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ELECTROTYPE MANIPULATION:

BEING

THE THEORY, AND PLAIN INSTRUCTIONS

IN THE ART OF

WORKING IN METALS,

BY PRECIPITATING THEM FROM THEIR SOLUTIONS,
THROUGH THE AGENCY OF
GALVANIC OR VOLTAIC ELECTRICITY.

BY

CHARLES V. WALKER,

HONORARY SECRETARY TO THE LONDON ELECTRICAL SOCIETY.

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ELECTROTYPE MANIPULATION.

I. INTRODUCTORY OBSERVATIONS.

1. THE object of the present treatise is not so much to dwell upon the philosophical principles on which the art of electrotype is based, as it is to trace in a familiar manner the several processes in manipulation, and the precautions to be observed in order to ensure success. The instructions given are the results of extensive experiment on the subject, during many months; and it will be the especial object of the writer to dwell minutely upon those *little* points which so materially influence the success of the experiments. It will be the endeavour to avoid, as much as possible, the use of scientific phraseology; so that the amateur, for whose use this work is written, may find as few obstructions as possible besetting his path. In the course of forming a large collection of medals by the Electrotype process, the author has, of necessity, been led to adopt such modes as convenience and economy dictated. These will be described in order, as the reader is led from the original medal to the perfect copy, ready for the cabinet.

2. Galvano-plastic, Electrotype, or Electro-metallurgy, is, as its several names indicate, intimately connected with Galvanic, or rather, Voltaic Electricity. In order, therefore, to convey correct notions on the subject, it will be requisite, before entering on it further, to give a brief outline of the principles of thi

to the copper, it would leave the battery by the wire attached to the *copper* plate, and, having passed through the interposed apparatus, would return to the battery by the wire attached to the *zinc* plate; the copper, which is the *negative* metal, forming the *positive* end of the battery; and the zinc the *positive* metal forming the *negative* end.

10. The *great* effects of voltaic electricity, into which it would be foreign to the present purpose to enter, are produced by the various modes of combining a large or small number of these pairs of metals, and on the nature of the apparatus interposed between the wires connected with the respective ends of the battery. The power, which from its effects Dr. Faraday has termed the Electrolytic * power, is that which alone demands our attention, because on the right understanding of this depends the successful application of the art of Electrotype.

11. If a series of about ten of these voltaic pairs or batteries be so arranged in the order of zinc, liquid, copper, and the wires terminating the ends of the battery, which for this purpose should be of platinum, be placed in a vessel of water containing sulphuric acid,† the water will be electrolyzed or decomposed by electricity; the hydrogen gas will be released at the wire connected with the negative end of the battery, and the oxygen, at that connected with the positive. If these gases be collected separately in tubes placed over the platinum, wires, the quantity of hydrogen will be double that of the oxygen.

12. If into this acid liquid some crystals of sulphate of copper be thrown, and the current be sent through, electrolysis will still take place,—the water will still be decomposed, but only *one* of the gases, the *oxygen*,

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* *Vide Exp. Researches.* Series 7, § 664.

† *In this and all other* instances the use of sulphuric acid is to *increase the conducting* power of the liquid;—to facilitate the passage *of electricity through it.*

will be obtained. The hydrogen, as it becomes released from the water, will take the place of the copper in the solution, and the *copper* will be liberated and become visible on the negative (§ 9.) wire. This experiment may be continued till all the copper is abstracted from the solution: the remaining liquid will be water, strongly acid.

13. A third modification of this experiment is by using for the positive wire, one of *copper*, instead of *platinum*. In this instance, the water is decomposed; but *neither* of the gases is visible. The hydrogen, as before, occupies the place of the copper in the solution, releasing the copper as in the last experiment; (§ 12.) the oxygen, instead of appearing at the positive wire, combines with the copper, of which it is composed, forming an oxide of copper: this oxide unites with the sulphuric acid, and forms a sulphate of copper. In proportion as the solution is weakened by the release of copper at the *negative* wire, it is supplied with copper from the *positive*.

14. It will be observed in these illustrations of electrolysis, that the metals are released at the *negative* plate. The science of Electrotype, discovered in England by Mr. Spencer, and on the continent by Professor Jacobi, consists in preparing for a negative plate models or moulds (§ 24. 28.) of objects to be copied; and in so arranging the battery, or apparatus, which generates the voltaic current, (§ 63, 64.) as to release the metals in a compact and solid form.

15. On these two points many precautions are to be observed; but a faithful compliance with the directions to be given will enable the least skilled to obtain metallic copies of the most beautiful works of art, by merely exercising ordinary care and a little patience.

16. Before closing these preliminary observations, it will be requisite to give a brief description of the Constant Battery. The voltaic pair immersed in a cell of acid water (§ 3.) is liable to three objections. First. The bubbles of hydrogen released on the copper pla

of necessity, prevent portions of this plate from being in actual contact with the liquid; and hence its power is less than it might be. Second: The dissolved zinc is partially released and deposited on the copper, or negative plate, according to the laws already illustrated; (§ 14.) hence arise counter-currents, which weaken the force. Third: The acid very speedily becomes saturated with oxide of zinc, and *all* action ceases.

17. Professor Daniell, has, by the invention of his constant battery, enabled us to overcome in a very great measure all these difficulties,—to remove all these objections. The deposition of the zinc is obviated by using two liquids, separated by a porous partition, or as it is called, a diaphragm, of animal membrane, paper, (§ 37.) earthenware, plaister of Paris, &c. (§ 44.) The liquid contiguous to the zinc is, as before, (§ 3.) acidulated water; that near the copper is a solution of sulphate of copper. By this arrangement, it will be seen, from what has been already stated (§ 12, 13.) that *copper* will be released, in place of *hydrogen* on the copper,—the negative plate.

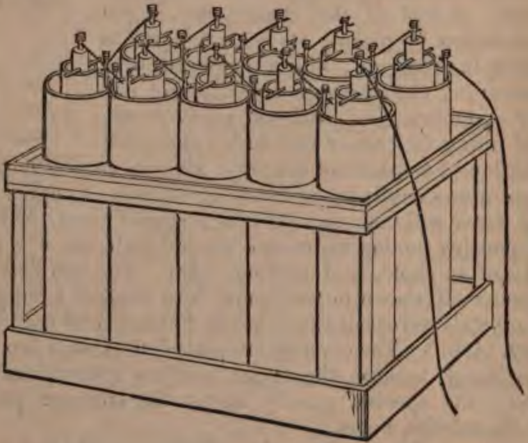
18. The deposition of copper on the negative plate prevents the deposition of zinc: for, according to certain laws, into which it will be foreign to the present purpose to enter, the metals are released from solutions in regular order. The fact, however, may be easily determined by using a *brass* plate, in any of the arrangements to be hereafter described; (§ 49, 51.) and it will be found to produce a *copper* medal. The zinc which forms a constituent part of the brass, remains in the solution.

19. The *continuous* action of this battery is preserved by *amalgamating* (§ 41.) the zinc, and supplying the cuprous solution with crystals of sulphate of copper. *(§ 46.)* The former prevents the acid acting *chemically on the zinc (§ 7, 40.)* and destroying it uselessly: the *latter keeps up* the strength of the solution, which is

being constantly exhausted by the reduction of the copper.

This instrument is termed a *constant* battery, from its power of continuing in action for a lengthened period of time. It has been constructed in various ways, being modified according to the taste of individuals, or to the use to which it is to be applied. But whatever *form* may be given to it, it is still the constant battery, invented by Professor Daniell, to whom alone the credit is due for devising so valuable an arrangement. The annexed wood-cut represents a cell of a Daniell's battery. The cell being of copper, itself forms the negative metal. A rod of amalgamated (§ 41.) zinc is placed, as shewn in the figure, within a tube of porous earthenware. Attached to each metal is a binding screw, to form connections. A cell of this description is put into action by placing its several parts as shewn in the figure; filling the porous tube containing the zinc with a mixture of one part sulphuric acid, and ten parts water; and filling the copper cell with a saturated solution of sulphate of copper. By *saturated* is meant a solution containing as much of the salt of copper as the water will take up. This is prepared most readily by pouring boiling water on a superabundance of crystals of sulphate, and stirring them. The perforated metal shelf, shewn in the figure, is to support a supply of crystals to recruit the exhausted strength of the battery. (§ 46.) The crystals are placed thus *high up* in the liquid, because the upper portions are exhausted *first*; the specific gravity keeps the stronger parts of the solution below.

