the proper strength by small additions of fused protochloride of tin. This bath is convenient for a preliminary tinning of zinc; when the ammoniacal alum may be replaced by any other kind of alum, or by sulphate of alumina; but for wrought and cast iron and steel this substitution cannot be made.

Electro-Tinning.—The bath is composed of rain or distilled water, 110 gallons; pyrophosphate of soda or potash, 11 lbs.; crystallized protochloride of tin, 21 oz.; or 18 oz. of the same salt fused, in order to have it free from an excess of acid; put the water into a tank entirely lined with anodes of tin sheets, united together and connected with the positive pole, carbon or copper, of the battery. Then introduce the pyrophosphate of soda or potash, and stir it in; when dissolved, the protochloride of tin is put into a sieve of copper half immersed in the solution. A milky-white precipitate is produced, which disappears after continued agitation. When the liquid has become clear and colourless, or only slightly yellow, the bath is ready; then place upon transverse metallic rods, connected with the negative pole, the previously cleansed objects which are to be tinned. The anodes are

not sufficient to keep the bath saturated; when the deposit is too slow add small portions of equal weights of tin, salt, and pyrophosphate; put in by the aid of the sieve, as if fragments of protochloride of tin fall to the bottom of the bath they become covered with a crust, which prevents their solution. The tinning thus obtained upon any kind of metal is quite resisting, and has a white and dead lustre resembling that of silver. A bright lustre may be obtained with the scratch-brush or the burnishing tool. As the reduction of these baths requires an intense current, and the working of the batteries is expensive, the best process is preferable.

Tinning by Double Affinity.—The bath is composed of—1. Distilled water, 66 gallons; cream tartar, 6½ lbs.; protochloride of tin, 10½ oz. The powdered cream of tartar is dissolved in 44 gallons of warm water, and the tin salt in 22 gallons of cold water. The two solutions when mixed become clear, and the resulting bath has an acid reaction. Or, 2. distilled water, 66 gallons; pyrophosphate of potash or soda, 13 lbs.; protochloride of tin, crystallized acid, 21 oz.; or the same fused, neutral, 14 oz. The whole is dissolved at the same time on a metal sieve, and, after stirring, the bath is clear. Either of these solutions is kept in a barrel with the top off. This barrel has at its lower part two tubes placed one above the other, connected with a small boiler built below the level of the bottom of the tank. The tube, starting from the bottom of the tank, reaches nearly to the bottom of the boiler; the other tube, which is placed about three inches from the bottom of the tank, is connected to the top of the boiler; a bent safety tube, connected only to the boiler, prevents any explosion, should there be an obstruction in the other tubes. A small quantity of water or mercury in the bent arm of the safety tube will prevent the escape of steam, when it does not exceed the working pressure required. When the boiler and tank are filled with liquid, as soon as heat is applied the expanded and lighter liquid will rise through the upper pipe

into the barrel, while the colder and denser one will flow into the boiler through the lower pipe. A continual circulation is thus obtained, which keeps up a constant agitation of the contents of the bath. Large pieces are cleaned and rinsed, and piled in the bath with a few fragments or spirals of zinc; the surface of the zinc should be about the thirtieth of that of the tinned articles. For small objects, such as pins or hooks, dispose them in layers about an inch thick upon perforated plates of zinc, which allow of the circulation of the liquid, and have their edges turned up so as to prevent the objects from falling off. These plates should be removed from the bath in the inverse order in which they have been put in. These zinc plates must be scraped and cleaned, so as to present fresh surfaces of zinc instead of the white crust, which prevents its contact with the articles to be tinned. The time for the operation varies from 1 to 3 hours. Then remove all the objects, and add to the bath 9 oz. of pyrophosphate, and as much of fused protochloride of tin. Whilst the solution is going on, scratch-brush the large articles, and stir the small ones about with an iron fork, to change the points of contact. The objects are then again steeped in the bath for at least 2 hours. The large pieces are scratch-brushed again, and the small ones rendered bright by mutual friction. Then dry the whole in dry and warm fir-wood saw-dust. Cast-iron cooking vessels thus tinned have a bright appearance, and have the advantage of never communicating any taste, smell, or colour to the food cooked in them, even when the tinning, after long use, has completely disappeared.

Colour of Tin Deposit.—If the tin deposit is grey and dull, although abundant, prepare the bath, once or twice, with the acid crystallized protochloride of tin. With a very white deposit, but blistered and without adherence or thickness, replace the acid salt by the fused one. In the latter case, also diminish the proportion of tin salt, and increase that of pyrophosphate; a great

deal of the success of the operation depends upon the quality of the pyrophosphate. When a tinning bath has been worked for a long time, decant the liquor to separate the pyrophosphate of zinc formed. And when, after several years, the solution is entirely used up from the alteration of the salts, it should be kept in preserving tubs, where the objects to be tinned are put after cleansing.

To Tin Zinc.—The proportions of the bath are as follows;—Distilled water, 66 gallons; pyrophosphate of soda, 11 lbs; fused protochloride of tin, 35 oz. A thin tinning is obtained by simple dipping, and one of any thickness by the aid of the battery.

Whitening by Tin.—This is effected by boiling for two or three hours in long copper troughs, crude cream of tartar with tin plates supporting a layer of about $\frac{1}{2}$ an inch of the pins, or other small articles, to be whitened. The whole charge is composed of alternate layers of pins and tin plates, so that each layer of pins is between two tin plates. This process will not succeed with iron without an intermediate coat of copper has been deposited.

GILDING. — Gilding by Dipping. — The baths employed contain gold in the form of a double salt of protoxide, and should possess little stability, that is to say, be decomposed and abandon the gold under feeble influences, and should dissolve the copper placed in them in an equivalent proportion to that of the deposited gold, thus forming a new double salt in which the copper is in the same degree of oxidation as the gold. When the articles have been previously amalgamated, it is mercury and not copper which is substituted for gold in the solution.

Preparation of the Gold Bath.—Distilled water, 17 pints; pyrophosphate of potash, or soda, 28 oz.; hydrocyanic acid of $\frac{1}{8}$ prussic acid, $\frac{1}{3}$ of an ounce; crystallized perchloride of gold, $\frac{2}{3}$ of an ounce. The pyrophosphate of soda is most generally employed, and is obtained by melting, at a white heat, the ordinary crystallized phosphate of soda. The

pyrophosphate of soda may be obtained in the form of crystals, which is a proof of a definite composition. The quantity of chloride represents a little more than $\frac{1}{3}$ of an ounce of pure gold treated by aqua regia. Put 16 pints of distilled water in a porcelain vessel, or an enamelled cast-iron kettle, and add, by small portions at a time, and stirring with a glass rod, the pyrophosphate; heat, filter, and let it cool down. The chloride of gold is prepared by introducing into a small glass flask pure gold finely laminated, $\frac{1}{3}$ of an ounce; hydrochloric acid, pure, nearly 1 oz.; nitric acid, pure, $\frac{1}{2}$ an ounce. The flask is slightly heated, effervescence and abundant nitrous vapours result, and in a few minutes the gold has entirely disappeared, leaving a reddish-yellow liquor. The flask is then put upon a sheet of iron, with a hole in its centre, and supported by a tripod. The whole is heated by a gas or spirit lamp to evaporate excess of the acids; too much acidity may cause great irregularities in the working of the bath, and even prevent its action altogether. An excess of nitric acid causes a jumping of the heated liquors, and may overthrow the whole; it is preferable to have the hydrochloric acid predominating. The evaporation is finished when vapours escape slowly from the flask, and when the liquid has become of an oily consistency and of a deep red colour. The flask is then removed from the fire by wooden pincers, and set to cool upon a ring of plaited straw. If a more rapid evaporation is desired, heat the flask over ignited charcoal, or the spirit lamp; agitate the liquid to prevent any of the gold from returning to the metallic state. Well-prepared chloride of gold, when cold, forms a saffron-yellow crystalline mass. If the colour is red, it has been too much evaporated, and will do very well for electro-baths; but for dipping baths it must be heated again after a small addition of the two acids. If the perchloride of gold, by too protracted a heat, has passed to the state of insoluble protochloride, or even of metallic gold, the treatment must be begun again with the indicated mixture of pure

nitric and hydrochloric acids. The perforated sheet of iron, upon which the flask rests, is intended to prevent the action of heat upon the sides of the vessel, which will decompose the films of chloride of gold wetting the flask at these places. When the chloride of gold is cold and crystallized, dissolve it in the flask with a little distilled water, and pour the solution through a paper filter held in a glass funnel into a clean bottle; this is to separate a small quantity of silver always found in the gold of the trade. Rinse the flask and filter with the unemployable water, so as to get all the gold into the bath. Pour the filtered solution of chloride of gold into the cooled one of pyrophosphate, and stir with a glass rod. Lastly, add the hydrocyanic acid, and the bath is heated nearly to the boiling point for use. If the solution of pyrophosphate is still tepid, add the hydrocyanic acid before the chloride of gold. Hydrocyanic or prussic acid is not absolutely necessary; but, without it, the bath is too easily decomposed, and the gold is too rapidly precipitated upon the objects placed in it. When the solutions are mixed in the cold, the liquor is yellow or greenish-yellow; but becomes colourless by the increase of temperature. If the liquor becomes current red, or wine-les violet, it is an indication that there is too little hydrocyanic acid; add it, drop by drop, until the liquor becomes colourless. An excess of this acid is objectionable, but there is a very simple method of keeping the baths in good working order, by adding prussic acid gradually to those too rich in gold; or correcting any excess of prussic acid with a small proportion of chloride of gold, until the gilding is produced without difficulty and of the proper shade. Thus prepared, the bath will produce very fine gilding upon well-cleansed articles, which must also have passed through a very diluted solution of nitrate of binoxide of mercury, without which the deposit of gold is red and irregular, and will not cover the soldered portions. The articles are supported by a hook or in a stoneware ladle perforated with holes, or

in brass gauze baskets; they must be constantly agitated whilst in the bath. Gilders usually employ three baths, placed in close proximity to each other, and heated upon the same furnace; the first bath is one deprived of gold by a previous operation, and is used for removing all excess of acid which may remain upon the articles: the second bath still retains some gold, but not enough to give a sufficiently rich gilding. The pieces passed through it begin to receive the deposit, which will be finished in thickness and shade in the third bath. A gas furnace, easy to manage, and clean in its working, may be arranged by having a properly supported sheet-iron plate, with holes cut out where the kettles are to stand. Under each kettle place suitable gas burners; when the baths have been heated nearly up to boiling point, lower the gas, so as not to increase the temperature. This method produces much more gilding with a given quantity of gold, than one bath alone. The gilding is done in a few seconds; the finishing operations consist in rinsing in fresh water, drying in dry and warm saw-dust, and burnishing, if desired.

Colouring Process.—If the gilding is dull and irregular in colour, melt together in their water of crystallization, at about 212° Fahr., equal parts of sulphate of iron, sulphate of zinc, sulphate of alumina and potash, and saltpetre. Cover the articles with the mixture, and put them into a cylindrical and vertical grate. This is placed in the centre of a furnace, where the charcoal burns between the sides and the grate which holds the articles. When the moistened finger is presented to one piece, and a slight hissing sound is heard, the heat has been sufficiently raised; put all the articles rapidly into a very diluted solution of sulphuric acid, where the coating of salts is quickly dissolved; the articles present a warm, uniform shade of colour. If the copper articles are not entirely gilt by the first operation, the ungilt portions will show themselves by a red colouration, and the articles must then be deprived of gold, cleansed, and gilt

anew. Sometimes, when the first gilding is imperfect, instead of colouring by the process just described, the articles are placed for a few moments into the electro-bath. For articles which require a good plating there is an easy method by this process of obtaining as good results as by the battery; it consists in gilding several times, by dipping; before each dipping, the article is passed through the solution of nitrate of binocide of mercury. Gilding by dipping is superior to that by electricity in depth of shade, brightness, and especially in not scaling off, as the deposit is of pure gold only.

Ormolu.—This operation consists in smearing, by means of a brush, the gilt and scratch-brushed objects with a thin paste of nitrate of potash, alum, and oxide of iron, which have been well mixed and ground under the muller, and to which has been added a solution of saffron, annatto, or any colouring substance, according to the shade desired. If the gilding is strong and thick, the objects are heated until the previous coating curls over at the approach of a wet finger. If the gilding is a mere film, the mixture is simply allowed to stand upon the articles for a few minutes. In either case, the whole is rapidly washed in warm water holding in suspension a certain quantity of the materials for ormolu; they are then rapidly dried, when they appear of a darker shade; remove any portions too much coloured by striking them vertically with a brush having long bristles. If the tint does not appear satisfactory commence the operation afresh, after washing off the ormolu in a diluted solution of sulphuric acid.

Green and White Gilding.—These shades may be graduated at will, and are obtained by adding, drop by drop, until the desired shade is arrived at, to the bath of double pyrophosphate of soda and gold, a solution of nitrate of silver. For the solution of nitrate of silver, dissolve in 5 oz. of distilled water, $\frac{1}{2}$ oz. of nitrate of silver crystallized, or of lunar caustic. Before gilding green or white, yellow gild the objects in the ordinary bath, then pass them rapidly through the mercurial solution, and, lastly, dip

them into the gold bath holding the nitrate of silver, which parts rapidly with its silver upon the first articles steeped in it. It is necessary to maintain the constancy of the shade by the addition of a few drops of the silver solution when required.

Gilding Silver by Dipping.—The silver articles, previously cleansed and scratch-brushed, are boiled for about half an hour in the gold bath of pyrophosphate, to which add a few drops of sulphurous acid, or, preferably, hydrocyanic acid, in excess of the quantity needed by the primitive bath. This gilding is very fine, but without firmness. The deposit is rendered more rapid and thicker when the silver articles are stirred with a rod of copper, zinc, or brass.

Gilding on Porcelain, Glass, or Crystal.—Mix first in a crystal mortar, and then between a muller and a ground plate glass, neutral chloride of platinum with rectified essence of lavender, so as to form a thin syrup, which is applied with a brush in very thin layers upon the glass, porcelain, or other ceramic object. After drying, heat in a muffle up to a dark red; this temperature reduces the platinum to the metallic state; it then appears with a perfect polish. After cooling, pass the whole object through aquafortis, which is without action upon the platinum, but destroys the impurities which may tarnish its surface. Rinse in plenty of water, wrap the object with a few turns of fine brass wire, having numerous points of contact with the platinized places, and dip into the gold bath. After a few minutes the platinum is covered with gold which has the same adherence and polish. Rub the gold with chamois leather; this method dispenses with burnishing, which is costly, and often impracticable in the deeply indented parts. If the gilding is too red, add to the bath a few drops of a solution of double cyanide of potassium and silver (liquor for silver electroplating). This method is preferable to that of baths with separate battery; the gilding has a bright instead of a dead lustre, and its adherence is greater.

Duterc's Process for Bright Gold Gilding consists in applying with a brush to the objects a mixture of sulphide of gold and various essences, which are then submitted to a dull red heat.

Gold Dipping Bath with Bicarbonates.—The bicarbonate bath is prepared in a cast-iron kettle, turned clean and smooth inside on the lathe, and gilt by the protracted ebullition of nearly spent gold baths. Water $3\frac{1}{2}$ galls.; bicarbonate of potash or soda, $\frac{1}{2}$ oz.; pure metallic gold, transformed into chloride, $4\frac{1}{4}$ oz. The whole is boiled for at least 2 hours, and fresh water added to replace that evaporated. A part of the gold, in the form of a violet-black powder, precipitates, and requires the cooling and decanting of the liquor. This is boiled again and the gilding proceeded with, in the same manner as before described, except that the mercurial solution should be more diluted than for the baths of pyrophosphates. The operation is finished when about half of the gold in the liquor is deposited. The remainder goes to the saved waste. The bicarbonate process is inferior in most respects to the pyrophosphate, and is now rarely used.

Gilding by Diluted Bath.—This bath should be employed only as a complement to the cleansing process, before a more resisting gilding, as its results have little durability. Water, 2 galls.; bicarbonate of potash, 7 oz.; caustic potash, 63 oz.; cyanide of potassium, 3 oz.; metallic gold to be transformed into chloride, $\frac{1}{4}$ oz. The whole is brought up to the boiling point, and a pale gilding is obtained even upon articles imperfectly cleansed, and without using nitrate of binocide of mercury. It is possible to add $\frac{1}{8}$ oz. of chloride of gold several times to this bath without any other substances. Afterwards maintain it at the proper strength by additions of gold and salts in the above proportions, and it will last for an indefinite period. This bath will gild about 140 oz. of small jewellery with $\frac{1}{8}$ oz. of gold, whereas a pyrophosphate bath gilds only about $3\frac{1}{2}$ oz. of small articles with the $\frac{1}{8}$ oz. of gold extracted from the liquor.

Gilding by Stirring and Gold Amalgam.—In the centre of a charcoal stove put a crucible holding a given quantity of pure and dry mercury, and when the temperature has reached about 212° Fahr. add $\frac{1}{2}$ the weight of gold. Stir with an iron rod until the amalgam has acquired the consistency of butter, throw it into cold water, and keep it there for use. Cleanse the articles to be gilded in aquafortis, put them in a stoneware pan, and pour over them a diluted solution of nitrate of binocide of mercury, taking care to move the articles about all the time, in order to cover them with a regular white coating of mercury. Add the desired proportion of amalgam; on stirring the articles this is spread all over them. Then rinse the articles in cold water, place them in a large and deep copper ladle, perforated with numerous small holes, and having a long handle. Hold the ladle over a charcoal fire, and constantly stir it about in order to have the heat equal everywhere. The mercury of the amalgam is soon volatilized, and the gold remains adherent to the articles. If instead of a yellow gilding a red one be desired, this is got by waxing, which consists in pouring upon the pieces, kept in the ladle and upon the fire, in a well mixed and fluid state;—oil, 25 parts; yellow wax, 25; acetate of copper, 10; red ochre, 40. The articles must be constantly agitated, and the mixture allowed to burn out, when the whole is thrown into a very diluted solution of sulphuric acid. The waxing is only to be done after the complete volatilization of the mercury. When removed from the pickle, the gilding has the dull ochre appearance, and must be scratch-brushed. Small articles are brightened in a long narrow bag, where they are put with copper pearls, or the waste from these pearls, and wet with vinegar water; a to-and-fro motion is imparted to the bag, and the gilt articles and the copper granules polish each other. Rinse and dry in saw-dust, and burnish if required.

Cold Gilding with the Ray.—Dissolve finely laminated pure gold in aqua regia made of nitric acid, 5 parts; sal am-

monic, 2; saltpetre, $\frac{1}{2}$. Heat carefully upon a gentle fire; when all the gold has disappeared, pour the cooled contents of the flask into a flat-bottomed stoneware pan. Into this liquor, place one upon the other, and in sufficient quantity, squares of linen cloth, strike them with a glass rod, in order that they may equally absorb the chloride of gold. Each square of cloth is taken out with wooden pincers, well drained, and spread for drying in a dark chamber. When nearly dry, each piece of cloth, supported upon glass rods, is placed on top of a charcoal fire, and soon takes fire. The combustion is aided by the presence of the saltpetre, and is finished upon a marble slab. Grind the ashes under a muller, collect and keep them between the folds of a parchment leaf, around which a wet cloth has been folded. The powder is then ready to use; mix it upon a slab with a few drops of water, and with this paste rub the well-cleaned surfaces of the silver to be gilt. The smooth surfaces are rubbed with the thumb, the fillets or grooves with a fine cork cut to the proper shape, and the corners or angles with a stick of soft wood, such as linden or poplar; the articles are then burnished. This gilding is very thin, but quite resisting, especially after the action of the burnishing tool, which forces the gold into the pores of the silver. If a red shade be desired, add a small proportion of pure copper to the gold to be dissolved in aqua regia.

Gilding with the Brush or with Shell Gold.—The gold powder is prepared by rubbing the cuttings of gold-beaters' foil under the muller; to prevent them from being blown away, add a small quantity of white honey. When fine enough put the paste into water, by which the honey is dissolved. After several washings, settlings, and decantings, allow the powder to dry. In case of hurry, the washing may be performed upon a paper filter. The dry powder is again ground with a little gummy water, and the paste spread over the inside of a mussel-shell. The gold powder is mixed with gum water, and applied with a brush upon the parts to be

mended, and allowed to dry. If a green gold powder be desired, mix silver foil with the gold cuttings. An addition of rose copper foil produces a red gold. The preparation is the same for silver powder employed for mending slight defects in silver articles not exposed to friction.

GOLD ELECTROPLATING.—It is not always necessary in electrogilding to use a battery, for the contact of two heterogeneous vessels, especially within a salt or acid liquor, is enough to produce electricity; thus it is sufficient to plunge the articles, attached by zinc wires, into gold baths prepared for the use of batteries, to have the operation taking place in the same manner as with a separate battery. Electroplating in the cold is employed for large pieces, such as clocks; whilst electrogilding by heat is more adapted to the gilding of small articles, such as forks and spoons. The deposits produced by hot gilding are more smooth and clean, the colour is deeper, and the articles when removed from the bath may not require colouring; and with the same quantity of gold, gilding by heat is much more durable than that obtained from cold baths. Steel, tin, or lead can be gilt in hot baths, but not in cold.

Gold Electroplating Baths.—1. Distilled water, 2½ gallons; cyanide of potassium, ordinary 70 per cent., 10½ oz.; pure gold, 3½ oz.; aqua ammonia, 17½ oz. Heat the gold in a glass flask with 2 oz. of pure hydrochloric acid, and 4½ oz. of pure nitric acid. When the gold is dissolved, continue the heat in order to expel the acid fumes, and until the colour of the liquid is dark red, nearly black. Remove from the fire, and dissolve the crystalline mass formed in cooling in 3 or 4 pints of water, and pour into a large porcelain dish. Add the ammonia, which produces an abundant yellow precipitate of gold ammonium; pour upon filtering paper, and the filtered liquid, which still contains traces of gold, is kept with the saved waste. Wash the precipitate remaining upon the filter several times

with cold water, until it no longer smells of ammonia. It must not be dried, as it is a fulminating mixture, and consequently very dangerous. Next dissolve in the vessel used as a bath the cyanide of potassium in the distilled water. Filter, and add the wet gold ammonium, which rapidly dissolves when stirred, and forms a clear gold bath. But before using it cold, the ammonia should be expelled by boiling for about one hour. For a newly-prepared cold electrogilding bath, the ordinary cyanide of potassium is preferable, on account of the potash it contains, which renders the liquor a better conductor of electricity. But for the preservation of the strength, the pure cyanide is better, as it possesses the advantage of a constant composition, and does not load the solution with foreign salts. The gold solution for maintaining the metallic strength of the bath is prepared as follows:—Transform the gold into precipitate of gold ammonium, as above described, place it in water, 2 pints of water to 4 oz. of gold, then add cyanide of potassium until the liquor is colourless. If there is not sufficient water with the gold ammonium, the liquor will be dark red, and will not be decolorized by cyanide. 2. Distilled water, 2½ gallons; cyanide of potassium, pure, 7 oz.; or ordinary cyanide, according to strength, 10 to 14 oz.; pure gold, 3½ oz. Make a neutral chloride of gold, as in the preceding formula, and, when cold and crystallized, dissolve it in 3½ pints of water. Filter if needed. Dissolve the cyanide in 14 pints of water, filter, and mix the two solutions, which become colourless. When it is possible to boil this bath for half an hour before using it, it becomes a better conductor of electricity, and the gilding is more uniform. Its strength is maintained by additions of neutral chloride of gold and pure cyanide of potassium, from 1 to 1½ of pure cyanide to 1 of gold. Both the above baths may be diluted with once or twice their volume of water; the gilding will remain fine, but the proportion of gold deposited will be less in a given length

of time. 3. Yellow prussiate of potash, 7 oz.; pure carbonate of potash, 5 oz. sal ammoniac, 1 oz.; pure gold transformed into chloride, ½ oz.; water, 2½ gallons. Boil all the salts together, less the chloride of gold, separate by filtration the precipitate of carbonate of iron, then add the chloride of gold dissolved in a little water, and allow the bath to cool off. Any kind of gold salt, and the oxide, or even finely-powdered metal, may take the place of the chloride of gold; but the latter is preferred on account of the facility of its preparation, and of its solubility. Any kind of gold salt will be transformed into cyanide by the cyanide of potassium. The small proportion of the chloride of potassium resulting from the transformation of the chloride of gold into cyanide does not prevent the good working of the baths. The addition of a little prussic acid produces a brighter, but thinner, gilding. The indicated cyanides may be replaced by the cyanides of sodium, calcium, and ammonium. Cold gilding baths are generally kept in porcelain or storeware vessels; but for large volumes of liquor use wooden troughs lined with gutta-percha plates. The sides of the troughs support anodes of laminated gold, which dip entirely into the liquor, and are held by small platinum wires; they are connected with the positive pole of the battery. Suspend the articles by means of metallic slinging wires to a movable frame of clean brass rods connected with the negative pole. The deposit of gold should be pure yellow, but it has sometimes a dull earthy grey colour. In that case scratch-brush it with the greatest care, and then pass it through the ormolu colouring. The gold anode conducts the electricity, and also maintains the metallic strength of the bath up to a certain point; but it is necessary to add now and then either the oxide or the chloride of gold, and a certain proportion of cyanide of potassium, to make up for that transformed into carbonate of potash and cyanide of ammonia. The proportion of cyanide is about double that of the chloride of

gold added; this is ascertained by the colour of the bath and the shade of the deposit; if the proportion of the chloride of gold is too great, add more cyanide. If gold predominates, the deposit is quite black or dark red; when the cyanide is in excess, the gilding is very slow and grey, and it will sometimes happen that pieces already gilt will lose their gold. When the bath is not in use, the gold anode must be removed from it, otherwise it will be dissolved. If the anode were partly immersed in the bath, it would be rapidly cut at the level of the liquid; for this reason use the platinum wires, which are not acted upon. It is remarkable that the solutions of cyanides, even without the action of the electric current, rarely dissolve all the metals except platinum in the cold or at a moderate temperature, and that at the boiling point they have scarcely any action upon the metals. Cold electrogilding should be done slowly; and it is necessary to often look at the pieces in the bath, and scratch-brush those with an irregular deposit, or with dark spots. The intensity of the current should be often changed by increasing or diminishing the number of the elements, or the strength or the volume of the liquors in the battery. With too much intensity in the current, the deposit is black or red; it is yellow with the proper amount of electricity. With a weak current those portions opposite the anode only get covered with gold; it is well to change the position of the objects often, in order that the deposit be regular. With a freshly-prepared bath, it may happen that surfaces already gilt will lose their gold by changing their positions. This is a sign that the bath contains too much cyanide of potassium, and too little gold, or that the electric current is too weak. When the deposit obtained in cold baths is unsatisfactory in appearance, although the quantity is sufficient, the proper shade may be imparted by—1. The gilt article is steeped in a solution of nitrate of binocide of mercury, until it has become white. It is heated afterwards

to volatilize the mercury, and scratch-brushed. 2. Place the article into concentrated sulphuric acid, then heat it until abundant white fumes are disengaged, throw it, still hot, into a weak pickle of sulphuric acid. In this case, the acid has destroyed the organic impurities which may exist in the deposit, and reduces the subsalts of gold to the metallic state. 3. Smear the article with a thick paste of water and powdered borax, or with biphosphate of lime of the consistency of honey, and heat until igneous fusion takes place. Then put the article into diluted sulphuric acid, which dissolves the borax or the biphosphate, and leaves the gold with its natural bright lustre. When, after scratch-brushing small gilt articles, their colour is not entirely satisfactory, it may be improved by plunging the articles again into the bath but for an instant, and then immediately into boiling water. For gilding German silver, the solution should be worked at rather a low temperature, and with a less surface of anode. The solution should be just so weak in precious metal, that the German silver will not precipitate the gold without the aid of the battery; otherwise the deposit will take place so rapidly that the gold will peel off when being burnished or scratch-brushed.

Gold Electroplating in Hot Baths is more regular, more rapidly obtained, and possesses a deeper shade, than that by cold baths. 1. Crystallized phosphate of soda, 21 oz.; bisulphite of soda, 3½ oz.; pure cyanide of potassium, ¼ oz.; pure gold, transformed into chloride, ¼ oz.; distilled water, 2½ gallons. This is satisfactory for electrogilding silver, bronze, and other alloys rich in copper. For gilding wrought and cast iron and steel directly, without a previous coat of copper, the bath is modified as follows:—Distilled water, 2½ gallons; phosphate of soda, 17½ oz.; bisulphate of soda, 4½ oz.; pure cyanide of potassium, ¼ oz.; gold transformed into chloride, ¼ oz. The proportion of gold indicated is that of the metal employed, and it is not necessary to mind

the weight of the chloride, if the proper amount of gold is dissolved in aqua regia. Ten parts of metallic gold corresponds to about 18 parts of neutral chloride, or to 23 or 22 parts of acid chloride such as is usually sold. Steel articles, after cleansing by alkalis, must be passed rapidly through a very diluted solution of hydrochloric acid, wiped, and dipped into a very hot bath with an intense galvanic current at the beginning, which is gradually diminished by partly withdrawing the platinum anode. Small articles of steel, such as pens, or watch hands, are threaded on a thin brass wire, and separated one from the other by glass beads. After cleansing, they are put into the boiling bath, rinsed, dried, and polished in hot and dry saw-dust. It is preferable to give zinc, tin, lead, antimony, or the alloys of these metals, a previous coat of copper, or to begin the gilding in a hot gold electro-bath, nearly worn out, and to scratch-brush the articles carefully. The gilding is completed in a new hot bath, with a strong current.