Note on Voltaic Batteries.—While on the subject of voltaic pairs, it would be as well to pen a few lines on those powers of the battery, not directly connected with the art of Electrotype.—If a cell of the constant battery be charged as directed, (§19.) and a piece of fine platinum wire be stretched from the screw attached to the zinc, to that attached to the copper, it will attain a red, or a white heat. This is termed the "heating power" of a battery. The larger the cell, the greater thickness of wire will be heated. If *too thin* a wire be used, the passage of the electricity will be so much retarded as to produce no visible indications of heat. The *length* of wire that can be heated depends on the cooling power of the contiguous *air*; "a current that will heat one inch of platinum, will heat a hundred inches."* The law which regulates the comparative length of wires heated by different combinations of the batteries is this: If one such cell as that described, heats x inches, and another cell y inches, the two arranged in series will heat $x+y$ inches.†



If a series of cells be arranged, as in the annexed figure, by uniting the copper of one to the zinc of the

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* *Faraday's Researches*. Thirteenth Series. § 1631.
† *Transactions Electrical* Society. p. 63. § 36.

other, and points of charcoal be attached to the terminating wires, upon bringing these points into contact and then separating them, the well known phenomenon of the voltaic flame is produced. The *length* of this flame depends on the number of cells used; the size or *thickness*, (if we may use the term,) on the size of the cells. The flame from a hundred cells is very brilliant; in some experiments made with a series of upwards of three hundred, it was needful to screen the eyes with a black silk veil. Few things resist the intense heat of this flame; the metals are speedily dissipated in fumes; platinum and gold are melted and vapourised. The arrangement of cells in series will produce a shock on the human frame, intense in proportion to the *number* in the series. Thirty will produce the effect: three hundred will produce more than a man with ordinary nerves could endure. The power of batteries to decompose solutions has been already described; (§ 11, &c.) on a right application of this power depends the success of electrotype experiments. A solution very easy of decomposition is one of iodide of potassium. A battery consisting of a *wire* of zinc and one of copper, will decompose this solution contained in a piece of blotting or bibulous paper. Water is more difficult of decomposition. Ten cells of a Daniell's battery are a convenient number to effect the decomposition of this. A series of twenty will release very little more gas than one of ten; but *two* series of ten placed *side by side* will do twice the work of *one* series. By an arrangement of this kind it is that the maximum of decomposing power is obtained from a given number of cells. And by regulating the number and nature of the batteries, according to the nature of the solution acted on, the electrician is enabled to retain a command over the most refractory bodies. From this it is manifest, that no direct reply can be given to the enquiry, Which is *the best form* of battery? The nature and form must *depend on* the objects for which it is intended.—One species of battery produces effects closely analagous to those obtained by the common electric machine. This is termed a water-battery. One or two thousand cells containing pairs of plates (copper and zinc) are connected in series, and charged with water.—There is a beautiful regularity in the action of batteries, that cannot fail to interest the most casual observer: it is a regularity to which the attention of the electrotypist should be especially directed. When a number of cells are connected in series according to the plan represented in the wood-cut, precisely the same amount of action occurs in each. If in one an ounce of zinc is consumed, so also is it in every other; and in each too, a weight of copper is deposited on the surface, equivalent to the ounce of zinc. And, if the terminating wires of this apparatus be placed to produce the decomposition of a solution, precisely the same amount of this will be decomposed, as is equivalent to the quantity of zinc consumed or copper released in each cell. If water be the subject of experiment, the same arrangement of battery will release more or less gas, according to the degree of conductibility given to the water by means of sulphuric acid; the less conductible it is, the greater resistance it offers to the passage of the battery current, the less gas is released, and the less zinc is consumed: as the conductibility increases, the rate of decomposition is higher, and the energy of the action in each battery cell is greater. There is a harmony in all this consistent with what we have hitherto learned of the laws of nature. The knowledge of this law is no small addition to the science of electricity: and it must not be forgotten, that the development of this beautiful system of things is due to an *English* philosopher, whose perseverance in research, has been crowned with continued success. Without dilating longer on these *general* features of the science, I shall pursue the object *at present in view*, and endeavour, with as much brevity *as is consistent*, to explain the process of the Elect type art, with so much of its theory, as, joined with what has been already said, may guide the experimenter safely through each process.

II.—PREPARATION OF MOULDS.

20. I can very reasonably conclude that the amateur will commence his experiments on the smaller works of art; and, as a knowledge of the mode of manipulation to copy these, will, with a little practical experience, easily pave the way towards accomplishing greater works, I shall dwell principally on the art of copying medals, medallions, seals, &c., taking the reader with me, through the entire process.

21. There are many materials fitted for forming moulds; but of these I recommend two, which will be found to answer most purposes,—*fusible metal*, and *wax*. The former is applicable to all medals of ordinary size—those two inches and under in diameter. The latter to larger medals, and to plaister medallions.

22. **Fusible Metal.**—This is an alloy, consisting of bismuth, tin, and lead; it melts at a low temperature, a few degrees beneath that of boiling water: and has been used as a philosophical toy, in the form of spoons, which melt in hot tea. For this purpose it generally contains a small portion of mercury. Since the discovery of Electrotype, it has been prepared for that purpose, without mercury, and may be obtained at most of the philosophical instrument makers.

23. The proportion of the different ingredients in a pound of this alloy is :—

	oz.
Bismuth	8
Tin	3
Lead	5
	16=1lb.

These should be melted together in a *clean* iron ladle, taking care to keep it on the fire no longer than is necessary to produce the complete liquefaction of the several ingredients. When melted, pour the metal on a stone or marble slab in drops. Then, after having *rubbed the ladle clean*, with coarse paper, return the pieces of metal, re-melt them, and pour them out in drops as before. A third melting will ensure the ingredients being well mixed. There is very little fear of failing in converting this metal into moulds, if the ladle is rubbed between each melting; and if the metal is removed from the fire the *instant* it is melted. The former ensures a bright surface to the mould; the latter preserves the alloy from change by oxidation.

24. *To make a mould in fusible metal.*—Melt some in the iron ladle, and pour it on a slab; then, from the height of two or three inches, drop on it the medal to be copied, taking care that the medal is COLD. In a few *seconds* the metal will be solid, and may be placed to cool; when it is cold, either with or without a few slight taps, the two will separate; and, if proper care has been taken, a *perfectly sharp* mould will be obtained. The novice must not, however, be disheartened if his first attempts to obtain good moulds fail: for there are so many little accidents which may happen, that the most practised manipulator may have to repeat his attempts. A slight shake of the hand may drop the medal irregularly;—too much sunk, for instance, on one side. A film of oxide may rest on a portion of the surface of the melted metal, and render a portion of the cast *dull*. Dull looking moulds must always be rejected, for so minutely correct is the process of Electrotype, that the dulness of the mould will be transferred to *every* copy made from it. Even if an original medal be incautiously handled, the slight trace of a finger-mark will be transferred to the mould; and thence to the Electrotype copies.

25. The fusible metal will not always pour in

round mass, to receive the medal: unless the slab is perfectly level, it runs into a stream. This is a great inconvenience, but may be remedied by having a shallow cavity (saucer fashion) made in the marble; or by using any article of *earthenware*, which the kitchen or the laboratory may furnish, suited to the purpose. I have been in the habit of using the brown stone-ware saucers, in which blacking is sold; and in them have produced some of my best moulds. They are to be inverted, and the metal is to be poured on them ; when it will form a round mass, with the additional advantage of being thicker in the middle,—the better fitting it to receive the relief of the medal. If an attempt fails, and it is necessary to drop the medal again, it should be allowed to become quite cold before using. The impressions obtained from *warm* medals are far less likely to be sharp, than those obtained from *cold*.