Preparation of the Gold Bath.—1. Put four-fifths of the distilled water into a porcelain dish, or an enamelled cast-iron kettle, heated over a charcoal stove, and dissolve in it, by the aid of stirring, the crystallized phosphate of soda. When this is entirely dissolved, remove the liquor from the fire, filter if necessary, and allow it to cool off. 2. Place the gold in a glass flask, with $\frac{1}{2}$ oz. of pure nitric acid and 1 oz. of pure hydrochloric acid. Heat slowly until the gold has dissolved, and then more rapidly to expel the excess of acid. There should remain a thick liquid of a blackish-red colour. Remove the flask from the fire, and by cooling the contents form a brown-red crystalline mass. The cooling is important. 3. Dissolve in a porcelain dish, in half the remaining water, the bisulphite of soda and the cyanide of potassium. 4. Then dissolve the neutral chloride of gold in the remaining water, and pour it slowly, stirring with a glass rod, into the cold solution of phosphate of soda; add the

solution of bisulphite and of cyanide. The whole liquor soon becomes colourless; the bath is then ready. If the chloride of gold were thrown into the solution of phosphate of soda while hot, there would be danger of a partial reduction of the gold in the form of a metallic powder. The hot electrogilding baths for small quantities of liquor are kept in porcelain dishes, but for large baths use enamelled cast-iron kettles. The temperature may vary from 120° to 175° Fahr. Small articles, such as jewellery, are kept in the right hand with the conducting wire, and plunged and agitated in the bath. The left hand holds the anode of platinum wire, which is steeped more or less in the liquor, according to the surface of the articles to be gilt. Large pieces are suspended to one or more brass rods, and are not moved about. The gilding is very rapid, and a sufficient thickness is obtained after a few minutes. The shade of the gold deposit is modified by the amount of the platinum anode dipping into the liquor. If it dips but a little, relatively to the surface of the articles, the gilding is pale; by immersing it more the shade will become deeper and deeper, until it is red. The platinum anode is connected by a conducting wire to the positive pole of the battery, and the conducting wire starting from the negative pole, touches or supports the articles to be gilt. As a rule, it is preferable to replace the impoverished baths by fresh ones, instead of keeping up their strength by additions of metal, especially for small articles. When gilding large pieces, maintain the strength of the baths by successive additions of chloride of gold, or, what is better, of equal parts of gold ammonium and pure cyanide of potassium. In this manner baths may be made to last a long time, but they are open to the inconvenience of furnishing a red or green gilding, if many articles of copper or of silver have been gilt in them. Articles of copper, or its alloys, should be perfectly cleansed, and may be passed through a very diluted solution of nitrate of binoxide of mercury. Silver

requires to be heated, dipped, and perfectly scratch-brushed. For this metal the gilding should be strong, in order to prevent the corners and raised parts from becoming white and bare; and it is a good precaution to give it a coat of copper or brass, or a first gilding in an old bath. 2. Phosphate of soda, 14 oz.; bisulphite of soda, 3½ oz.; bicarbonate of potash and caustic potash, 1½ oz. of each; cyanide of potassium and pure gold for neutral chloride, ½ oz. of each; distilled water, 2½ gallons. All the substances except the chloride of gold may be dissolved together, and filtered if necessary; then the solution of chloride of gold is added. This bath is heated at from 120° to 140° Fahr., and produces a very fine gilding, but it requires an intense electric current. It does not suit for the direct gilding of iron or steel. 3. Yellow prussiate of potash, 5½ oz.; carbonate of potash, pure, 1½ oz.; hydrochlorate of ammonia, ½ oz.; pure gold for neutral chloride, ½ oz.; water, 1 gallon. Dissolve the first three salts in hot water, and filter the solution; after cooling add the gold solution, and boil for half an hour, taking care to replace the evaporated water. 4. Pure cyanide of potassium, 1½ oz.; pure gold, for neutral chloride, ½ oz.; water, 5 pints. Dissolve the chloride of gold in the whole of the water, and add the cyanide, which dissolves and makes the liquor colourless. This bath may be employed with little regard to temperature, and is simple in its ingredients. Unfortunately it is not uniform in its working, as it will ungold one face of the object while the other face becomes gilt, or may produce a red gilding at the bottom and a yellow one at the top. These inconveniences will partly disappear by a long ebullition.

Management of Hot Gold Baths.—The baths may be more concentrated, the quantity of water may be diminished, without changing the proportions of the salts and of the gold. But it is preferable to use diluted solutions, which deliver the metal in smaller quantity in a given time, but more homogeneous in substance. The articles should be kept

in constant agitation; there is then no difference of specific gravity among the layers of the liquor, and the gilding possesses a uniform colour. A foil or a wire of platinum is preferred to a soluble anode of gold when electrogilding by the aid of heat, as it is not dissolved, and is more handy for regulating the intensity of the current, by immersing it more or less in the liquid. Thus with the same bath and battery three different shades can be obtained; a pale colour, with the anode dipping but slightly; a yellow colour, when the immersion is greater, and a red gold, if the whole anode is in the liquor. In a bath of pink gold, composed of gold, copper, and silver, by increasing or diminishing the length of the platinum anode in the liquor, the deposit will have a white, yellow, or red shade, as the various metals require different degrees of intensity for their reduction in the galvanic current. In hot electrogilding baths, and especially with small articles, keep them in the right hand constantly moving in the liquid, while the left hand is employed in changing the position of the platinum anode, so as to suit the surface and the nature of the articles, and obtain the desired shade. The hot baths may have their strength maintained by successive additions of chloride of gold with a proper proportion of the other salts; but it is preferable to wear out the bath entirely and to prepare a new one. When a bath is exhausted, the gilding is red if much copper has been gilt in it, and green in the case of silver articles. It may then be used for a first coat upon objects which are to be finished in a new bath. Thus green or white golds result from the simultaneous deposit of gold or silver in various proportions; red gold from the alloy of copper and gold; and pink gold from the combination of gold, silver, and copper.

Green and White Golds.—Add to one of the above baths a solution of the double cyanide of silver and potassium, or a diluted solution of nitrate of silver, until the desired shade is obtained. The tints will vary from a leek-green to a very pale whitish-yellow. This kind of

gilding mixed upon the same articles with red, yellow, or pink gold, will produce splendid effects of contrast, especially upon chased parts, where the green gold has a velvety lustre.

Red Gold.—Mix in suitable proportions the electro-copper bath already described with one of the baths for electrogilding; or use an old bath in which a great many copper articles have been gilt, with an intense current of electricity. Yellow gilding may be made to pass to red, by heating it after it has been covered with a paste of acetate of copper, cream of tartar, and common salt. Plunge the heated piece into a weak solution of sulphuric acid, and carefully scratch-brush afterwards.

Pink Gold or New Gold.—This kind of gilding is the most difficult to obtain on account of the different tendency of the various metals to galvanic decomposition. Pink gilding, to be perfect, should present at the same time the red, yellow, and white shades, in such a manner that a practised eye will distinguish them. The articles are first gilt yellow by the pyrophosphate bath for dipping, or by the hot electro-bath. Then, without drying, but keeping them in fresh water, small packages are made weighing from 1 oz. to 2 oz. each; pass lightly through the mercurial solution, and then red gilt in an old and hot bath, where a great deal of copper has already been gilt, or in a new bath composed of 10 parts of hot electrogilding bath, first formula, and 3 to 4 parts of the first coppering solution, with battery. For imparting the whitish tint of articles gilt by stirring and of the gold alloy for jewellery, the red gilding is passed through a boiling and nearly exhausted bath of pyrophosphate, to which add one-tenth, or a twentieth, or a thirtieth of its volume of a silver bath, or simply a few drops of a concentrated solution of nitrate of silver. In either case a bluish of silver is deposited upon the red gilding. This gilding should be scratch-brushed or burnished, and may be chased, but the lustre soon disappears on account of the proportion of copper. To obtain the proper pink gilding, if

the first deposit is unsatisfactory, plunge the articles for a few seconds into a mixture of 5 parts of sulphuric acid to 1 of nitric acid. The copper and silver are dissolved, and the yellow gilding reappears, upon which the operation may be begun anew. Besides the variations of colour in gilding due to the dipping of the anodes more or less into the bath, and to the strength of the electric current, moving the articles about in the bath will at all times enable the operator to vary the colour of the deposit from pale straw yellow to a very dark red. The temperature of the solution likewise influences the colour of the deposit, the colour being lightest when the solution is cold, and gradually becoming darker as the temperature increases.

Gilding Watch Parts.—In gilding small articles for watchmakers, gold is seldom directly applied upon the copper; there is generally a preliminary operation, called graining, by which a grained and slightly dead appearance is given to the articles.

Preparation of the Silver Parts.—Marks of the file are obliterated by a rubbing upon a wet stone, and lastly upon an oilstone. Any oil or grease is removed by boiling the parts for a few minutes in a solution made of 100 parts of water and 10 of caustic soda or potash; rinse in clean water, which should wet them entirely if all the oil has been removed. The articles are threaded upon a brass wire; cleanse them rapidly in the compound acids for a bright lustre, and dry them carefully in white wood saw-dust. The pieces are fastened upon the even side of a block of cork by brass pins with flat heads. The parts are then thoroughly rubbed over with a brush, entirely free from grease, and charged with a paste of water and very fine pumice-stone powder. Move the brush in circles, in order not to rub one side more than the other; thoroughly rinse in clean water, and no particle of pumice-dust should remain upon the pieces, or the cork. Next place the cork and the pieces into a weak mercurial solution, which very

slightly whitens the copper, composed of—water, 2½ gallons, nitrate or binonide of mercury, ¼ of an ounce; sulphuric acid, ¼ of an ounce. The pieces are passed quickly through the solution, and then rinsed. This operation gives strength to the graining which, without it, possesses no adherence.

Graining Powders.—1. Silver in impalpable powder, 1 oz.; cream of tartar, finely pulverized and passed through a silk sieve, 10 oz.; common salt, pulverized and sifted as above, 2 lbs. 2. Silver powder, 1 oz., cream of tartar, 4 to 5 oz.; common salt, white and clean, 13 oz. 3. Silver powder, 1 oz., cream of tartar, 3 oz.; common salt, white and clean, 2 lbs. All these substances should be as pure as possible, and perfectly dry. Cream of tartar is generally dry; common salt often needs, before or after it has been pulverized, a thorough drying in a porcelain or silver dish, in which it is kept stirred with a glass rod or a silver spoon. The mixture of the three substances must be thorough, and effected at a moderate and protracted heat. The graining is the coarser the more common salt there is in the mixture; and it is the finer and more condensed as the proportion of cream of tartar is greater, but it is then more difficult to scratch-brush.

Silver Powder.—The silver powder is obtained by immersing cleansed copper plates in a very diluted solution of nitrate of silver made with distilled water. The more diluted the solution is, the finer is the precipitate of silver upon the copper, and the more easily it is removed. In a glass or porcelain vessel ¾ of an ounce of crystallized nitrate of silver are dissolved in 2½ gallons of distilled water, and 5 or 6 bands of cleansed copper ¾ of an inch wide are placed in it. These bands should be long enough to allow of a portion being above the liquid. The whole is kept in a dark place for 24 hours, and now and then stirred with the copper bands. This motion is sufficient to loosen the deposited silver, and present fresh copper surfaces to the action of the liquor.

When no more silver deposits on the copper, the operation is completed, and there remains a blue solution of nitrate of copper. The silver powder is washed by decantation, or upon a filter, until there remains nothing of the copper solution. It is then carefully dried, avoiding contact with hard bodies. Nuremberg powder is produced by grinding a mixture of honey and silver foil upon a ground-glass plate with a muller until the proper fineness is obtained. The silver is separated by dissolving the honey in boiling water, and washing the deposited metal in a filter, until there is no remaining trace of honey. The silver is then carefully dried at a gentle heat.

Graining.—A thin paste made of one of the above powders and water is spread by means of a spatula upon the watch parts held upon the cork. The cork itself is placed upon an earthenware dish, to which a rotating movement is imparted by the left hand. An oval brush with close bristles, held in the right hand, rubs the watch parts in every direction, but always with a rotary motion. A new quantity of the paste is added two or three times, and rubbed in the manner indicated. The more the brush and the cork are turned the rounder becomes the grain, which is a good quality; and the more paste added the larger the grain. When the desired grain is obtained, the pieces are washed and then scratch-brushed. The wire brushes employed, which usually come from Nuremberg, are made of brass wires as fine as hair, very stiff and springy. It is necessary to anneal them upon an even fire to different degrees; one soft, or half annealed, for the first operation of uncovering the grain; one harder, for bringing up the lustre; and one very soft, or fully annealed, used before gilding for removing any marks which may have been made by the preceding tool, and for scratch-brushing after the gilding, which, like the graining, must be done by giving a rotary motion to the tool. Decoctions of liquorice or saponairo are employed in this operation.

Resists.—1. If it happens that the same watch part is composed of copper and steel, this latter metal requires to be preserved against the action of the cleansing acids and of the graining mixture, by a composition resist. This consists in covering the pinions and other steel parts with a fatty composition, which is sufficiently hard to resist the tearing action of the bristle and wire brushes, and insoluble in the alkalis of the gilding bath. Yellow wax, 2 oz.; translucent colophony, $3\frac{1}{2}$ oz.; extra fine red sealing-wax, $1\frac{1}{2}$ oz.; impalpable peroxide of iron or polishing rouge, 1 oz. Melt the colophony and sealing-wax in a porcelain dish upon a water bath, and afterwards add the yellow wax. When the whole is thoroughly fluid, gradually add the rouge, and stir with a wooden or glass rod. Withdraw the heat, but continue the stirring until the mixture becomes solid, otherwise all the oxide of iron will fall to the bottom of the mixture. The flat parts to receive this resist are slightly heated, and then covered with the mixture, which melts and is easily spread. For covering steel pinions, employ a small gouge of copper or brass fixed to a wooden handle. The metallic part of the gouge is heated upon an alcohol lamp, and a small quantity of resist is taken with it. The composition soon melts, and, by turning the tool around the steel pinion, this becomes coated. Use a scratch-brush with long wires, as their flexibility prevents the removal of the composition. When the resist is to be removed after gilding, place the parts in warm oil or into tepid turpentine, then into a very hot soap-water or alkaline solution, and, lastly, into fresh water. Scratch-brush and dry in warm saw-dust of white wood. The holes of the pinions are cleaned and polished with small pieces of very soft white wood, the friction of which is sufficient to restore the primitive lustre. The gilding of parts composed of copper and steel requires the greatest care, as the slightest rust destroys their future usefulness. Should some gold deposit upon the steel, it should be removed by rub-

bing with a piece of wood and impalpable pumice-dust, tin putty, or rouge. 2. Again, when it is desired to obtain gildings of several colours upon the same object, resists, generally made of some kind of varnish, are used; after having gilt an article of a uniform red or green colour, it is covered with a fat varnish, made drying by the addition of chromate of lead, at those places which are to resist the action of the new bath. By means of resists and successive baths, several different shades can be obtained upon the same object. The resist varnishes are applied with a brush or pencil, and should be thoroughly dried in a stove before placing the object into another solution. These varnishes may be coloured with various oxides or coloured salts, in order to facilitate their use upon those places which should be sharply marked; chromate of lead and artificial ultramarine blue are well suited for the purpose. Resist varnishes are also used for preserving the reverse parts of articles which have to receive the gilding only on the front. When the operation is finished, the resist is easily removed by a washing, first with essence of turpentine, gasoline, benzine, or benzole, and then with alcohol; when benzole is used, it is sufficient to wash the article in boiling water, and then to dry it in warm saw-dust of fir-wood. It comes out perfectly clean. This is not always the case with rectified turpentine, and it may be necessary to plunge the object into a hot alkaline lye, then to rinse and dry it in warm saw-dust.

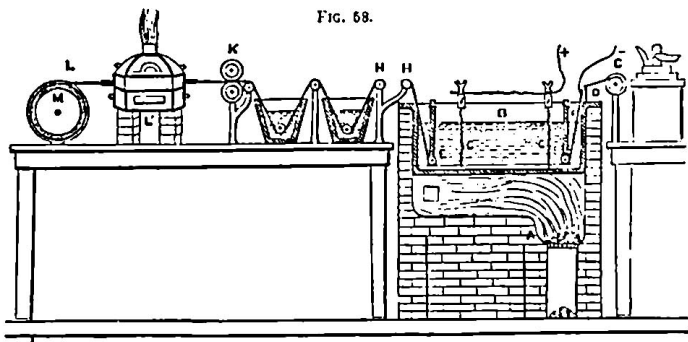
Gilding.—After the preparations described, the gilding may be effected by some of the processes already mentioned. Hot baths must not be employed for those pieces covered with the resist. Heat $\frac{1}{8}$ of an ounce of finely laminated and pure gold in order to destroy all organic substance, dissolve in a glass flask with $\frac{1}{8}$ of an ounce of pure nitric acid, and $\frac{1}{8}$ of an ounce of pure hydrochloric acid. When the gold is dissolved, evaporate the excess of acids, leaving in the flask a syrupy dark-red liquid; the whole is then removed from

the fire and allowed to cool. Dissolve the chloride of gold in about 2 oz. of distilled water, and pour into a large glass vessel. Dilute with about a pint of distilled water, and pour into the liquor a certain excess of pure ammonia, which precipitates the gold in the state of a yellow powder of ammoniuret of gold, or fulminate of gold, which is a detonating powder when dry. The proportion of ammonia is sufficient, when a new quantity of this reagent, being added to the clear liquid above the settled powder, does not produce any new precipitate. The clear liquor is decanted and kept among the saved waste. Collect the settled powder upon a small filter, previously wetted with distilled water, there wash with distilled water until all ammoniacal smell has disappeared. The filter and its contents are afterwards put into a glass or porcelain vessel with a quart of distilled water and $\frac{2}{3}$ of an ounce of pure cyanide of potassium, which rapidly destroys the gold and passes through the filter. The whole is filtered again, boiled for 15 to

inches. The articles to be gilt are suspended to metallic holders, connected with the zinc pole of a battery, and of a shape appropriate to the nature and form of the watch parts. One or more platinum wires are used for anodes, and are disposed in the centre or round the bath. The battery most generally employed is composed of three, four, five, or six small Daniell's elements. Those with balloons, on account of their constancy, should be preferred. The slower the gold deposit, the finer and more adherent it is. When the coating is sufficient, wash the articles in clean water, and fix again upon the cork in order to proceed to the last scratch-brushing with a decoction of liquorice, or of horse-chestnut.

Gilding Thin Wires.—Gilt silver is fine; gilt copper is half fine; and copper or brass alone, is false. At the present time, nearly all gilt wire is gilt by electricity; the baths and the batteries are the same as those already mentioned, but for the success of the operation a certain disposition of the apparatus is required. Upon a brick furnace A, Fig. 58, which

FIG. 58.



20 minutes, filtered again, and left to cool. The bath obtained is excellent for gilding the most delicate watch parts, with an electric current regulated to suit the surfaces to be gilt. Several of these baths, in various degrees of exhaustion, are generally kept in glass or porcelain vessels flat-bottomed, and holding from 7 to 9 pints within a depth of 4 to 5

may be heated either with solid fuel or gas, is a cast-iron enamelled kettle B, about 3 feet long, 18 inches wide, and 4 to 7 inches deep, for holding the gold bath. If gas is used as fuel, the burner should be an elliptic ring with 25 or 30 jets attached to it, or the same kettle may be used as a cold bath if desired, the fire being optional. At one end of

the apparatus, near the battery, are two wooden stands C, supporting an iron rod which passes through a certain number of wooden spools carrying the wire to be gilt. These spools turn freely upon the rod, and the unwound wires, before dipping into the bath, are pressed against a copper or brass rod D connected with the negative, zinc, pole of the battery; thus the wires are connected with this pole. The wires dip into the bath, to about two-thirds of its depth, and are kept stretched by small grooved pulleys E E of glass, porcelain, or ivory, rolling freely upon glass or ivory axes, which are kept near the bottom by supports screwed on the top edges of the kettle. At the bottom of the bath, and crossing the wires to be gilt, are two or more platinum wires G G, the vertical branches of which communicate with the positive, or carbon, pole. These platinum anodes must nowhere touch wires to be gilt, as these two kinds of wire represent the two poles of the battery in the bath. At the other end of the apparatus is another series of wooden reels M, upon which the gilt wire is wound up. These reels are fixed to the square iron axis which traverses them, and which is turned by gearing, slowly enough to ensure a good gilding to the wire, during its passage through the bath. After passing through the gilding bath, the wires are rinsed and dried by winding over two wooden rollers H H revolving freely upon their axes, and plunged by means of grooved rollers into the first trough, filled with a weak solution of cyanide of potassium, which cleans and brightens the gilding; they then pass into the second trough filled with water, which is constantly replaced, which removes the salts from the wires. The drying rollers K, covered with several layers of calico, are moved by gear in opposite directions; the wires are thoroughly dried in a flat tube L, kept at a dull red-heat in the furnace L'. In a kettle of the size named, 20 wires may be gilt at the same time. Copper wires are generally previously silvered and passed once through a draw-plate, to avoid the cleansing process

before gilding. The more intense the battery, or the slower the wires pass through the bath, so will the deposit of gold be increased; and it will be well to weigh the bobbins before and after the operation, for which purpose the spools for winding up and winding out should be of the same weight. This gilding requires constant supervision, either for uniting the broken wires, the severed parts of which may touch the anodes and stop the operation; or for regulating the intensity of the battery, which, if too powerful, will produce a red gilding, or, if too weak, a green gilding. Baths of double cyanide of gold and potassium are employed, cold or slightly tepid; baths with phosphate and bisulphite of soda are used for hot electrogilding, but they are concentrated until the proportion of water is one-half of that indicated. As the platinum anodes do not make up for the metallic loss of the bath, it is frequently necessary to add new portions of metal and salts, in the manner already described. Pure gold wire is sometimes gilt, in order to impart to it a more uniform and deeper shade. After being gilt, the wire is passed through the draw-plate or the rollers. By the draw-plate it is diminished by about one-fourth or one-half of a number to remove the dulness of the deposit, and bring up the lustre. When the gilt wire is flattened between the rollers, its surface is bright or dull, according to the state of the surface of the rollers. Silvering, or any other metallic electrodeposit upon thin wires, can be effected in a similar manner.

Gilding with a Dead Lustre.—1. By the slow deposit of a large proportion of gold. This gilding is very durable, but dull and earthy in appearance, and is costly. 2. By acids; giving a dead lustre to the metallic surface, before gilding, and by the processes indicated in the cleansing operations. This is employed for small articles, or when gilding by dipping, for bronze articles, or large embossed work. 3. With frosted silver, by depositing upon the object to be gilt a coat of frosted silver, and then

gilding in a good bath; this method is expensive, the burnished parts are greenish, and the intermediary coat of silver is more easily blackened by sulphur fumes than gold. 4. By copper, by depositing a solution of sulphate of copper decomposed by a battery a coat of this metal, which possesses a pink dead lustre. The whole is rapidly passed through the compound acids for a bright lustre, and the mercurial solution, and then gilt in a good bath. When the dead lustre obtained in the bath is perfect, the compound acids may be dispensed with, and merely place the article in the mercurial solution before it is gilt. This mode is generally preferred, as the gilding is very handsome in lustre and colour. The burnished parts will be red, if vinegar or soap-water is used; and of a fine yellow colour, if the burnishing tool be wetted with a decoction of flax-seed, or of marsh-mallow root. If the gold deposit is of insufficient thickness, it will blacken in time, by the oxidization of the intermediate coat of copper. 5. Dead lustre by mercury, or the old process of gilding by fire, which furnishes the most durable gilding, although costly.

Gilding by Fire or Mercury.—Mercury gilding will furnish gold with a bright or a dead lustre, scratch-brushed, ormolued, and with different shades. The amalgam of gold is prepared in the manner described in the process of gilding by stirring, only a little less mercury is used, in order to have an amalgam about as hard as wax. This amalgam is crystalline, and a certain crackling sound is heard when the crystals are crushed between the fingers. A stock of amalgam is generally prepared in advance, and is divided into small balls of nearly equal size, the value of which is ascertained from their number, and from the total weight of gold employed. These balls are kept in water, but should not remain too long without being used, as the different parts do not then present the same composition. The amalgam is spread with the finger upon a flat, hard stone, called the gilding stone; and having dipped a scratch-

brush of stout brass wire into a solution of nitrate of binoxide of mercury until it becomes completely white, it is passed over the amalgam, a portion of which is carried away. The object, previously well cleansed, is scratch-brushed in every direction, and the brush must be frequently dipped into the mercurial solution to facilitate the regular and even spreading of the amalgam. This operation requires great care to obtain a uniform coat upon the hollow and raised parts. When the back part of a piece does not require gilding, the flat outline, and the back edge, should be gilt, so that the naked copper shall cause no injury in the subsequent operations. The article, when uniformly covered with the amalgam, is heated upon a charcoal fire without draught, which rests upon a cast-iron plate. It is advisable to employ a gilding forge, which allows the workman to watch the operation from behind a glass frame, which protects him from the mercurial vapours. The entire attention is now required for watching the process. With the left hand covered with a thick glove of buckskin, turn the piece in every direction upon the fire, and, as the mercury disappears, with the right hand strike the article in every direction with a brush, the handle and the bristles of which must be long to equalize the gilding, and to push the remaining amalgam upon those parts which appear less charged with it. When all the mercury has volatilized, the gilding has a dull greenish-yellow colour, resembling that of boxwood; examine whether the coat of gold is continuous. Should a few empty places appear, add more amalgam, and heat the whole again. The next operation is scratch-brushing, which furnishes a pale green colour, and requires another heating for arriving at the desired shade. The reheating should expel any remaining mercury, and produce a fine orange-yellow colour. In case a bright lustre is required, submit the object, with the aid of heat, to the ormolu process already described. To obtain dead lustre, the object is firmly fixed to an iron rod, by wire of the same

metal, and smeared with a hot paste for dead gilding, composed of saltpetre, common salt, and the double sulphate of alumina and potash. The whole is heated upon a brisk charcoal fire, without draught, and moved about until the mixture dries and begins to fuse, when the article is immediately placed in a barrel half filled with water. The covering of salts dissolves, and the dead lustre appears; this operation requires a certain amount of practice. The gilding must be strong to stand the dead lustre process, especially when the first trial is not successful. The red lines left by the iron wire disappear by plunging the object into a not too diluted solution of nitric acid, or pure hydrochloric acid. Mercury gilders do not employ pure gold; what they use is previously alloyed with a certain portion of copper or silver. With the latter metal the gilding is green. Red gilding is either obtained with a dark ormolu or with the green for red, already mentioned.

Gilding with a partly Dead, partly Bright Lustre.—1. Gild those parts with the amalgam which are intended for a dead lustre, and heat, scratch-brush, and reheat to the orange-yellow colour. Then, with the battery, give a sufficiently strong gold deposit to the whole, without regard to the parts already mercury-gilt; scratch-brush all the surfaces carefully, and smear the electro-gilt portions first with a thin mixture of water, glue, and Spanish white, and afterwards with a thick paste of yellow clay. After drying, cover the mercury-gilt portions with the paste for dead gilding, and proceed as already described. The Spanish white, &c., are dissolved in a dilute solution of hydrochloric acid. The glued paste is to preserve the electro-gilt portions from the heat; these are again wire-brushed with all the care necessary for not scratching the dead lustre. Brushing to finish. This method will sometimes produce red spots on those places which have been heated too much, or where the coat of gold was not thick enough. 2. Gild with the amalgam, and bring

up the dead lustre upon those portions which are to receive it, and preserve them entirely with the resist varnish. After thorough drying, cleanse the object by dipping it into acids, in the usual manner, and gild in the electro-bath. The resist varnish stands all these acids and solutions. When the desired shade is obtained, dissolve the varnish with gasoline or benzine, which, unless there has been friction applied, does not injure either the shade or the velvety appearance of the dead lustre. Wash in a hot solution of cyanide of potassium, then in boiling water, and allow to dry naturally. The resist varnish may also be removed by allowing the object to remain for a time in concentrated sulphuric acid at 66° Baumé, which has no action whatever upon the gilding. In this case, washing with cyanide is unnecessary, pure water is sufficient. Gilding with a dead lustre, whatever process is employed, only suits those objects which will never be subjected to friction. Even the contact of the fingers injures it. A new freshness is imparted to old dead gildings by a washing in caustic lye, and then in a dilute solution of nitric or sulphuric acid. This process removes dirt, grease, dust, and smoke, but will not remedy scratches. In the latter case, the objects must be scratch-brushed, and then heated with the composition for a dead lustre.

Gilding Zinc with a Dead Lustre.—There is no artistic bronze, whatever the elegance and delicacy of its shape, which may not be reproduced in zinc with an accuracy which often deceives a practised eye. A great many articles have a simple coating of brass, bronzed afterwards to imitate similar objects of real copper, brass, or bronze; but others are gilt by mercury, either with a dead lustre, scratch-brushed, or burnished. With tin solder fill all the holes and the smallest defects which may exist in the zinc object, and, at the same time, remove all seams, burrs, and rough spots. Afterwards, scour the piece by passing it, for a few seconds only, through a boiling solution of 100 parts of water and 5 or 6 parts of caustic soda; if

left too long in this caustic lye it will spoil the polish of the zinc, which dissolves. After this scouring the object is rinsed in fresh water. It is then steeped for half a minute in a pickle composed of 1 part of sulphuric acid, and 10 parts of water, and lastly rinsed in boiling water. Then place the object in a cold or warm electro-bath of copper or brass, for a few moments, until it is covered with a thin metallic coating; which is deposited very uniformly if the object has in it no tin solder, and is perfectly cleansed; the deposit is black and dull on those parts which have been soldered, or imperfectly cleansed. In this case, thoroughly scratch-brush the article, and dip again into the electro-bath until the deposit is sufficiently thick. Most gilders use a warm bath for the first coating, scratch-brush, and complete the deposit in a cold bath. If a bright gilding is desired, the article may be rinsed in fresh water, and then dipped into an electrogilding bath.