26. Having obtained a mould, varnish the back and edge,—and also a portion of the front, when the surface of the mould around the impression is larger than necessary. The best varnish is good sealing-wax dissolved in spirit of wine.

27. It will now be ready for use, and is to be attached to a copper wire. The end of the wire must be *quite clean ;* the wire is placed across the flame of the candle, with the clean end beyond the flame; it is to be touched with a piece of rosin, and pressed on the edge of the mould. The mould will instantly melt to receive it, and in a few seconds it will be cold and firmly fixed. The moulds should be wrapped in paper, if they are not intended for immediate use.

28. *Wax Moulds.*—The manipulation with this material is very simple. The wax employed is the common white wax, or the ends of wax candles. It is to be melted in an earthen pipkin, and kept on the fire a *few minutes* after it is well melted. The medal to be *copied* should be made warm, the warmer the better ;

(the object being to prevent the sudden chill of the wax when poured on.) It is then surrounded with a rim, composed of a ribbon of paste-board. The end of this may conveniently be secured by a small *cleft stick.* The surface of the medal should then be *very* slightly covered with olive oil. The hot wax is then poured on. It will require five or six hours to become sufficiently cold for removal.

29. There will be at times a difficulty in removing these moulds from medals with elaborate work. If this is the case, *boiling* water should be poured into a cup, or any vessel smaller than the medal; and the medal, with the wax upwards, should be placed on this. The sudden influx of heat will expand the metal, and generally cause the separation without further difficulty. This will occur in a *few seconds.* Care must be taken that it does not remain so long as to allow the heat to be conducted to the wax; for in this case the mould will become softened, and require an hour or two to solidify before the attempt could be repeated.

30. The use of wax would be very limited, if it were confined solely to taking moulds from *medals.* Fortunately, it will produce minutely correct copies of plaister casts. This circumstance will render it invaluable to the electrotypist, who employs his scientific resources towards the formation of a collection of works of art. For he is thus enabled to transfer impressions of the frail and perishable *plaister* to the durable *copper*; and to transfer them with all their beauty and all their perfection. Those who have obtained but a casual insight into the treasures transferred to this delicate, but brittle material, have seen enough to assure them that there is an ample store to suit every taste and every temper. For a few pence, specimens of first-rate execution may be obtained from any of the plaister shops *in London*;—they are often to be met with in the hands of the Italian boys, who frequent the streets. C *should be* taken that the specimens selected are

from defect. A few weeks' experience among medals will be of more avail, in guiding the judgment, than pages of written instructions.

31. To copy Plaister Casts.—Pour some *boiling* water into a plate; stand the cast *face upwards* in this water: the water must not be deep enough to reach the *face* of the cast. In about two minutes, the cast will be filled with water. In this condition, it will be advisable to stand it on the stove by the fire-side, for another two minutes, in order to drive off by evaporation any superabundance of water that may be on the surface. Then, without loss of time, wrap round it a ribbon of pasteboard as before, (§ 28.) and *immediately* pour in the melted wax. After the wax is solid, let it remain for two or three hours, and the mould may be lifted off from the plaister, without further trouble.

32. *To render wax moulds conductible.*—They, whose knowledge of electricity is the most elementary, are aware that wax is a non-conductor; and as such will not be of any service to convey the voltaic current. In order to render its surface conducteous, many plans have been devised. There is one which combines the three advantages of simplicity, certainty, and economy: and this alone will be described. It is to cover the surface with black-lead; the application of this substance is due to Mr. Murray.

33. This article is known in commerce under the several names of plumbago, graphite, and black lead. The latter might naturally enough induce those unacquainted with the subject, to conclude that *lead* held a prominent place in its composition. This, however, is not the case; it contains no lead at all; it consists of carbon and iron;* the principal portion being *carbon*. This substance has been already mentioned; (§ 5.) it is a very good conductor. Plumbago is largely used in the arts: the finer sorts for drawing-pencils, the *inferior* in domestic economy, for polishing iron-work.

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* Its chemical name is carburet of iron.

It does not seem that the difference of quality in this substance depends entirely upon the quantity of carbon it contains. The common qualities, such as are used for polishing stoves, are very good conductors; and, if tolerably *pure*, will answer our purpose as well as the best among the finer specimens. Unfortunately, however, the common kinds of black-lead are largely adulterated: among the substances used for adulteration, are plaister of Paris and charcoal. To obtain this article sufficiently pure for Electrotype purposes, through the ordinary channels, is a matter of some doubt. The demand, however, has caused a supply through a new channel. The instrument makers, who sell the apparatus for Electrotype experiments, generally keep plumbago in a fit condition for applying to wax moulds.

34. It must be applied DRY. Having breathed slightly on the mould, dip a soft brush into the plumbago, and rub it briskly over the surface: continue this, breathing on it occasionally, till the whole presents the well known black-lead polish. Be very careful to rub the brush into every spot. The brush I use is similar in shape to a camel's hair pencil, but more stiff. With care this operation will not affect the sharpness of the mould in the slightest perceptible degree. When the mould seems to be covered, if, upon breathing on it, any parts appear *whitish*, repeat the operation. A clean wire slightly warmed, and pressed against the back of the mould, will become firmly imbedded in it. Then rub the wire and the wax about it with the plumbago brush, in order to complete the connection between the two. The mould is then ready for use.

35. *Plaister of Paris Moulds.*—In like manner sealing-wax impressions may be coated. If the plumbago will not adhere, moisten the seal *slightly* with *spirit of wine.* Another mode of making moulds is with *fine plaister.* They are to be saturated with wax or tallow, by standing them in a shallow vessel, containin

these substances in a melted state; and when cold to be coated with plumbago. (§ 34.) Though most medals may be copied by the wax or fusible metal, yet some may prefer this substance in particular instances. There are many works of art to the copying of which it is peculiarly applicable. The best fine plaister should always be used: it should be *fresh;* if kept any time, it must be preserved from the air in jars or otherwise. It should be carefully mixed with water to the consistence of cream; there is no necessity to hurry mixing it,—good plaister will always afford abundance of time before it "sets:" when well mixed, let a small quantity be poured on the object to be copied, and be brushed into all the parts with a camel's-hair pencil; this removes air bubbles: then pour on the plaister to the thickness required. If the objects to be copied be oiled first, little difficulty will be experienced in removing the plaster-mould when "set." These moulds are not like those of wax and fusible metal, reconvertible into others: and, on that account, should only be made in those cases where the other substances are not applicable. Any mould, when once made, will, with proper care (§ 60, 65.) produce successively as many Electrotype copies as the operator pleases. The wax and plaister moulds, however, must be re-covered with plumbago each time they are used. (§ 70.)

III.—VOLTAIC APPARATUS TO BE USED.

36. The moulds thus prepared are fitted to fill the place of the negative or copper plate, in the generating * cell of a simple constant voltaic pair; (§ 17.) or of the negative plate in a decomposition † cell. In

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* This term is applied to that cell containing the single voltaic pair of zinc and copper, or other metal. (§ 3.)

† *This term* is applied to the second cell, into which the *terminating wires* (§ 11, 12, 13.) are brought.

either case they occupy the place where hydrogen is evolved, if the liquid is acid water; (§ 4, 11.) and where copper is evolved, if this acid water contains sulphate of copper. (§ 17, 12, 13.)

37. For the simplest mode of obtaining an Electrotype medal, the reader is referred to the description given (§ 3.) of a single voltaic pair. Instead of using the copper-plate as there described, attach (§ 27.) to the end of the wire one of the fusible moulds. (§ 26.) Bend the wire into the shape of the letter ∩, so that the mould shall face the zinc:—wrap the zinc in a piece of brown paper; pour within the paper some salt and water, or some water very slightly acidulated with sulphuric acid; and immerse the whole into a vessel containing a saturated solution of sulphate of copper, into which a little sulphuric acid has been poured.

38. This apparatus will represent a single cell of a constant battery; (§ 17.) not constructed on the best principles, it is true, but sufficiently so for an introductory experiment. The copper of the solution will be released on the fusible mould: (§ 17.) after five minutes' immersion the mould will be covered with a very brilliant coating of pure metallic copper;—after thirty hours, or less, with proper arrangements, (§ 50.) this coating will be thick enough to remove:—when removed, it will present a perfect resemblance to the original medal.

39. To complete, however, the character of this constant voltaic pair, the zinc must be amalgamated, (§ 19.) and a more convenient diaphragm than paper must be employed. (§ 44.)

40. Besides the *electric* action on common zinc, the acid acts on it *chemically*:—whether the former action be going on or not, the latter will not cease, so long as *there is any* zinc to be acted on, or any acid to act on *it. This arises* from the quantity of foreign matter *contained in* the zinc of commerce:—this matter, which

is mostly metallic, forms, with the particles of zinc, very many small voltaic pairs, all acting independently of the negative plate, (§ 3, 17.) and at the expense of the zinc and acid. *Pure* zinc is not thus destroyed; but as the trouble of purifying it is great, it is seldom used.* Amalgamated zinc is quite as applicable.

41. The process of amalgamation is this:—place some mercury in a saucer or plate; pour on it some water and sulphuric acid; brush the liquid and mercury over the surface of the zinc, till the whole is covered with a *bright* coat of mercury.

42. Before describing the diaphragms, I may mention the mode I have adopted for casting the zinc. Take a common hearthstone; soak it in water to soften it; then cut in it as large a cavity as it will admit of, about half an inch deep. Melt cuttings of zinc in an iron ladle, over a good fire; lay the bent end of a copper wire in the hearthstone mould; and pour on it the melted zinc.

43. DIAPHRAGMS.—Paper is very inconvenient in experiments of any duration: it seldom, perhaps never, prevents the partial mixing of the liquids it is designed to separate; and its use is always attended with a great waste of the sulphate of copper; the metal from which is released in great abundance, and deposited within the folds of the paper. The same may be said, though in a less degree, of animal membrane. (§ 17.) Either will do very well for solitary experiments; but both are inconvenient, when the experiments are continued. Something more substantial, and more durable is requisite. For this purpose porous tubes have been constructed of the material used for butter coolers: others have been made of pipe-clay. These are very convenient for diaphragms; they may be obtained from any of the London instrument makers.

44. Those who are engaged in making a collection

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* *It may be obtained at the instrument makers' prepared for Electrotype purposes.*

of medals may find it convenient to construct their own diaphragms of plaister of Paris. An oval groove, a quarter of an inch wide, whose external diameters are three inches and two inches, is cut in a piece of chalk or Flanders brick; into this is poured melted lead, to form an oval *collar* of lead. When cold it is removed. Two pieces of sheet copper are wrapped, the one round the outer edge and the other round the inner of this collar. The height of the copper round the inner edge is half an inch less than the other. An oval bottom of copper is cut to fit this inner sheet, when it is fitted on the collar of lead. The whole is carefully secured into form; and is placed standing with the lead downwards. Plaister of Paris is then mixed with water and poured into this mould: it fills the space *between* the sheets of copper, and that *above* the oval bottom of the inner sheet; when the plaister is set, the outside of the mould is unwrapped, and taken off; the collar of lead is slipped off; the oval piece of copper is drawn out by means of strings previously attached to it; and the inner sheet of copper is compressed a little, and carefully drawn away. The plaister used for this purpose is the common kind employed by builders. If possible, it should be *quite new and fresh.* The value and durability of the diaphragm depends very much upon this. Water should be poured on the plaister till it is covered; and it should be carefully stirred until the stick employed to stir it leaves a trace or furrow behind it; and should then be poured into the mould immediately.

45. These casts are very durable; and will be found a great acquisition to those, who, from local circumstances may not be able to obtain other kinds of porous ware. They are as good as *all* other diaphragms; better than a very large proportion, more economical *than any.*

46. If in the introductory experiment already described, *(§ 37.)* the amalgamated zinc and these diaphragms be employed, a constant battery is obtained, with all its parts complete. And if, in addition, a bag of crystals of sulphate of copper be hung in the blue solution, in order to recruit its strength, which is exhausted in proportion to the copper released, the action may be continued for days or even weeks. And by removing the fusible mould as soon as a sufficient thickness of copper is obtained, and supplying its place by another, three or four medals may be copied in a week. The acid water around the zinc must be occasionally renewed.

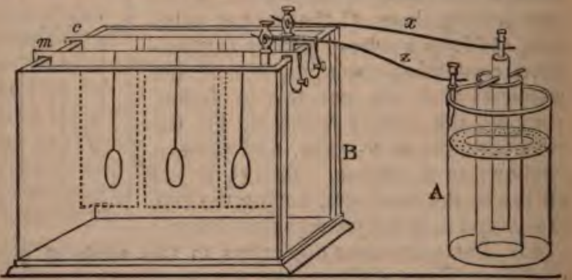
The annexed wood cut represents a single-cell apparatus, constructed on the principles now laid down. *Z* is a rod of amalgamated zinc, *m* the mould, *w* the wire joining them, *C* the copper solution, (§ 37.) *p* a tube of porous earthenware, containing a solution of acid and water. (§ 48.) To put this in action, pour in the copper solution, fill the tube with the acid water, and place it as shown in the figure. *Last* (§ 60.) of all put in the bent wire, having the zinc at one end and the mould at the other.

47. There are some objections to this mode of proceeding. The metal obtained is exceedingly hard, but very *brittle* : if the strength of the solution is much diminished, it is impossible to separate the copy from the mould, except in small fragments. If the solution is still more reduced, the copper will be deposited in a dull red, a violet, or a black powder, instead of in a metallic form. The colour of this powder depends on the weakness of the solution. The practised experimenter is so convinced of the uncertainty and trouble attending this mode, that he will never adopt it from choice; especially as other modes may be adopted *with equal* facility. (§ 48, 51, 52.)

48. *A* valuable improvement was devised in Russia,

by Professor Jacobi,* and in England by Mr. Mason.† It consists in using a decomposition cell, analagous to that already described. (§ 11.) The constant voltaic pair (§ 17.) of copper and zinc is used in the generating cell. (§ 36.) To the end of the wire attached to the copper is fastened a *plate of copper*: to the end of the wire attached to the zinc is affixed *the mould*. The sheet of copper and the mould are placed face to face in the decomposition cell: this cell is filled with a mixture of one part saturated solution of *sulphate of copper*, and four parts *water acidulated* with one-tenth strong sulphuric acid.

This arrangement will be better understood from the annexed figure. *A* is a cell of Daniell's Battery, elsewhere described; (§19, 56.) *B* the decomposition cell, filled with the dilute acid solution of sulphate of copper; *c* the sheet of copper to furnish a supply; *m* the moulds to receive the deposite. To charge this, pour in the several solutions, connect the wire *Z* with the copper sheet and the copper of the battery. *Last* (§ 60.) of all attach the wire *x* to the zinc and the moulds.



49. By an action already illustrated, (§ 13.) the *copper* from the solution is transferred to the mould;

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* *Vide Jacobi's Galvano-Plastic.*

† *Vide Proceedings* of the Electrical Society, April 1840, p. 203.

and the copper sheet is dissolved, being converted with the sulphuric acid into sulphate of copper; thus keeping up the strength of the solution. The time is somewhat longer by this method: two days will produce a medal of very good substance, firm and *pliable*.

50. In speaking of the *time* required for these experiments, it must be borne in mind that this depends much on the *temperature*. If the solutions are kept boiling, a medal may be made in a few hours: in severe weather, the action of the battery almost ceases. During the past winter, from November to March, my batteries were placed within a few yards of the fire. But for this, I could not have carried on the operations.