Dead Lustre Gilding, equal in appearance to the best mercury gilding, is obtained—1. With silver. An electro-silvering bath is prepared by dissolving in $2\frac{1}{2}$ gallons of water, $5\frac{1}{2}$ oz. of fused nitrate of silver, and adding 9 oz. of pure cyanide of potassium; this at first produces an abundant precipitate, which soon dissolves. The filtered liquid is the silver bath, in which is steeped the zinc article previously coated with copper or brass. Under the influence of a proper electric current, the silver deposited is of a handsome frosted dead lustre appearance, and perfectly white. The object is then rapidly and thoroughly rinsed, and dipped into an electrogilding bath, of which we shall give the composition. The dead gilding by this process is very fine and silky, but is soon darkened by the sulphuretted hydrogen of the atmosphere and of gaslight, which sulphurizes the silver through the thin film of gold. 2. The galvanoplastic process is both more durable and more economical than that with silver. Add to the necessary quantity of water, one-tenth of its volume of sulphuric acid; in this dissolve as much sulphate

of copper as it will hold at the ordinary temperature. This solution will mark from 20° to 24° Baume, then add enough water to reduce its specific gravity to 16° or 18° . This galvanoplastic bath is generally held in large vessels of stoneware, slate, wood, or gutta-percha; and porous shells are immersed in it, filled with a weak solution of sulphuric acid and of amalgamating salts. Plates or cylinders of zinc are put into these cells, and are connected by binding screws with one or more brass rods, which rest upon the sides of the trough, and support the articles which are to receive a dead lustre in this bath. The articles of zinc, previously coated with copper or brass, suspended to the rods, remain in the solution of sulphate of copper until they have acquired a satisfactory dead lustre. A few seconds after the articles have been placed in the bath, withdraw and examine them carefully; should the previous coat of copper or brass be insufficient to resist the corroding action of the acid solution of sulphate of copper, there is produced a muddy dark deposit, which is easily removed with the finger. Should this occur, the object must be scratch-brushed and placed again in the former alkaline baths of copper or brass, in order to increase the deposit which protects the zinc in the galvanoplastic bath. When the galvanoplastic dead lustre is successful, the deposit is perfectly regular, and of a pink shade which possesses great freshness. When it is irregular, marbled, crystalline, of a vinous or fire-red colour, and dull or earthy in appearance, these defects are due to the following causes; either the bath is in a bad state of conductivity or of saturation; or the surface of the zinc is too large in proportion to that of the objects, and therefore too much electricity is given out; or the previous electro-deposits of copper or brass were insufficient or inferior in quality. The remedy for either of these inconveniences is easily found out, and only requires a little care and attention. The galvanoplastic dead lustre being satisfactory, two preliminary operations are needed to ensure the success of the

gilding. They consist in rapidly passing the object, after rinsing, through a solution made of water, $2\frac{1}{2}$ galls.; nitrate of binoxide of mercury, $\frac{1}{2}$ of an oz.; sulphuric acid, $\frac{1}{2}$ of an oz.; then, after rinsing, place it in another solution composed of water, $2\frac{1}{2}$ galls.; cyanide of potassium, 14 oz.; nitrate of silver, $3\frac{1}{2}$ oz. The object acquires a slightly white tinge in this liquor, and is again rinsed in fresh water, before being put into the following gilding bath;—Distilled water, $2\frac{1}{2}$ galls.; phosphate of soda, 21 oz.; bisulphite of soda, $3\frac{1}{2}$ oz.; cyanide of potassium, pure, $\frac{1}{2}$ of an oz.; chloride of gold, neutral, $\frac{1}{2}$ of an oz. The mode of preparation of this bath is given in the receipt for hot gilding bath. This bath should be nearly boiling, and worked with an intense galvanic current. The anode is a platinum wire, which, more or less immersed in the liquor, allows of the regulation of the amount of electricity according to the volume, weight, and surface of the object to be gilt. This gilding requires an energetic electric action at the beginning; this is obtained by steeping the platinum wire deeply in the liquid, to have the entire surface of the piece covered instantaneously; as the thickness of the deposit increases, the anode is gradually removed from the bath until it only dips in a little. The gilding by this method has a remarkable freshness of tone. Before using the bath with battery, the zinc articles may be passed through a preparing bath; this is the same as a gold bath for dipping. Or the gilding may be done in two operations. After having deposited about half of the gold intended for the object, remove it from the bath, wash, pass again through the mercurial solution, and replace in the gold bath for finishing the gilding. After gilding, the articles are rinsed in clear boiling water for a few seconds to remove any saline matters; they are then dried in the stove, or in warm saw-dust of firewood. All friction should be carefully avoided, so as not to scratch the dead lustre. When parts of this gilding are burnished, their colour is

green if the frosted surface has been obtained in the silver bath, and red if the galvanoplastic bath has been employed. These inconveniences are remedied by dipping the burnished article, for a short time, into the gold bath, this last deposit of gold must be so thin as not sensibly to impair the brightness of the burnished parts. Dead lustre electrogilding upon zinc will only suit such objects as have no friction to bear, and which are not often handled; it is especially useful for clocks and similar articles, which remain under glass. The dead lustre gilding here described can be applied to all metals and alloys, provided that those corroded by the solution of sulphate of copper be previously coated with copper or brass; these previous coatings are always desirable, as they prevent crystalline and irregular deposits often formed upon metals which are not corroded by the bath of sulphate of copper. The galvanoplastic dead lustre upon copper is much finer when the pieces have been previously covered with copper or brass in the alkaline baths. Faded gildings may be renovated by dipping them into a weak tepid solution of cyanide of potassium, and afterwards into very dilute nitric or sulphuric acid. Imperfect gildings may be removed by inverting the poles in a solution of cyanides, connecting the gilt articles with the positive pole, carbon or copper, and the negative pole, zinc, with the anode, which becomes gilt. This process is employed for removing the gold from articles of iron, steel, and silver, which cannot be submitted to the ungilding bath. Silver, copper, and brass may also be removed by similar processes.

Dissolving Gold from Gilt Articles.—Iron and steel articles are ungilt, without any injury to themselves, by dipping them into a bath of 10 parts of cyanide of potassium and 100 parts of water and connecting them with the positive pole of a battery. A wire or foil of platinum is fixed to the negative pole. This is inverting the position of the poles; and in this case the gold applied upon the iron or steel is dissolved in the

solution of cyanide, and partly deposited upon the platinum anode, from which it is removed in a regular gold bath. When there is only a film of gold upon iron or steel, it may be removed by the cyanide alone, without the aid of electricity, but this method is slow. Silver, copper, and their alloys may also be ungilt by this process; but the cyanide dissolves, at the same time, the gold, and part of the other metals; it is therefore preferable to operate as follows:—For ungolding silver, it is heated to a cherry-red heat, and immediately thrown into a pickle of more or less diluted sulphuric acid. The gold scales off, and falls to the bottom in the shape of spangles. The operation is repeated until gold no longer appears upon the surface of the silver, which is then white and frosty. This process is not adapted to light and hollow articles, for which the preceding process is better. For copper and its alloys, in small articles, such as false jewellery thinly gilt, either by battery or by dipping, use the following bath:—1. Sulphuric acid, 10 parts; nitric acid, 1 part; hydrochloric acid, 2 parts. The large quantity of sulphuric acid allows of the solution of gold, whilst it does not sensibly attack copper or its alloys. The sulphuric acid is put alone into a stoneware jar, and the mixture of hydrochloric and nitric acids, kept in a stoppered bottle, is gradually added to it as the operation proceeds. The same sulphuric acid may last a long time, if it is kept well covered, and its dissolving action promoted by successive additions of nitric and hydrochloric acids. The articles should be often withdrawn to watch the operation, which is terminated when no gold is seen, and when the copper has acquired a uniform blackish-grey coat; or by plunging the objects into the compound acids, they will be perfectly cleansed when the gold has all dissolved. 2. Saltpetre and common salt may be substituted for nitric acid and hydrochloric acid; the salts must be finely powdered, and stirred with a glass rod. 3. For large objects, such as clocks or chandeliers, concentrated sulphuric acid, 66° Baumé,

is put into a glass or stoneware vessel supporting two brass rods. One of these rods is connected by a conducting wire with the last carbon of a battery of two or three Bunsen's inverted elements, and supports the objects to be ungilt, which are entirely covered by the sulphuric acid. The other rod supports a copper plate facing the object, and is connected with the last zinc of the battery. The electric fluid traverses the sulphuric acid, and carries the gold from the positive to the negative pole; as the copper plate is not prepared for retaining the gold, it falls to the bottom of the bath in a black powder, which is easily recovered. So long as the sulphuric acid is concentrated, and even under the action of the galvanic current, it does not sensibly corrode the copper; and as it rapidly absorbs the dampness of the atmosphere, the vessel in which it is contained should be kept perfectly closed, when the ungolding process is not in active operation; and the pieces for ungolding should be put in perfectly dry. If it is intended to sacrifice the gilt articles of copper or silver, let them remain in pure nitric acid, which dissolves all the metals except gold, which either floats at the surface of the liquid as a metallic foil, or falls to the bottom as a blackish powder. If the liquor is diluted with distilled water, and filtered, all the gold will remain on the filter, and the solution will contain the other metals.

SILVERING.—*Whitening with Silver in a Pot.*—This operation is still employed for whitening small wares for which durability is of secondary importance, and which simply require the whiteness of silver; such are hooks and eyes, or buttons. This whitening is made as follows:—1. Dissolve a certain quantity of pure granulated silver in double its weight of pure nitric acid. The solution is largely diluted with water, and the metal is precipitated in heavy white clods by common salt or hydrochloric acid. All the nitrate of silver has been decomposed when a further addition of hydrochloric acid or common salt to the clear supernatant liquid does

not produce any turbidness. The clear liquors are then thrown away, and the chloride of silver obtained is washed several times, to deprive it of all free acid. If this precipitate is to be kept some time before use, it should be removed from the sunlight, which blackens it rapidly. The chloride of silver, with a little water, is thoroughly mixed with at least 80 times its weight of finely powdered bitartrate of potash, and kept in a stoneware pot. 2. Pure silver for making the chloride, 1 part; powdered cream tartar, salt, 83 parts of each; a few spoonfuls of the paste thrown in, and dissolved in boiling water contained in a pure copper kettle. The articles are dipped into this bath by a hook, or in a basket of wire gauze, such as indicated in receipt for gilding by dipping. Or have another basin of copper, shallow and perforated with holes, which rests against the upper sides of the kettle. By means of handles, this basin can be removed at once with its contents. Stir the articles with a wooden spatula; and at each operation add a quantity of paste, proportioned to the surfaces to be whitened. These baths do not work well when freshly made, but improve as they are more used. They acquire a dark green tint, due to the copper which is dissolved, and which takes the place of the deposited silver. Varnishing, colouring, and cleansing may be done in aqua fortis; but these cleansing methods are inferior to those employed for gilding; in general, use the worn-out acids of gilders. Brighten the articles by friction with saw-dust. The smallest particle of iron, zinc, or tin introduced into the whitening bath imparts a red colour to the brass or copper articles in the liquor. The iron is separated by a magnet; the zinc is dissolved in pickles of hydrochloric or sulphuric acid, which, when cold, do not sensibly corrode the copper articles; tin or lead must be picked out by hand. If the operation has not succeeded, the articles are plunged for a few seconds into a boiling solution of water, $2\frac{1}{2}$ galls.; nitrate of silver, $3\frac{1}{2}$ oz.; ordinary cyanide of potassium, 21 oz. This bath retains its strength for a long time, and

increases the brightness and whiteness of the deposit. The process of silvering by dipping has nearly superseded this method.

Plated Silver is obtained by rolling together a plate of copper of the first quality, and one of silver; these are either welded, or simply united by placing their hot and clean surfaces together, wetted with a concentrated solution of nitrate of silver. The two metals are reduced and drawn out about equally by the pressure of rolls, and long sheets or bands of silvered metal are thus obtained, with which a great many articles may be manufactured. By this mode of operation, a great quantity of material is lost, as the objects have to be cut out from a sheet entirely silvered, and the waste retains a large proportion of that metal; the cut sections present parts without silver, which must be hidden by ledges, or by silvering by another method. There is also the absolute necessity of employing pure copper, which is more costly, less sonorous, and not so tough as its alloys; but the greatest defect of the process is the difference of thickness of the silver, according to the shape of the object. Raised surfaces are the most exposed to friction, and it is just there that the coat of silver is the thinnest; the conditions are reversed with electro-silvering, and the parts in relief receive a more abundant deposit of silver, which is a satisfactory result. The best plated silver is manufactured by applying upon an ingot of pure copper weighing 9 parts, another ingot of pure silver weighing 1 part, to coat one side only; add another part of silver, if it is intended to coat both sides. The two are rolled together until the desired thickness is obtained. The silver of the plated metal will be bright if the rollers are well polished, and dull with rough rollers. The only solder which does not injure plated silver is tin solder; and when the objects manufactured are required to resist a warm temperature, nuts and screws are employed. The electroplating of old wares made from copper with a covering of silver, is often difficult. Supposing it is required to electroplate an old cruet-stand, the

bottom is separated from the wire, either by unscrewing or unscrewing. Smooth by emery cloth, or pumice-stone and water, or by powdered bath-brick brushed over with a hard brush. Spots of verdigris are removed with a few drops of hydrochloric acid. The great difficulty consists in giving a good electro-deposit upon the edges or mounts where there may be some lead or lead solder; apply to such parts, with a rather soft brush, a solution made by dissolving 4 oz. of mercury in nitric acid, and adding about half a pint of cold water. This solution is lightly brushed over the lead mounts only; the article and brush are then to be well rinsed, and the brush and plain water applied in the same way. The solution of mercury will turn the edges black, or dark grey, but the subsequent brushing will render them bright again. The frame when well rinsed is ready for the depositing bath. If, on its first immersion, any black spots appear, the frame may be removed, again brushed over, and finally returned to the bath. If the edges do not receive the coating of silver as readily as the other parts, the solution may require a little more cyanide, or a greater battery power, or an increase in the surface of the anode. These lead edges may be prepared for receiving the silver deposit by a previous coat of copper applied as follows;—The edges are plunged into a solution of sulphate of copper, with a little free sulphuric acid in it; then, by touching the lead edge with an iron wire, it is immediately coated with a bright deposit of copper, which is rinsed and becomes a good conductor for the further electro-deposit of silver. The coating of tin underneath the bottom of cruet frames is very difficult to plate, unless in a solution made expressly for it; therefore it is preferable to remove it either with abrading materials, or with nitric acid employed with care. This process of depositing copper will be found useful not only for old plated ware, but also for many articles on which are found unruly spots of tin solder.

Silvering with Silver Foil.—This method is never practised except upon objects

already manufactured, in their definite shape; and is adapted to all kinds of copper, bronze, or brass. It is, in certain respects, superior to plated silver; but is very difficult of execution, and has less adhesion to the metal underneath. After annealing the articles, they are thrown whilst hot into a bath of sulphuric acid with a small proportion of hydrochloric and nitric acids. They have then a dull and dead lustre, owing to a multitude of small holes, which are so many points of attachment for the silver foil. The objects, thus prepared, are tightly fixed upon an iron rod, which is held in a vice. Their temperature is raised to about 300° F., by means of incandescent charcoal put at the proper place, so as to open the pores of the metal, which, by cooling afterwards, will imprison the silver applied. The silver foils, taken from the book with small tweezers, are cut to the proper size upon a cushion with an ivory or steel knife. After each foil is deposited upon the object, it is made to adhere by a light pressure of a rag pad, and afterwards by the friction of a steel burnishing tool. The parts of the silver foil which do not adhere are removed with a soft brush. Gold-beaters prepare silver foil either with bright or dead lustre. The latter is made to adhere only by the pressure of the pad, and not by the burnishing tool. This dead lustre cannot compare in fineness with that obtained by the battery; however, it resists handling and the sulphur gases of the atmosphere better. Articles thus silvered are only burnished after all the silver foils have been applied; round or cylindrical objects are burnished upon the lathe, other forms by the hand; there are always places and lines showing the vibrations of the burnishing tool. This method of silvering is only employed for very large objects, such as high chandeliers and other church ornaments. Spoons and forks may be covered with silver foil, as follows;—First slightly silver with a dead lustre in a silver bath by dipping, heat, and then cover with silver foil, by the pressure of an iron scratch-brush striking vertically, forcing the silver foils

into the pores of the metal underneath. Burnish by the usual method; it is impossible to obtain a dead lustre by this method.