51. The advantages derived from the introduction of a decomposition cell are not limited to the production of single copies. Two or more may be made without any further consumption of material in the battery. If, for instance, two jelly-pots be placed side by side for decomposition cells, and the plate of copper, (§ 48.) be placed in one, and the mould (§ 48.) in the other: then, if the two cells be connected by means of a bent *copper wire*, dipping into the liquid of each, a circuit will be completed for the passage of the voltaic current. In *one* cell, the copper plate will be dissolved as before; (§ 49.) and copper will be deposited on one end of the bent wire: in the *other* cell, the end of that wire will be dissolved, and copper will be deposited on the mould. If the bent wire is removed and a *mould* is fixed (§ 27.) on one end of it to receive the copper released in the *first* cell,—and a plate of copper* on the other end, to furnish a supply in the *second* cell, the *one* action of the battery will produce *two* medals.

52. This mode of proceeding is not confined to taking merely *two* copies at a time; it may be extended

* Soldering is not necessary for this purpose; let a hole be punched in the copper and the wire be passed through and twisted. It is then as well to varnish the wire, (§ 26.) to protect it. Wires may be united by binding screws, cleft sticks or twisting.

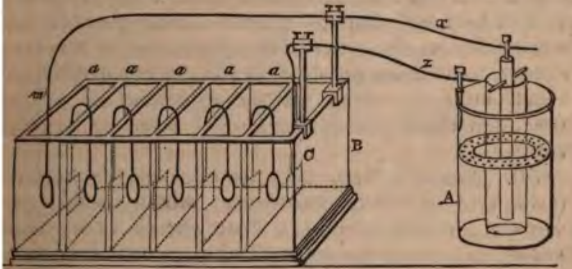
much further by using more cells. Experience has taught me that *six* is the most convenient number. The cells are to be connected, each to each, by bent wires, having a mould on one end and a piece of *copper* on the other. In proportion to the number of cells used, the *strength* of the solution (§ 48.) in them must be reduced by adding water, and its *conductibility* increased by adding acid. It is desirable to place the moulds and the sheets of copper as near together as possible, taking care that they do not *touch*. A single pair of copper and zinc in the battery or generating cell (§ 46.) will thus produce a series of *six* medals in three days, if the temperature is not much below sixty.

53. Those who possess the earthenware troughs belonging to the Wollaston battery will find the cells, on account of their shape, very convenient for this purpose. These troughs commonly contain twelve cells: I have been in the habit of connecting six with one battery, and six with another; and producing, by the use of one trough, two dozen electrotype medals per week. The *shape* of these cells permits the moulds and copper plates to be placed face to face, which, with other precautions, ensures an *even* deposite;—and near to each other, which shortens the length of liquid to be passed through, and thus facilitates the operation. The metal obtained by placing the moulds in series is of the best description. By those who may desire to adopt this mode of *multiplying* the number of medals produced, without *increasing* (§ 54.) the expense of the generative process, troughs may be obtained equally convenient with the Wollaston, but less expensive. They are made in well-varnished wood, of various sizes, and are divided into six cells, by means of plate glass or glazed porcelain partitions.

54. The advantage of this mode, in point of economy, will be manifest, when it is remembered that for *every ounce of* copper released from the solution in the *generating cell*, an *ounce* will be deposited on each mould

page 10); and about an *ounce* of zinc will be consumed
effecting this. Whether, therefore, one, (§ 48.) or
ix, (§ 52, 53.) or even twenty, moulds be placed in
eries, the *same quantity* of *zinc* will be required.
lence an ounce of zinc may be made to furnish elec-
icity enough to produce, according to the will of the
xperimenter, one, or six, or more medals, *each* weighing
n ounce.

Annexed is an engraving of a Daniell's battery, thus
onnected with a series of six cells, in each of which
a mould. A, the battery; B, the trough; z, wire
onnecting copper plate C with the negative (§ 4.) plate



f the battery; x, wire connecting mould m with the
nc of battery; a, a, a, a, a, five bent wires, each
aving a mould at one end and a piece of copper at the
her. (§ 52.) A little management is requisite in charg-
g this, in order to preserve the bright surface (§ 60) of
e medals produced.—Charge the battery as elsewhere
rected; (§ 19. 46.) connect the copper-plate C with
e battery;—place a *wire* with its extreme ends dip-
ng in the *extreme* cells of the trough; then, having
eviously connected the zinc and mould with the wire
place the zinc in the porous cell and the mould in
s place at m; in about two minutes, it will be covered
ith copper; *after* this, there is no fear of chemical
60.) action; then remove the end of the copper wire

from cell containing *m*, and place it in the next cell;—complete the circuit with the bent wire *a*, having a mould at one end, and a sheet of copper at the other; after waiting two minutes for a deposite of copper, remove the end of the wire one cell further forward; and so continue till the six moulds are placed in.

55. I have hitherto spoken of the battery in very general terms: it has been described (§ 46.) as consisting of a piece of amalgamated zinc, and one of copper, the former placed within a plaister cell, and excited with acidulated water, the latter outside the plaister cell in a vessel, containing a strong acid solution of sulphate of copper. A more minute description is here requisite. It will be found that the *size* of the copper plate materially affects the power of the apparatus: if it is large enough to embrace on all sides the plaister diaphragm, much more electricity will be generated in a given time, and the deposited copper will be smoother in its texture.

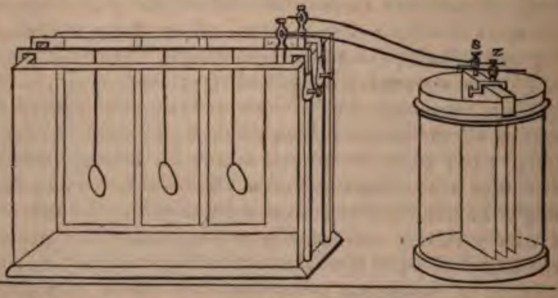
56. *Daniell's Batteries.*—Small Daniell's batteries (§ 19. 46.) have been constructed, which are very convenient for this purpose. They consist of a copper vessel, to contain the blue solution, and to form itself the negative plate; and a zinc rod, within a porous tube. These are fitted up with a perforated shelf for containing a supply of crystals, and binding screws to form the necessary connections.

57. I have been in the habit of rendering the Electrotype art available in the production of the very apparatus which is destined to be employed in the art; and have produced a compact, neat, and very simple *battery*, by the same process by which the battery thus formed will produce copies of medals. I take a large jelly-pot, and placing within it some wax, stand it by the fire, till the wax is melted, and the vessel thoroughly heated; then turn it about, so that the wax shall spread over every part of the interior: and having done this, pour away the superfluous wax. When it is cold,

I rub plumbago in the manner formerly described, (§34.) over the wax adhering to the *sides*. This vessel is then filled with the dilute (§ 48.) solution of sulphate of copper; and is made to form a decomposition cell. (§ 48.) I then place in it the copper-plate (§ 48.) connected with the copper of a generating cell, taking care that the plate does not touch the blackened surface of the sides:—and connect the zinc of the generating cell with the surface of plumbago, by bending its wire in the form of a hook against this surface. In two or three hours, the whole of the interior where the plumbago is, will be covered with metallic copper. The vessel will now form one of the best and simplest generating or battery cells that can be constructed: this deposition of copper forms the copper-plate, (§ 3.) of the voltaic pair. The plaister diaphragm, (§ 44.) and the solutions will complete the apparatus. It is desirable to have a strip of the inner surface uncovered with plumbago, in order to facilitate the removal of the copper when it becomes thick; or the *whole* of the interior surface might be covered with plumbago; and when, after having been used for a week or two, the deposited copper should become thick enough, it might be drawn out, or the earthenware cell might be broken from it, and thus a complete cell of a Daniell's battery (§ 46.) might be obtained without a seam or join. To connect a wire with this coating, it is only necessary to brighten the end, and bend it so that it shall pass closely. This method of forming a generating cell offers very great facility towards the application of Electrotype on a large scale. By the extension of this principle, apparatus of any size can be economically constructed: a water-butt, for instance, could be converted into a battery cell, if the object to be copied required a large quantity of electricity.