Cold Silvering by rubbing, with the thumb, a cork, or a brush. The results are better than those by the whitening process, but not very durable; the method is useful to repair slight defects upon more durable silverings, and to produce mixtures of gold and silver, or gold, upon slightly gilt objects, thus avoiding the use of resist varnishes. Make a paste by thoroughly grinding in a porcelain mortar or with a muller, and, as far as practicable, not in the light;— 1. Water, $3\frac{1}{2}$ to 5 oz.; white fused nitrate of silver, or, preferably, the chloride, 7 oz.; binocalate of potash, $10\frac{1}{2}$ oz.; bitartrate of potash, $10\frac{1}{2}$ oz.; common salt, 15 oz.; sal ammoniac, $2\frac{3}{4}$ oz. 2. Chloride of silver, $3\frac{1}{2}$ oz.; bitartrate of potash, 7 oz.; common salt, $10\frac{1}{2}$ oz. When finely pulverized in a porcelain mortar, triturate it under a muller upon a plate of ground glass until there is no granular feeling. Keep the paste in a porcelain pot, or in a black glass vessel, to preserve it from the light, which decomposes it rapidly. When about to use it, add a little water so as to form a thin paste, which is applied with a brush or pencil upon the cleansed articles of copper, or upon those gilt by dipping, or even upon those gilt by the battery, provided that the coating is thin enough to allow the copper to decompose the silver paste through the coat of gold; allow the paste to dry naturally, or with the aid of a gentle heat. The chemical reaction is more or less complete, according to the thickness of the gold deposit, and the dry paste is of a pink shade, or entirely green. The salts are removed by a thorough rinsing in cold water, and the silver appears with a fine frosted appearance, the brightness of which may be increased by a few seconds' immersion in a very diluted solution of sulphuric acid, or of cyanide of potassium. This silvering bears the action of the wire brush and of the burnishing tool very well; and it may also be oxidized. Should a first silvering not be found sufficiently

durable, after scratch-brushing, apply a second or a third coat. This silvering is not so adhering or white on pure copper, as upon a gilt surface. For the reflectors of lanterns the paste is rubbed upon the reflector with a fine linen pad; then, with another rag, a thin paste of Spanish white, or similar substance, is spread over the reflector and allowed to dry. Rubbing with a fine and clean linen rag will restore the lustre and whiteness of the plated silver.

For Plated Silver Reflectors—A bath made of water, $1\frac{1}{2}$ pint; nitrate of chloride of silver, 2 oz.; cyanide of potassium, $10\frac{1}{2}$ oz. Add sufficient Spanish white, or levigated chalk, in fine powder, to produce a thin paste, which is kept in a well-closed pot. This paste is spread by a brush or a pad of old linen, all over the surface of the reflector, and allowed almost to dry, when it is briskly rubbed over by another clean dry rag of old linen.

Silvering by Dipping in a Warm Bath.—For small articles a bath is made by dissolving in an enamelled cast-iron kettle in 2 galls. of water $17\frac{1}{2}$ oz. of ordinary cyanide of potassium. Also dissolve $5\frac{1}{2}$ oz. of fused nitrate of silver in $1\frac{1}{2}$ pint of water contained in a glass or porcelain vessel. The second solution is gradually poured into the first one. Stir with a glass rod. The white or greyish-white precipitate produced soon dissolves, and the remaining liquor is filtered if a perfectly clear bath is desired. When brought to the boiling-point it will immediately silver the cleansed copper articles plunged in it. The objects must be quickly withdrawn. The silvering should immediately follow the cleansing, although the rinsings after each operation should be thorough and complete. This bright and light silvering is adapted for set jewellery, which cannot be scratch-brushed without flattening the clasps, and to which a bright lustre is absolutely necessary, as a substitute for the foil of burnished silver placed under the precious stones of real jewellery. The employment of the solution of nitrate of binocalate of mercury is useless, and even injurious, for this

bath. It is useless to keep up the strength of the solution by new additions of cyanide and silver salt; thus reinvigorated, it gives results far inferior to those of the former solution. The bath should, therefore, be worked out as long as the silvering is satisfactory, and when exhausted, put away with the waste. With this process a battery and a soluble anode may be used to obtain a more durable deposit; but the operation is no longer a simple dipping, and properly belongs to electro-silvering by heat. A solution which, when boiling, produces a very fine silver coat, with a dead, or partly dead, lustre, upon cleansed coppers, is made by dissolving with the aid of heat, in a well-scoured copper kettle, distilled water, 9 pints; ferrocyanide of potassium, 21 oz.; carbonate of potash, 14 oz. When the liquid boils add the well-washed chloride obtained from 1 oz. of pure silver. This should boil for about half an hour, and be filtered before using; part of the silver deposits upon the copper kettle, and should be removed when a new bath is prepared. On account of this inconvenience the process has been nearly abandoned, although the products are remarkably fine. All the dipping silvering baths, which contain a comparatively great excess of cyanide of potassium to the proportion of the silver salt, will silver well copper articles perfectly cleansed, even in the cold; whereas this property diminishes in proportion to the increase of the amount of silver in the bath, or with the decrease of the amount of cyanide. For small articles, partly copper and partly iron, such as those used for saddlery and carriage wares, a particular process of silvering is used. The bath is composed of;—Water, 9 pints; caustic potash, 6 oz.; bicarbonate of potash, 3½ oz.; cyanide of potassium, 2 oz.; fused nitrate of silver, ¾ oz. The cyanide, caustic potash, and bicarbonate are dissolved in 7 pints of water in an enamelled cast-iron kettle, then the remaining quart of water, in which the nitrate of silver has been separately dissolved, is added to the former solution. For the silvering operation a certain

quantity of articles is cleansed, thoroughly rinsed, and put into a small enamelled kettle. Enough of the silver bath is poured in to cover the articles entirely, and the whole is brought to a boil for a few seconds, and stirred with a wooden spatula. When the silvering appears satisfactory, the liquor employed is put with the saved waste; the same liquid is never used for two batches of articles. This process gives a somewhat durable silvering with a dead lustre, of a greyish white, which is increased in whiteness and brightness by soap and burnishing.

Silvering by Dipping in a Cold Bath.—As the bath is cold it is always ready for use, and the deposit is finer and more unalterable, because only chemically pure silver is deposited, without any mixture of subsalts. The bath is formed of bisulphite of soda, to which is added nitrate of silver, until it begins to be dissolved with difficulty. It is therefore with a double sulphite of soda and silver that the cold silvering by dipping is effected. Bisulphites of potash, ammonia, and other alkalies may be substituted for the bisulphite of soda, but the latter is to be preferred, because its preparation is cheaper, more easy, and better known.

Preparation of Bisulphite of Soda for Cold Silvering.—Put into a tall vessel of glass or porcelain, water, 10 pints; crystallized carbonate of soda, 10 lbs. Pour a little mercury into the bottom of the vessel, so that the glass tube carrying sulphurous acid gas, which has to be placed into it, may not be stopped by the crystals formed during the operation. Arrange an apparatus for the production of sulphurous acid gas, and let the washed gas pass through the vessel holding the carbonate of soda. Part of the soda is transformed into sulphite of soda, which dissolves, and a part falls to the bottom as bicarbonate. The latter is, however, transformed into sulphite of soda by a continuous production of sulphurous acid, and the carbonic acid escapes. When all has dissolved, continue the passage of sulphurous acid until the liquid slightly red-

dens blue litmus paper, and then put the whole aside for 24 hours. After that time some crystals are found upon the mercury, and the liquid above, more or less coloured, is the bisulphite of soda for silvering. The crystals are separated from the mercury, drained, and kept for gilding baths. They are not suitable for silvering. The liquid bisulphite of soda thus prepared, should be stirred with a glass rod, to throw off the carbonic acid which may still remain. The liquor should then be again tried with blue litmus paper. If it turns a deep red, add a little carbonate of soda for neutralizing the excess of sulphurous acid; if red litmus paper becomes blue, there is too much alkali, and more sulphurous acid gas should be passed through the liquid, which is in the best condition when litmus paper becomes violet or slightly red. This solution marks from 22° to 26° Baumé, and must not come in contact with iron, zinc, tin, or lead.

Cold Silvering Bath for Dipping.—A stoneware or glass vessel is about three parts filled with the liquid bisulphite of soda, a solution of nitrate of silver in distilled water, of medium concentration, is gradually added while the bath is continually stirred with a glass rod; a white flocculent precipitate of sulphite of silver is produced by stirring; this is dissolved by the bisulphite of soda. The silver solution is added so long as the precipitate readily disappears, and stopped when it becomes slow to dissolve. This bath is always ready to work, and instantaneously produces a magnificent silvering upon copper, bronze, or brass articles which have been thoroughly cleansed, and passed through a weak solution of nitrate of biniodide of mercury, although this last operation is not absolutely necessary. According to the length of time of the immersion the bath will give, a very fine whitening by silver is as cheap as any of the other described processes. A bright silvering, especially adapted for setting jewellery; or a silvering with a dead lustre, still more durable, without electricity, and in the cold. The loss of silver is made

good by additions of nitrate of silver. When the proportion of bisulphite is not sufficient to dissolve the metallic salt, add some bisulphite of soda to restore the bath to its primitive state. Silver is slowly deposited upon the sides of the vessel; this may be dissolved in nitric acid for future uses.

Solution of Silver or Gold for Silvering or Gilding without the Aid of a Battery.—1 oz. of nitrate of silver is dissolved in 1 quart of rain or distilled water, and a few crystals of hyposulphite of soda are added which form a brown precipitate soluble in a slight excess of hyposulphite. Small articles of steel, brass, or German silver may be silvered by dipping a sponge in the solution and rubbing it over the surface of the article to be coated. A solution of chloride of gold may be treated in the same manner, and applied as described. A more concentrated solution of either gold or silver may be used for coating parts of articles which have stripped or blistered, by applying it with a camel-hair pencil to the part, and touching the spot at the same time with a thin clean strip of zinc.

SILVER ELECTROPLATING.—*Bath.*—Water, 2½ galls.; cyanide of potassium, pure, 17½ oz.; pure silver for cyanide, 8½ oz. The composition of commercial cyanide of potassium is exceedingly irregular. The pure, or No. 1, contains from 90 to 100 per cent. of real cyanide, and is especially employed for gilding and silvering baths. No. 2 contains from 60 to 70 per cent. of real cyanide; it is the article prepared by Liebig's method, and is used for electro-baths of copper and brass. No. 3, which marks from 55° to 60°, is for scouring and preparing baths, and for photographic operations. 1. Put in a porcelain dish, holding a quart, pure granulated silver, 8½ oz.; pure nitric acid at 40° Baumé, 17½ oz. Heat by charcoal or gas. The dish should be supported by an iron triangle, and not in direct contact with the fire. The acid rapidly attacks and dissolves the silver with an abundant production of yellow nitrous vapours, which must not be

inhaled. When the vapours have disappeared, there remains a liquid more or less colourless, according to the proportion of copper held by the commercial silver, which is seldom entirely pure. The heat is then increased in order to evaporate the excess of acid, which escapes in white fumes. The material in the dish swells up and dries, and, with a further increase of heat, melts like wax. The dish is then removed from the fire, and being held with a cloth, the molten mass is made to flow upon the sides, where it soon solidifies; the fused nitrate of silver, lunar caustic, is more or less white, or grey, according to the purity of the silver employed. When perfectly cooled, turn the dish upside down, and by a gentle tap on the sides, the mass is detached. 2. Dissolve the nitrate of silver in ten or fifteen times its weight of distilled water; hydrocyanic acid poured into this solution immediately produces an abundant white precipitate of cyanide of silver. A sufficient quantity of prussic acid has been employed when, by adding a few drops of it to the clear liquid, no precipitate or turbidity appears. Throw the liquid upon a filter of calico stretched on a wooden frame, the cyanide of silver remains on the cloth, the solution with the nitric acid and excess of prussic acid passes through. Wash the precipitate left upon the filter two or three times with pure water. 3. This cyanide of silver is put into the vessel intended for the bath, and stirred with the $2\frac{1}{2}$ galls. of water. The cyanide of potassium is then added, dissolves it, and also dissolves the cyanide of silver, thus giving a solution of a double cyanide of potassium and silver. Those who employ small baths, often renovated, may substitute for the cyanide of silver the chloride, or the nitrate of this metal. In the latter case, the quantity of cyanide of potassium should be increased. Such baths will be prepared as follows;—1. The nitrate of silver is prepared in the manner indicated above, and $5\frac{1}{2}$ oz. of it, nearly equal to $3\frac{1}{2}$ oz. of pure silver, are dissolved in $2\frac{1}{2}$ galls. of water. 2. The cyanide of potassium

No. 1, about $8\frac{3}{4}$ oz., is then added. Stir to facilitate the solution, filter the liquor, to separate the iron contained in the cyanide. This operation may in some cases be dispensed with, because the iron rapidly falls to the bottom of the bath, and the solution becomes limpid. The proportion of cyanide of potassium employed is more than is required for dissolving the silver, as $1\frac{1}{2}$ part of good cyanide is sufficient for 1 part of silver; but unless there is an excess of cyanide of potassium, the liquors do not conduct electricity well, and the deposit of silver is granulated and irregular. The silvering is effected with a battery, and with baths either warm or cold. The latter method is generally adopted for articles which require great solidity. The hot process is used for small articles, and is preferable for steel, iron, zinc, lead, and tin which have been previously electrocoppered. The hot baths are generally kept in enamelled cast-iron kettles, and the articles are either suspended, or moved constantly about in them. The preliminary cleansing in acids, and passing through the mercurial solution, are necessary. A somewhat energetic current is needed, especially when the articles are moved about, in order to operate rapidly. There is too much electricity when the articles connected with the negative pole of the battery become grey or black, and produce many bubbles of gas. A platinum, large wire or thin foil anode, is generally preferred to the soluble anode of silver employed in cold baths, but the solution is rapidly impoverished. In hot silvering baths, the separate battery is often replaced by a zinc wire wrapped around the articles. The points of contact of the two metals are black or grey, but the stain disappears by plunging the object into the liquor for a few moments, after it has been separated from the zinc, and carefully scratch-brushed. Instead of separate batteries, a simple apparatus may be made of a glass, porcelain, or stoneware vessel holding the bath, and in the centre of which is a porous jar filled with a solution of 10 per cent. of cyanide of potassium or common salt. The

cylinder of zinc, immersed in this porous jar, carries a larger circle of brass wire, the cross diameters of which are soldered to the zinc. This brass ring projects over the bath, and the articles, suspended to the ring by slinging wires, hang down into the bath. At the beginning, the operation goes on rapidly, and the deposit is good; but, after a time, the solution of zinc traverses the porous cell and impairs the purity of the bath. An impoverished hot bath is reinvigorated by additions of equal parts of cyanide of potassium and silver salt. It is necessary to replace the water in proportion as it is evaporated. When the silver baths rapidly deposit metal without the aid of electricity, it is a proof that they are too rich in cyanide, or too poor in silver. A deposit effected under such conditions is rarely adhering, especially when upon articles previously coppered, because the excess of cyanide dissolves the deposited copper, and the silver which takes its place may be removed with the finger. The remedy consists in adding to the bath only enough silver salt and no more, so that a piece of copper will not become sensibly silvered in it, without the aid of electricity. The cold electro-silvering baths generally employed for electroplating such articles as table-spoons or forks are contained in large rectangular wooden troughs lined with gutta-percha, or made of riveted wrought iron. They are sufficiently high to allow about 4 inches of liquid above the immersed object, whose distance from the bottom and sides should be nearly the same, to give a regular deposit of metal at both extremities of the object. The upper ledge of the trough carries two brass rods all round, which do not touch one another, one above the other, so that other metallic rods, being put across, will rest upon the higher or the lower rod, but not both at the same time. Each rod is connected with one of the poles of the battery by conducting wires, the points of contact of which should be perfectly clean. The rod which supports the articles to be silvered is connected with the negative pole represented by zinc in most batteries; and the other,

supporting the anodes, is attached to the positive pole, which is carbon with Bunsen's elements, copper for Daniell's, and platinum with Grove's cells. A certain number of spoons and forks fixed to a rod, by means of copper wires, are cleansed at the same time, and the rod is placed upon the negative conducting rod of the trough. Then, facing these articles, hang upon the positive conducting wire of the trough another metallic rod to which the soluble silver anode is attached like a flag. Next comes another series of spoons and forks, faced by another soluble anode, in such a manner that each row of spoons and forks is between two anodes. The articles to be silvered all rest upon the negative conducting rod, and the soluble anodes upon the positive one. This disposition is for obtaining an equal deposit upon all the pieces. The objects require turning upside down during the operation, in order to prevent a thicker deposit on the lower parts, as the richest part of the solution is the densest, and therefore lies near the bottom of the trough. The denser layers, being richer in metal, deposit it more abundantly upon the direction which they follow, and form grooves which cannot be filled by the lighter and poorer currents. It is, therefore, advantageous to keep the objects in constant motion. In this case the frame supporting the articles does not rest upon the trough, but is suspended above the bath, and receives its motion from a small eccentric, or other motive power. The silver deposit will adhere strongly, if the articles have been fully amalgamated in the solution of nitrate of binocide of mercury, and have remained in the silver bath from 12 to 15 hours, according to the intensity of the current. The silvering will be the better and finer as the intensity of the current is weaker, up to a certain limit. A sufficient quantity of silver may be deposited in 3 or 4 hours, but the result is not satisfactory, and the burnishing is very difficult. When the articles have acquired a film of silver, they are sometimes removed from the bath and thoroughly scratch-brushed, cleansed in

alcohol, or, preferably, in a hot silvering bath, thence again passed through the mercurial solution, and finished in the former cold electro-bath. This first scratch-brushing, which is not always necessary, obviates the tendency of certain alloys to assume a crystalline appearance, and corrects imperfections of the cleansing process. Electro-silvering baths do not generally work so well when freshly prepared, as when they have been used for a certain time; the deposit is often granulated, bluish, or yellowish. It is therefore desirable to mix a portion of old liquors with those recently prepared, or new baths may acquire an artificial age by boiling them for a few hours, or adding to them one or two thousandths of aqua ammonia.

To prevent Electro-silver Plating turning Yellow by Contact with the Air.—This change of colour is due to the deposit, by galvanic action, of pure silver and of a subsalt, the subcyanide of silver, which is rapidly decomposed and darkened by light. It is therefore necessary to remove the subcyanide by one of the following methods;—1. The articles are left immersed in the bath for some time after the electric current has been interrupted, when the subcyanide of silver is dissolved by the cyanide of potassium. 2. Having smeared the objects with a paste of borax, they are heated in a muffle until the salt fuses and dissolves the subcyanide. This process anneals and softens the metal. 3. The poles of the battery are inverted for a few seconds, that is to say, the articles become soluble anodes, and the electric current carries away the subcyanide of silver in preference to the metal; this operation should be very short, otherwise the silver will entirely abandon the objects and will coat the silver sheets.

Silver-plating Britannia Metal, Pewter, and all Combinations of Lead and Tin.—These are best placed in a solution containing a good deal of free cyanide, and the deposit should be rapid at first. The surface of the anode should be about three times that required for German silver and the battery power strong, but not too intense. It is better not to

disturb these articles in the solution at the beginning of the deposit. Afterwards they may be shifted for obtaining a uniform coat. If the articles, when they have been a short time in the plating bath, present an unequal surface, remove them, and brush over again as before; then, after well rinsing, return quickly to the bath and allow them, if possible, to remain without further disturbance.

Small Silver Bath for Amateurs.—The bath is a cylindrical stoneware, glass, or porcelain vessel. After cleansing and amalgamation, the articles are attached by clean copper wires to the circumference of a brass ring, supported upon the top of the apparatus by three or four soldered cross wires. The ring is connected with the negative pole of the battery, and the positive pole with a platinum anode, or a cylinder formed of a sheet of silver rolled round, which dips into the middle of the apparatus. The articles must be now and then turned upside down, and sideways, so that each face of the object will be, in turn, directly opposite the silver anode, and thus also the points of contact with the suspending wires receive their quota of metallic deposit. Points, edges, corners, and all raised parts, offer a more easy passage to the electric current, and therefore become more coated with metal. As the wear of tablespoons and forks is greater on their convex sides, those parts should face the silver anode longer than the concave portions.

Bright Lustre.—Bisulphide of carbon, in small proportion, imparts a bright lustre to electroplated articles. Put an ounce of bisulphide of carbon into a pint bottle containing a strong silver solution with cyanide in excess. The bottle should be repeatedly shaken, and the mixture is ready for use in a few days. A few drops of this solution may be poured into the plating bath occasionally, until the work appears sufficiently bright. The bisulphide solution, however, must be added with care, for an excess is apt to spoil the solution. In plating surfaces which cannot easily be scratch-brushed, this brightening pro-

cess is very serviceable. Care must be taken never to add too much at a time.

Deposits on Solder.—The difficulty of obtaining regular deposits of gold or silver over articles which have parts soldered may be greatly obviated by scratch-brushing those parts dry, that is, without the usual liquid employed. This renders these refractory parts better conducting, provided that during the operation no impurities are left on these spots.

Method by which the Weight of Deposited Silver is directly ascertained.—

1. The articles are cleansed by the processes already described, then dried in saw-dust or otherwise, and weighed in a scale. However rapidly this may be done the surface of the copper will be slightly oxidized and tarnished; to recover their former cleanliness the articles must be plunged into a strong pickle of sulphuric acid, and then into the mercurial solution. After rinsing, and immersion in the bath, practical experience will teach when it is nearly time to withdraw the articles from the solution. They will have to be weighed several times before the intended weight of silver has been deposited. 2. Cleanse the articles, and put them immediately into the bath, except one, which is treated as above, and used as a test. This piece is now and then removed from the bath to ascertain its increase of weight, and when it has acquired its proportion of silver it is supposed that the other pieces are also finished. Strongly amalgamated articles will not become sensibly oxidized during the drying which precedes their weighing. When the objects have been dried in order to ascertain the proportion of deposited silver, they should not be returned to the bath without having been cleaned in a hot solution of cyanide of potassium, which dissolves the grease from the handling, and passed again through the solution of nitrate of bin-oxide of mercury, and rinsed. Alcohol may be substituted for the hot solution of cyanide, but the results are not so sure, and the expense is greater. Both

these methods are tedious, and only give approximate results. 3. Remove one dish of an ordinary pair of scales, substitute for it a metallic frame which supports the articles to be silvered, and communicates through the beam and the column with the negative electrode of a battery; connect the soluble anode with the positive pole. When the articles are suspended to the frame, and are in the bath, the equilibrium of the scale is established by weights upon the other dish; add to this a weight equal to the silver it is desired to deposit. The operation will be finished when the equilibrium of the beam is re-established. This method is not mathematically accurate, but is sufficiently exact for all practical purposes. An automatic arrangement, by which the electric current may be broken at the time the articles in the bath have received a sufficient deposit of silver, is easily arranged, and saves time and metal.

Anodes.—Should the anodes become black during the passage of the electric current, the solution contains too little cyanide of potassium and too much silver. In this case the deposit is adherent, but too slow, and the bath loses more silver than it can gain from the anodes. Carefully add sufficient cyanide of potassium. If the anodes remain white during the current, the proportion of cyanide of potassium is too great, the deposited silver is often without adherence, and the anodes lose more metal than is deposited; add silver salt until it dissolves with difficulty. When in good working order the soluble anodes become grey during the passage of the electricity, and white when the circuit is broken. The specific gravity of the bath may vary from 5° to 15° of the Baumé hydrometer for salts, and still furnish good results. There is a simple and rapid process for ascertaining the state of the bath, and establishing the proper ratio between the silver and the cyanide. About half a pint of the liquor is put into a tall glass, and a solution of $\frac{1}{4}$ of an ounce of nitrate of silver in 3 oz. of distilled water is poured into the former, drop by drop.

If the white precipitate produced is rapidly dissolved by stirring, the liquor is too rich in cyanide, or too poor in silver; should the precipitate remain undissolved after long stirring, the liquor is too rich in silver and too poor in cyanide of potassium. When the precipitate is dissolved but slowly, the liquor is in the best condition.

Burnishing. — By burnishing, the roughness of an object is flattened down until the surface is smooth and polished, like a looking-glass. Burnishing is an important operation for electro-deposits which consist of a multitude of small crystals with intervals between them, and with facets reflecting the light in every direction. The deposited metal is hardened, and forced into the pores of the underlying metal, and the durability is thus increased to such an extent, that with the same amount of silver a burnished article will last twice as long as one which has not been so treated. The instruments employed for burnishing are made of different materials, and must be of great hardness and a perfect polish. Such are hardened cast steel, agate, flint, and blood-stone. For metallic electro-deposits steel and blood-stones are especially employed. There are several qualities of blood-stone; its grain should be close, hard, and without seams or veins; it should leave no white lines on the burnished parts, nor take off any metal, and its colour should be of an intense black-red. The steel must be fine and close grained, and perfectly polished. Should the polish of any burnishing tool alter by use, it is restored by friction upon a skin or leather attached to a wooden block, which is fixed to the bench. The leather is covered with polishing rouge in impalpable powder, or, preferably, with pure alumina obtained by calcining ammonia alum in a forge fire. Venetian tripoli, rottenstone, tin putty, emery, or many other hard substances finely powdered may be employed. The burnishing tools are of various shapes, such as a lance, a tooth, a knife, a half-sphere, or a dog's tongue, and a considerable stock is necessary. The burnishing is divided into two dis-

tinctions; the first consists in roughing, and the second in finishing. The tools for the first have a sharp edge, whilst for the second operation they have a rounded surface. The tools for the hand or the lathe are fixed by copper ferules into short round wooden handles, so that the hand is not influenced by their weight; the tools for the arm or the vice are fastened to wooden handles sufficiently long to rest their slender part upon the arm or the shoulder, the stouter lower portion is grasped by the hand. The burnishing tools and the objects must be frequently wetted by certain solutions, some of which facilitate the sliding of the instrument, or with others which have a chemical action upon the shade of the burnished articles. Of the first are pure water; solutions of soap, decoctions of linseed, and infusions of the roots of marsh-mallow or liquorice; the second includes wine-lees, cream tartar, vinegar, alum in water. When burnishing gold applied upon electro-deposits of copper, as in gilding with a dead lustre by that method, use pure water for fear of producing a disagreeable red shade. A solution of green soap is sometimes preferred by operators, although when old it imparts an unpleasant tinge, owing to the sulphides of the liquor. When the burnishing is completed, the surface is wiped longitudinally with a soft and old calico rag. The polish obtained by burnishing is called black, when it reflects the rays like a mirror; and should the presence of mercury or a bad deposit prevent the tool from producing a bright surface, the object is said to be greasy. Articles which have been previously polished, and which generally receive a very trifling deposit, are not burnished, but rubbed with chamois leather and the best quality polishing-rouge. Too thick or too rapid electro-deposits cannot be burnished, but must be polished by rubbing with a leather and a mixture of oil and powdered pumice-stone, tripoli, or tin putty. Coarse powders are used at the beginning, and impalpable ones at the end of the operation. Polished silver deposits

are more agreeable to the eye than burnished ones; but the hardening of the latter renders them more durable.

To Dissolve Silver from Silvered Articles.—Cold Bath.—For dissolving silver in the cold the objects are hung in a large vessel filled with the following mixture;—Sulphuric acid at 66° Baumé, 10 parts; nitric acid at 40° Baumé, 1, in which they remain for a greater or less length of time, according to the thickness of the coat of silver to be dissolved. This liquid, when it does not contain water, dissolves the silver without sensibly corroding copper and its alloys; therefore avoid introducing wet articles into it, and keep the liquid perfectly covered when not in use. As far as practicable place the articles in the liquid so as not to touch each other, and in a vertical position, so that the silver salt will fall to the bottom. In proportion as the action of the liquor diminishes, pour in small and gradual additions of nitric acid. Dissolving silver in the cold is regular and certain, but slow, especially when the proportion of silver is great. The other more rapid process is then resorted to.

Hot Bath.—Nearly fill a flat pan of enamelled cast iron with concentrated sulphuric acid, and heat to a temperature of from 300° to 400° Fahr.; at the moment of using it, pinches of dry powdered saltpetre are thrown into it; then hold the article with copper tongs in the liquid. The silver rapidly dissolves, and the copper or its alloys are not sensibly corroded. According to the rapidity of the solution more or fewer pinches of saltpetre are added. All the silver has been dissolved when, after rinsing in water and dipping the articles into the cleansing acids, they present no brown or black spots, that is, when they appear like new metals. These two methods are not suitable for removing the silver from wrought and cast iron, zinc, or lead; it is preferable to invert the electric current in a cyanide bath, or to use mechanical processes. Old desilvering liquors become green after use; to recover the silver they are diluted with 4 or 5 times their

volume of water, then add hydrochloric acid or common salt. The precipitation is complete when the settled liquor does not become turbid by a new addition of common salt or hydrochloric acid. The resulting chloride of silver is separated from the liquid either by decantation or filtration, and is afterwards reduced to the metallic state by one of the methods which will be described.