58. A very neat decomposition cell has been constructed, consisting of a box a foot deep, a foot long, and two or three inches wide; the size varies according

to circumstances. Two parallel wires are secured along the top; one may be connected with the zinc, and the other with the copper of the battery. On the former are hung the moulds,[*] by merely bending the wires attached to them, (§ 27.) into a hook; and on the latter is hung a sheet of copper. These wires may be placed nearer to each other as circumstances require. By this means, several medals may be made at the same time. It is a convenient arrangement; but does not economize the zinc, as when they are made in series. (§ 54.) One ounce of zinc produces six or more medals, not weighing *each*, but *all together* an ounce. The annexed engraving represents one of these troughs, connected with a Smee's battery. This battery consists of *platinized* silver, and *amalgamated* zinc. There is no diaphragm required, and the one exciting liquid is acid and water. This battery has of late been very



much used; one circumstance, of no small import, in its favour is, that it dispenses with the use of sulphate of copper. From the description already given of batteries the principle of action will be readily understood. The silver plate *S* of the battery is connected with the copper in the decomposition trough;—

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[*] *These troughs* are admirably adapted for obtaining copies of *large plaister casts*; such, for instance, as the Cartoons, the Elgin *Marbles, &c.*

the zinc *Z* is connected with the moulds. Those who employ this battery must attend to Mr. Smee's caution against dropping by accident any solution or crystals of sulphate of copper into it; for the copper would at once be deposited on the platinized plate, and alter the nature of the battery.

59. Enough has now been said to familiarize the reader with the nature and mode of employing these apparatus. He will use his own judgment as to the particular form he may select; the object in view has been so to simplify the "modus operandi," that those who attempt this very interesting art may find the way made smoother before them.

60. *Management of the Moulds.*—There are some circumstances, connected with the management of the moulds, to which it will be well here to advert. The copper solution will act *chemically* on the fusible metal, and will produce on its surface a dirty dark oxide, if the mould is placed in it before the battery is in action. To guard against this, it is necessary that every thing should be arranged before the mould is placed in the situation allotted to it. (§ 48.) The circuit should be completed by immersing the mould *last*. (§46, 48, 54.) With this precaution the immersion of the mould will be followed by an *instant* deposite of copper on its *whole* surface; after which there is no fear of the oxide. A circumstance no less strange than true in these experiments, is, that the surface of a fusible mould thus managed is never *wetted* by the liquid, in which it is placed; in fact it never comes into *actual contact* with the liquid; its immersion in the liquid and its receiving a coating of copper are *simultaneous;* the one is the *instantaneous* cause of the others. When the copy is removed, the mould is as *bright* and as *dry* as when first made.

61. The deposition of the copper on the plumbagoed surface (§ 34.) of the wax moulds, is not thus *instantaneous.* The film of conducting substance with which they are coated, is so thin that it will not convey suffi

cient electric fluid to produce this effect over the whole surface *immediately* on immersion. The deposition of copper is *gradual:* it commences in the neighbourhood of the wire attached to them, (§ 34.) and spreads gradually over the remaining portion. These moulds *do* become *wetted*, and the medals obtained from them come off with dirty surfaces; the medals also bring with them the whole or part of the plumbago, and hence the moulds require a fresh coat of this before they are used again. (§ 35.) These dirty specimens may be very readily cleaned, if required; the mode will be described in the sequel. (§ 68.) The production of dirty medals is the least evil arising from the use of plumbago moulds; there is one of far greater importance—one which requires some attention to escape. As the deposition of copper, which is *gradually* diffused over the whole surface, *commences* at one point contiguous to the connecting wire, it follows that the power of the battery at the first is concentrated in a *small* space. The consequence of this will be, that hydrogen will be evolved with the copper *at first*, (§ 63.) decreasing in quantity till enough of the mould is covered with a film of copper to increase the size of the surface to the requisite standard for releasing *copper alone:* after this all things go on well; but it is invariably found that the portion near the wire, from the irregularity of the premature deposite, is *rotten* or very brittle. To prevent this, I always *begin* by placing a *wire* in lieu of a *plate*, opposite the medal, in the decomposition cell; this reduces the power of the battery or the quantity of electricity passing;—as the copper deposits, I immerse the wire deeper, and when the mould is partially covered with copper, I remove the *wire*, place in the copper *plate*, and leave the experiment with the assurance of a successful result. It will occasionally occur in wax moulds and sometimes in *fusible metal* moulds of very elaborately executed *medals, that* bubbles of air remain in some of the complicated interstices; these must be removed, or the result will be infallibly disfigured. They are removed by lightly brushing the surface of the mould with a feather, *immediately* after it is immersed in the liquid.*

62. *Management of Battery apparatus.*—The Electro-typist, who expects to find *all* his experiments going on favourably, "thinks what ne'er was, nor is, nor e'er will be:" with the best intentions and the most careful arrangements he may *sometimes* fail. For, after having observed *all* the directions hitherto given, his battery may have *too little* work to do, or *too much.* The former will produce the *dark powder,* elsewhere mentioned; (§ 47.) the latter a hard *red, brittle* deposite. The terms *too much* and *too little,* are used in a very general sense, and will be better understood by describing the *causes,* the *results,* and the *mode of rectifying* these irregularities.

63. If the battery is *too large,* or the copper plate in the decomposition cell (§ 48.) is *too large;* or if the mould is *too small,*(§ 61.) *hydrogen* as well as *copper* will be released, and the deposite will be the *dark powder:* the same will occur if the solution in the decomposition cell contains too *much* acid or too *little* sulphate of copper. To rectify this, the battery may be made *smaller* by pouring out some of the solution, and so exciting less of its surface; or a smaller copper plate may be used in the decomposition cell; or crystals of sulphate of copper may be thrown into the liquid contained therein; or the copper plate and mould may be removed *far* apart. Each or all of these alterations may be made according as circumstances or convenience shall dictate; a few days' experience will be better than pages of instruction.

64. If the battery is *too small,* or the copper plate

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* If it should seem that any part of the mould is not sufficiently coated with plumbago, it must be removed from the solution, washed with water, dried with blotting-paper, and again rubbed with plumbago.

in the decomposition cell *too small;* or if the mould is too *large*, or if the decomposition cell contains too *little* acid or too *much* sulphate of copper, or if the weather be too *cold*, the copper will be deposited *very* slowly, and will present a dull red exterior, and be of a very brittle texture. The alterations necessary to rectify this defect will readily suggest themselves.

65. The medium between these two conditions fortunately has a very wide range, so that the chances of avoiding the two extremes are greatly in favour of the experimenter. The lines of demarcation within which the proper deposite is obtained, are, as may be imagined, not precisely defined. And hence the deposited metal possesses various gradations of character, according to the circumstances under which it is obtained. When all things are going on well, if the mould be lifted out * of the solution, it will present a *brilliant light, copper coloured* surface; this characteristic can never be mistaken after it is once seen. The deposited metal will present various thicknesses, according to the relative position of the mould and the plate of copper; if they are face to face, and parallel, the thickness will be uniform or nearly so; generally speaking, the copper on the lower part of the mould is thicker than that on the higher: this occurs from the specific gravity of the sulphuric acid, used to render the liquid conductible, determining it in a measure toward the bottom of the cell, rendering the lower part of the liquid more conductible than the upper. To cause a more uniform distribution, it is better to stir the liquid occasionally. Some moulds are better placed at the bottom of a vessel with the copper above them. When this is done, the liquid should be kept clean by straining, because all heavy deposites fall on the mould and disfigure the results. This arrangement will be understood by a glance at the wood-cut, consisting of *a flat trough to* be connected with a Daniell's battery;

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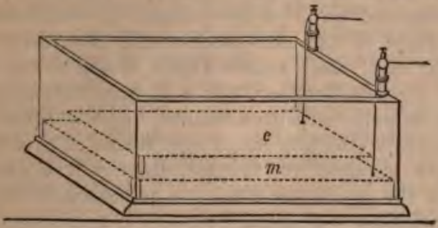
* *The mould* may be removed at any time with impunity.

m is the mould, placed beneath the plate of copper, *c*. If this mould is wax, arrangements must be made to prevent its swimming. This is readily done by securing a piece of wood to the trough, and fastening the wire of the mould to this.—I have now given directions applicable to perhaps all cases: a right comprehension of these and of the principles on which they are based, (§ 63.) will enable the veriest novice to labour with little or no fear of failure.



66. The medals are removed from the *fusible* moulds by gradually raising the edges with a pointed instrument, a brad-awl, for instance, and then using it lever-fashion to raise the medal out of the mould. Care must be exercised in this, for the contact between the two is so close, that the force occasionally required may cut the medallion. The separation from the *wax-moulds* requires no force, they are laid face downwards on a table, and after pressing the slight over-lapping edge of copper with the brad-awl, in different parts of the circumference, the two may be pulled apart.

IV.—BRONZING.

67. If proper precautions (§ 60.) are taken, the *medals from the* fusible moulds will generally present *a bright copper* surface; ocasionally, however, they will

has been polished, (§ 68.) a different, but very brilliant tint is produced. The colour is between red and brown. The richness of colour thus produced, is by many preferred to the true dark brown.

73. *Carbonate of Iron.* — I have produced very beautiful tints by using the substance commonly known as plate-powder, or rouge: after moistening it with water it is applied and treated precisely in the same manner as the plumbago. Some care and practice are required in its use, lest it should *stain* instead of *bronze* the medal. It may be as well to mention, that should the operator not succeed in bronzing any individual medal according to his taste, it may be cleaned as before directed, (§ 68.) and the operation may be repeated.

74. *Mounting the Medals.*—I have adopted a method of mounting the medals obtained from the *fusible* moulds, (§ 26, 60.) which gives a finish to their appearance, and enhances their value in the cabinet, where neatness, and not ornament, should prevail. I obtain pale green cards, the size of visiting cards; and cut some of these into single squares, *the width* of the card being the side of the square; others into smaller squares, *half the length* of the card forming the side of the square. A pencil circle is drawn the size of the medal; and two *ink* circles in order to 'throw' the medal 'forward.' Waste cards are then cut to fit the extra edge of the medal, and the part within the pencil circle is cut out. The two being fixed together with very strong gum water, the medal is placed in, and secured by another card gummed on at the back. The obverse and reverse are then gummed back to back, and thus the appearance of a perfect and solid medal is produced, equal, in point of workmanship and beauty, to the original. To hold the cards together until the gum dries, I use cleft-sticks. The medals obtained from *wax moulds*, having no addition to the edges, are not *well fitted* to be mounted thus: they may simply have

any roughness removed from their edges with a sharp file, and be placed in the cabinet without being fitted with cards.

V.—CONCLUDING OBSERVATIONS.

75. I have, in the preceding pages endeavoured, with brevity and clearness, to unfold the laws on which this very interesting and attractive art depends, and to furnish such practical directions as shall enable the least skilled to meet with success. I have dwelt on the copying of medals and plaister medallions alone, and have given such hints on the several stages of the process as have occurred to me during a long course of experiment. Much more could be added, but not without extending this treatise beyond the limits to which I have determined to confine myself. Enough has been said to render the subject familiar, and to enable those who are successful in copying the small objects here treated of, to carry their experiments to any extent. Busts, statues, vases, may, by proper application of the principles laid down, be as readily coated with copper as the small wax moulds. (§ 28.) Yea—anything to which a coating of plumbago can be given may serve as a mould on which to deposit the metal. Perhaps no better method could be devised for preventing the ingress of air into vessels whose contents are to be preserved, than covering these vessels with wax, and depositing on it a coat of copper. With no credit to my discernment, I might devise a thousand other instances in which this art will be available in the common concerns of life; but rather leave the merit to those who shall actually introduce it into these several spheres. The ornamental gardener will find it available in protecting from the effects of weather the busts and statues, which, when introduced with taste and judgment, are an agreeable relief to the dazzling beauties of the parterre. These are often, for the sake of economy, made of plaister of

Paris. They may be saturated as described elsewhere; (§ 35.) covered with plumbago, (§ 34.) and placed within a large vessel whose sides are covered with copper, (§ 57) and then by means which must now be familiar to the reader, a deposition of copper may be formed on them: this can be bronzed by the simple application of the black lead brush; and thus a sightly and permanent exterior will be produced. By the same means small and valuable wax figures may be preserved: the surfaces of these are of themselves very liable to crack, and fall off in chips. A *thin* covering of copper, without in the least degree affecting the fineness of the workmanship, will preserve it.

76. Engraved copper plates may be readily multiplied by electrotype. The battery must be in proportion to the size of the plate, and the plate must be used in lieu of the moulds. (§ 58.) Sometimes the copper deposite will adhere so strongly as to resist all attempts to remove it. This may be prevented by a very easy process.—Before the plate is used, heat it and rub bees' wax over the surface; continue the heat, and by the application of soft cotton, rub it perfectly clean from the wax. It may then be used without fear of adhesion. The deposite obtained on it is to be removed, and used as a mould; from this many copies may be taken, equal, in all points, to the original.

77. Much has been said and written on the subject of multiplying valuable plates by these means; and, without doubt, it will be employed in some instances. As, when a periodical of *extensive* circulation is illustrated with prints from copper-plates, *one* engraved plate will be worn out, before the whole impression i obtained. Here the art of electrotype offers a ver ready aid, and here it *is* applied. I have been given t understand that the publishers of a work of this description, who were in the habit of receiving from th *engraver four* plates, now content themselves with one *and obtain* Electrotype copies of this; and, as may

imagined, at a considerable saving of expense. But when a work of a higher order in the arts is published,—such, for instance, as the proposed engravings of the standard Portraits of the Queen and of Prince Albert, it is obviously not likely that the publishers, after incurring the great expense which they will of necessity incur, should so multiply the plates, and by their own act, so glut the market, as to depreciate the value of the proofs and prints, and certainly damp any hope of a remunerating return for their outlay. It is urged, on the other hand, that the *public* will patronize such works to the fullest extent. This I am inclined to doubt; for it requires something more than the uninformed taste of the thousand to appreciate, I will not say fully, but fairly the production of the labours of months,—aye, often of years. What will be a constant source of pleasure to the man of taste, cannot—it is against nature that it should—excite any very strong emotion in the minds of the majority. There is so much of association connected with the most esteemed prints, that their value is not recognized by the "great crowd;" and I am inclined to think that any attempt to promote an extraordinary circulation of prints from plates that have cost hundreds,—perhaps thousands—of pounds in engraving, would not be crowned with such success as to induce the projectors to continue. Time will disclose the truth or fallacy of these ideas. Still, however, the field for Electrotype is very—very wide.

78. Though copper is the only metal to which allusion has been hitherto made; yet, with proper care, *all* metals may be obtained from their several solutions. Silver may be first deposited in the moulds to give a silver surface, and then may be backed up with copper. The solution for the decomposing cell may be ammonia-carbonate of silver; and the place of the copper-plate should be supplied with a silver wire. To enter, however briefly, into the manipulation with other metals, would so much extend these pages beyond the bounds

assigned them, that I rather leave them with this b
glance. The art of Electrotype has been examined th
retically, and explained in a practical manner :
foundations have been disclosed, and the superstruc
has been so far traced, as to render its plan famil
That I have not followed the art through all its ramif
tions, is true : but this was not the object. On
point, I can only add, with regard to this treatise,

> Whoever thinks a faultless piece to see,
> Thinks what ne'er was, nor is, nor e'er will be.
> In every work regard the writer's *end*,
> Since none can compass more than they *intend*.

It is not for me to attach to this the concluding cou
of the passage; it is rather for those into whose ha
these pages may fall, to say—

> And if the means be just, and conduct true,
> Applause, in spite of trivial faults, is due.

CHARLES V. WALKE

Kennington, April 12*th*, 1841.

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ELECTROTYPE MANIPULATION:

PART II.