Resists and Reserves.—By reserves, certain parts of a metallic article, which may be already covered with an electrodeposit on its whole surface, are coated with another metal. To gild the parts in relief of an object of which the body is silvered, make a gold reserve, and use a silver reserve for silvering of certain parts of a body already gilt. This requires a little practice and care, and a firm hand to make thin lines with the hair pencil. Thoroughly scratch-brush and wipe the object; the parts intended to have the primitive colour must be covered by a brush with a resist varnish; dry in the air, or in a stove, or upon a gentle fire until it no longer feels sticky. Place in the bath; the galvanic deposit will only coat those parts unprotected by the varnish. The temperature of the bath should be low, and the current weak, for fear of having rough lines where the deposit touches the varnish, from the latter becoming softened, or from bubbles which are disengaged at the negative pole under the action of a strong electric current. When the deposit is completed, remove the resist varnish with warm essence of turpentine, and afterwards with tepid alcohol; gaseine or benzole are preferable, as they rapidly dissolve in the cold nearly all resinous and fatty bodies, or the varnish may be destroyed by a brief immersion in concentrated sulphuric acid when cold. It often happens that several colours and metals have to be placed upon the same object, such as silver with both a bright and a dead lustre, and yellow, green, red, white, or pink golds, or platinum. Varnishes are also employed for avoiding the deposit of the precious metals upon those parts which do not need them.

Resist or Reserve Varnishes.—Dissolve in boiled linseed oil or essence of turpentine, resin, or copal; these varnishes are not sufficiently coloured to distinguish the places where they have been laid on, mix with them therefore a certain proportion of red-lead, chrome yellow, or Prussian blue, which at the same time facilitates their drying.

OLD SILVERING.—To imitate old artistic productions made of solid silver, the groundwork and hollow portions not subject to friction are covered with a blackish red earthy coat, the parts in relief remain with a bright lead lustre. Mix a thin paste of finely-powdered plumbago with essence of turpentine, to which a small proportion of red ochre may be added to imitate the copper tinge of certain old silverware; smear this all over the articles. After drying, gently rub with a soft brush, and the reliefs are set off by cleaning with a rag dipped in spirits of wine. Old silver is easily removed, and the brightness of the metal restored, by a hot solution of caustic potash, cyanide of potassium, or benzole. To give the old silver tinge to small articles, such as buttons and rings, throw them into the above paste, rub in a bag with a large quantity of dry fir-wood saw-dust until the desired shade is obtained.

OXIDIZED SILVER.—This is not an oxidization, but a combination with sulphur or chlorine. Sulphur, soluble sulphides, and hydrosulphuric acid blacken silver, and insoluble silver salts, and particularly the chloride of silver, rapidly blackens by solar light. Add four or five thousandths of hydrosulphate of ammonia, or of quintisulphide of potassium, to ordinary water at a temperature of 160° to 180° Fahr. When the articles are dipped into this solution an iridescent coating of silver sulphide covers them, which after a few seconds more in the liquid turns blue-black. Remove, rinse, scratch-brush, and burnish when desired. Use the solution when freshly prepared, or the prolonged heat will precipitate too much sulphur, and the deposit will be wanting in adnerence; besides the oxidization obtained

in freshly-prepared liquors is always brighter and blacker than that produced in old solutions, which is dull and grey. If the coat of silver is too thin, and the liquor too strong, the alkaline sulphide dissolves the silver, and the underlying metal appears. In this case cleanse and silver again, and use a weaker blackening solution. Oxidized parts and gilding may be put upon the same article by the following method. After the whole surface has been gilt, certain portions are covered with the resist varnish, silver the remainder. Should the process of silvering by paste and cold rubbing be employed, the gilding should be very pale, because it is not preserved, and is deeply reddened by the sulphur liquor. When this inconvenience occurs from a too concentrated liquor, it is partly remedied by rapidly washing the article in a tepid solution of cyanide of potassium. Deep black is thus obtained upon cleansed copper;—Dissolve 3 or 4 oz. of blue ashes, hydrocarbonate of copper, in a sufficient quantity of aqua ammonia, place the cleansed copper in this solution, cold or tepid, it will be instantaneously covered with a fine black deposit. This coat is so thin that burnished articles look like varnished black.

NIELLED SILVER.—This is a kind of in-laid enamel work, and is obtained by the sulphuration of certain parts of a silver object. But instead of being direct, this is produced by inlaying the silver surface with a sulphide of the same metal prepared beforehand. For preparing the niel, heat a certain proportion of sulphur in a deep crucible; heat a certain quantity of silver, copper, and lead in another crucible, and when melted pour into the fused sulphur, which transforms these metals into sulphides; then add a little sal ammoniac, remove from the crucible, pulverize for use. First crucible—flowers of sulphur, 27 oz.; sal ammoniac, 2½ oz. Second crucible, which after fusion is poured into the first—silver, ½ oz.; copper, 1½ oz.; lead, 2½ oz. 1. After having reduced the niel to a fine powder, mix with a small proportion of a solution of

sal ammoniac, hollow out the engraving upon a silver surface, and cover the whole, hollows and reliefs, with the composition. The article is then to be heated in a muffle until the composition solders to the metal. Uncover the pattern by a level polish, when the silver will appear as over a black ground. This method is costly, as each article must be engraved. 2. Engrave in relief a steel plate, and press it against the silver plate between two hard bodies. The copy is hollow, and ready to receive the nickel. A great many copies may be obtained from the same matrix.

PLATINUM DEPOSITS by Dipping.—Copper and its alloys only will receive a satisfactory platinum deposit; iron, zinc, lead, or tin, coated with this metal, even after a previous coppering, give but defective results. The platinum deposits are obtained by dipping thoroughly cleansed copper articles in the following solution, kept boiling;—Distilled water, 100 parts by weight; caustic soda, 12 parts; platinum for neutral chloride, 1. The deposit is bright, durable, and of a dark colour, resembling oxidized silver.

Thin Platinum Electro-deposits.—The platinum baths for electro-deposits will succeed when the chloride of platinum is dissolved in a solution of a salt with alkaline, neutral, or acid reaction, but sulphites and cyanides, even those having soda for base, should be excepted. Distilled water, 100 parts by weight; carbonate of soda, 40 parts; platinum for neutral chloride, 1. Temperature of the bath, from 160° to 180° Fahr. Distilled water, 100 parts by weight; phosphate or borate of soda, 60 parts; platinum for neutral chloride, 1. Distilled water, 100 parts by weight; pyrophosphate of soda, or chloride or iodide of sodium, 30 parts; platinum for dry chloride, 1. These baths only give exceedingly thin deposits; if the coating were allowed to increase most of it would be without adherence, and often in the form of scales. The deposit is black or steel grey.

Thick Platinum Electro-deposits.—Fill a glass flask with $\frac{1}{2}$ of an ounce of

finely-laminated spongy or black platinum, and a mixture of 5 $\frac{1}{2}$ oz. of hydrochloric acid, and 3 $\frac{1}{2}$ oz. of nitric acid at 40° Baumé. Place the flask upon a piece of sheet iron perforated in the centre, so that the bottom of the flask alone receives the heat. After an abundant production of orange-yellow fumes, the platinum will disappear and leave a red liquid, which should be heated until it becomes viscous enough to stick against the sides of the flask. This latter part of the operation may be effected in a porcelain dish, the shallow form of which aids in the evaporation of the acids in excess. After cooling, the residuum is dissolved in 17 $\frac{1}{2}$ oz. of distilled water, and filtered if necessary. Dissolve 3 $\frac{1}{2}$ oz. of phosphate of ammonia in 17 $\frac{1}{2}$ oz. of distilled water, and mix the two solutions. This produces a precipitate of phosphate of ammonia and platinum in a liquid of orange colour, which should not be separated; pour into it, stirring all the while, another solution of 17 $\frac{1}{2}$ oz. of phosphate of soda in 1 $\frac{1}{2}$ pint of distilled water. Boil the mixture, and replace the evaporated water, until no more ammonia is disengaged, which is ascertained by the smell; and until the liquor, which was previously alkaline, begins to redden blue litmus paper. When the yellow liquor becomes colourless, it indicates the formation of a double platinum salt. The bath is then ready to deposit platinum upon articles of copper or its alloys, by the aid of heat and of an intense electric current. Copper coated with platinum resists nitric and sulphuric acids to a considerable extent. If iron, zinc, lead, or tin come in contact with the bath they will decompose it, and the metal deposited will be black. The dead lustre of platinum is pearl-grey; it is very hard, and cannot be brightened by scratch-brushes of brass, which render its surface yellow; powdered pumice-stone or iron wires should be employed. Platinum deposits may be burnished by an energetic friction, and the lustre obtained is very durable. Platinum may be removed from copper by a very long immersion

in the liquors given for ungilding, but the success is doubtful.

NICKEL DEPOSITS.—Nickel deposited by the wet way is white, with a slightly yellow tinge, having a dull pearl-grey dead lustre; it is obtained by dissolving the nitrate of nickel in its own weight of ammonia, and diluting the whole with 20 or 30 times its volume of liquid bisulphite of soda, marking about 24° Baumé. This application is found useful when articles require to be protected against the oxidizing action of damp or salt air, sulphurous gases, and weak acids. Nickel electrotypes stand the wear and tear caused by ink, and press much better than the ordinary copper ones. Another bath is a solution of nitrate of nickel, without excess of acid, precipitated by cyanide of potassium, and the precipitate redissolved by more cyanide. An acid solution of nickel may be precipitated by alkalis, such as potash, soda, or ammonia; after washing the precipitate, dissolve in cyanide of potassium. A moderate battery power and nickel anodes are employed.

Nickel Plating without a Battery.—Into the plating vessel, which may be of porcelain or copper, place a concentrated solution of zinc chloride, dilute it with from 1 to 2 volumes of water, and heat to boiling. If any precipitate separates, it is to be redissolved by adding a few drops of hydrochloric acid. As much powdered zinc as can be taken on the point of a knife is thrown in, which covers the vessel internally with a coating of zinc. The nickel salt, for which purpose either the chloride or sulphate may be used, is added until the liquid is distinctly green; then put in the articles to be plated, previously thoroughly cleaned, together with some zinc fragments. Continue the boiling for fifteen minutes, when the coating of nickel is completed. Well wash the articles with water, and clean with chalk. If a thicker coating is desired, the operation may be repeated. Wrought and cast iron, steel, copper, brass, zinc, and lead have been successfully coated by this process. It is necessary that the objects should be entirely covered by the plating liquid,

and that their surfaces should be thoroughly cleaned. Salts of cobalt, treated in the same manner, afford a cobalt plating, which is steel grey in colour, not so lustrous as the nickel, and more liable to tarnish.

ZINC DEPOSITS.—Zinc is deposited by the wet way and by the battery. The dead lustre colour is a grey bluish-white. Precipitate a soluble zinc salt by ammonia; this precipitate redissolved in an excess of alkali gives a satisfactory bath; any kind of zinc salt may also be dissolved in cyanide of potassium or a soluble sulphite. These deposits are entirely different as regards the durability, from the so-called galvanizing, when cleansed iron is plunged into a bath of molten zinc, and is thus protected against oxidation for a long time, which is not the case with electro-deposited zinc. For depositing upon copper or brass, in the wet way, prepare finely-divided zinc, by pouring the molten metal into a previously strongly heated iron mortar, and stirring until nearly cold. The powdered zinc thus obtained is placed in a porcelain vessel, and to it is added a concentrated solution of sal ammoniac. This mixture is heated to boiling; and the copper or brass objects to be coated with zinc, but previously well cleansed, even with an acid, are then placed in a liquid where they obtain a brilliantly white adhering layer of zinc.

IRON AND STEEL DEPOSITS.—Iron may be deposited by the wet way, but is very easily oxidized. It is obtained by decomposing by the battery a perfectly neutral protochloride of iron. This bath is rapidly altered by the air, and is transformed into sesquichloride, which is unsuited for the purpose. The double chloride of iron and ammonium, obtained by the protracted boiling of a solution of sal ammoniac upon iron filings, produces a very thin deposit of iron, very difficult to oxidize, which is employed for hardening the surface of engraved plates or of ordinary electrotypes. Double sulphates of iron and ammonia, or of iron and potash, and double chlorides of the same bases, have been

successfully used for electro-deposits of iron.

ANTIMONY DEPOSITS.—This has all the brightness of polished cast iron. Its dead lustrous is a slate grey, and it may be easily scratch-brushed and polished; it resembles black platinum, and may take its place in many cases. Boil for an hour, in a porcelain dish or enamelled cast-iron vessel;—Water, 2½ galls.; carbonate of soda, 70 oz.; finely-powdered sulphide of antimony, 17½ oz. Filter the boiling solution through paper or fine cloth; by cooling it deposits a reddish-yellow powder of oxysulphide of antimony. Boil this powder again in the same liquor, and the new solution is the antimony bath. It is necessary to use the bath constantly boiling. For the anode, use either a plate of antimony or a platinum wire.

LEAD DEPOSITS are obtained by the plumbite of potash or soda, which is prepared by the protracted boiling of ½ of an ounce of protoxide of lead in 3½ oz. of caustic potash or soda, dissolved in 2½ galls. of distilled water.

Coloured Electro-Chromic Rings.—After the plumbite of soda bath has cooled off, the metallic or metallized article, connected with the positive pole, is dipped into it. Then the platinum wire, communicating with the negative pole, is gradually introduced into the liquor without touching the article, which is immediately coloured in various shades; too much intensity in the current will hide all the various tinges under a uniform dark brown coat. When an article is unsatisfactory in its colouration, dip it rapidly into aquafortis, to dissolve the oxide of lead, and restore the metallic surface to its primitive state. This process may be used for the decoration of stoneware and porcelain previously coated with platinum.

REDUCTION OF OLD BATHS.—*Extraction of Gold.*—All the liquids which contain gold, except those in which there is a cyanide, are strongly acidulated by sulphuric or hydrochloric acids, unless they are already acid, and then largely diluted with water. Precipitate the precious metal by a solution of sul-

phate of protoxide of iron, copperas, and, after a few hours standing, it is ascertained that the liquor does not contain any more gold when a new addition of sulphate of iron does not produce any turbidity. The precipitated gold is in the form of a red or black powder; collect upon a filter, wash, and dry in an iron pan, with weights equal to its own, of borax, saltpetre, and carbonate of potash. Gradually introduce the powder into a refractory crucible heated to a white heat in a good air-furnace. When all is introduced, increase the heat and close the furnace, so that all the metal may fall to the bottom of the crucible. After cooling, extract the button of pure gold which remains. If it is desired to dissolve the powdered gold left on the filter in aqua regia, it will be necessary to wash it several times with diluted sulphuric acid, to remove the sulphate of iron with which it is impregnated. This mode of reduction is adapted to an impure chloride of gold, to the baths by dipping with the bicarbonate or pyrophosphate of soda, and also to the ungolding acids; but it is imperfect with baths holding a cyanide, which never completely part with all the gold they contain, by this process. The best manner of treating the latter liquors is to evaporate them to dryness in a cast-iron kettle, and calcine the residue to a white heat in a good crucible. A small proportion of borax or saltpetre may be added to aid the fusion, but generally it is unnecessary. The resulting button of gold at the bottom of the crucible is red when saltpetre has been employed, and green with borax; but these differences of colour have nothing to do with the purity of the metal. Gold may be separated from liquors which contain no cyanide, by an excess of protochloride of tin, which produces a precipitate easily reduced by heat. Sulphurous acid will also reduce the gold; but in this case, the liquor should be heated. Granulated gold is obtained by running the molten metal, in a small stream, and from a certain height, into a large quantity of cold water.

Extraction of Silver.—Liquors contain-