CONTAINING

THE THEORY, AND PLAIN INSTRUCTIONS,

IN THE ARTS OF

ELECTRO-PLATING, ELECTRO-GILDING,

AND

ELECTRO-ETCHING;

WITH AN ACCOUNT OF THE SEVERAL

APPLICATIONS OF ELECTROTYPE IN THE ARTS,

BY

CHARLES V. WALKER,
HONORARY SECRETARY TO THE LONDON ELECTRICAL SOCIETY.

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ELECTROTYPE MANIPULATION.

PART II.

I. Introductory Observations.

84. In compiling the fifth edition of the First Part of this work, it was found utterly impracticable to give, in the narrow compass of the additional pages, any *practical* instructions in the important branches of this art—*plating* and *gilding*. I therefore purposely said but little on the subject, reserving for this Second Part a succinct and particular description of the interesting process. I further propose to describe the method of etching the positive plate of the decomposition cell, (§ 48.) which will lead me to the interesting application of the same to plates, obtained by the process of M. Daguerre.

85. I prefaced my former treatise,—or rather the former portion of this treatise, for I consider this as but a sequel to that,—with a brief introduction to the philosophy of the process. I endeavoured to simplify, as much as possible, the beautiful theory of electro-chemical affinities, (§ 12, &c.) in order that, if my pages fell into the hands of any who were not versed in these things, they might obtain such an insight into the *modus operandi*, as not to be pursuing their labours entirely in the dark as to the *why* and the *wherefore*. It will be advisable to pursue the same plan now; and, before venturing to initiate my readers into the practice of gilding and plating, to

unfold more fully the principles on which these pr cesses are based.

86. And for this purpose I cannot, in the outset, d better than refer to the three experiments give (§ 11, 12, 13.), as illustrations of Electrolytical actio In the first of these, (§ 11.) I described the effect the action of a voltaic current on an acid solution viz. the development of oxygen gas at the wir through which the current *entered* the solution; an of hydrogen, where the current *left* the solution; an that, if platinum terminals were used, these gas might be collected pure. I then said (§ 12.) that, the solution contained sulphate of copper, oxyge would be released as before; but copper, in a metall form, would be obtained in place of hydrogen. An lastly, (§ 13.) I said that, if the termination at whic oxygen is released be of copper, then the oxygen, i stead of being *liberated*, will *combine* with the copp and form an oxide, soluble in the acid solution.

87. This is the theory of the process, when the d composition (§ 48.) cell is employed. When a sing cell is used, (§ 46.) the action is precisely analogou As for instance—when the zinc and copper of a sing pair are connected, the former being in an acid sol tion, and the latter in a solution of sulphate of co per, separated by a porous diaphragm, (§ 43.) transfer of electricity takes place *from* the zinc *throu* the solution *to* the copper; and, as before, copper released on the copper or *negative* metal of the pai and oxygen at the zinc or positive metal. As in th former case (§ 13, 86.) the oxygen combined with th *copper*, so in this it combines, and far more readil with the *zinc*. The more *positive* a metal is, th greater is its affinity for oxygen. And hence it that the single cell process takes much less time (§ 49 than the other. If in this arrangement the salt *gold or silver*, or platinum, &c. be used in solution in *stead of* sulphate of copper, the same general acti

takes place; and a result occurs, more or less similar to this, according to circumstances.

88. These *circumstances* were not very readily controlled in the early experiments with the noble metals. The salts were readily decomposed, far *more* readily than those of copper, but the metal was released in a state of oxide, more commonly than in a state of purity.

89. From what has been elsewhere (§ 62.) said on the subject of depositing the oxide, my readers must be familiar with the causes which operate in its production, and can soon frame a mode of obviating it. This mode is, however, more easy in theory than in practice. To illustrate this, let the experiment be made to decompose nitrate of silver, by either of the ordinary modes; (§ 46, 48.) and then, if it fails, as it doubtless will, let such alterations in the arrangements be made as are recommended for the copper solution; (§ 63, 64.) and it will be readily seen that this salt is not so under command as the cuprous salt. I should wander from the object in view, and trespass too much on these pages, were I to enter minutely into the chemical structure of the salts of the noble metals, and their electro-chemical affinities; it will be enough for the present purpose, if I advert to some facts of which my readers are not ignorant, and which bear upon the point at issue.

90. The deposition of oxide, as I have elsewhere stated, arises from the power of the battery being too great in proportion to the strength of the solution; (§ 63.) if this power is reduced to a lower standard, the deposition of oxide may be avoided, and pure metal obtained: but if the standard is too low, when *nitrate of silver* is the subject of experiment, the action of the electric current is not sufficient to overcome the chemical affinity between the nitric acid, and the object experimented on. Hence it is very difficult, *but not impossible*, to obtain a deposite of pure silver

from the nitrate:—in fact, long before the theory of electro-chemical deposites was understood, I made some experiments upon the electrolysis of this salt, and succeeded in producing an electrotype medal with a *silver* surface; being, I think, the *first* deposition of silver, that was effected by the electrotype art. But I was unsuccessful in my attempts to repeat the experiments; and simply because, in that instance I *chanced* to have in action a power nicely *balanced* with the work to be performed, but, in future instances, my power was either too *great* to release metal uncombined with oxide, or too *feeble* to overcome the chemical affinity between the elements of the salt* and the metal to be deposited upon.

91. That I did not *chance* to succeed in my second attempts is readily accounted for. For the range within which the true result is obtained from nitrate o silver is very contracted; with the salt of copper it i just the reverse. And hence, while in the latter case th *chances* are in favour of a *successful* termination of th experiment, (§ 65.) in the former the chances are i favour of a *failure*.

92. Much more might be said upon the difficulty o manipulating with certain of the salts of the mor negative metals, and on the difference existing betwee them. In some the range, within which success i embraced, is very contracted; in others more extended But as my object is rather to guide my readers to th sure result by the most certain road, I shall pass from alluding to what *cannot* be effected to speaking o what *can*.

93. Amongst the salts of silver and gold are tw possessing a wider range than the rest; and henc offering that facility for experiment, which is the grea object desired:—these are the ammonio-carbonates and the cyanurets. Other salts have been employe

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* *The term salt* is applied to compounds consisting of one of th *acids and a* metallic or other base.

with success, in proportion to the skill and knowledge of the manipulator; but these are more easily managed. With regard to the first, there is one *great objection* to be urged against it;—namely, that it is highly fulminating: if any of the crystals dry on the surface of the vessel, a slight touch will produce an explosion. This alone is sufficient reason to prevent its general application. In the cyanide no such objection exists: and, as it is the subject of a PATENT, I cannot but be right in concluding that it holds the first place in point of utility. I have used it in my experiments; and invariably with success.

II.—PREPARATION OF MEDALS AND MOULDS, FOR THE RECEPTION OF SILVER OR GOLD.

94. I shall assume that this book will be more read by those whose object is the copying of medals and works of art, than it will by those who wish to extend their experiments over a wide field; and hence I shall describe, as I did before, (§ 20.) the means of effecting this most readily; and at the same time furnish those, who desire a more extensive application of the process, with ample information upon the principles and practice, so as to enable their pursuing it to any extent they please.

95. There are two methods of obtaining a silver or a gold surface; one of which is common to any mode of plating or gilding; the other is *peculiar* to the art of releasing metals from their solutions, by the agency of a voltaic current. The former is effected by throwing down the metal upon the prepared surface of the medal; the latter by depositing a thin layer of the precious metal *in the mould*, and then depositing copper upon this, until the desired thickness is produced. It was by the latter method, the silvered specimen, already alluded to, (§ 90.) was made.

96. *Cleaning the surface of Medals.*—It is a matter of paramount importance that every portion of the surfaces to be either gilded or plated, should be *perfectly* clean. No *oxide*, no *polishing* powder, not a particle of dirt must be present. When fusible moulds are made according to the directions given, (§ 24, 25. 104.) and are cautiously (§ 60.) submitted to the voltaic action, electrotype medals will have a surface bright and perfectly clean : in which case they are fit for the present process, without being even *touched* with any thing ; in fact, it is far wiser to leave them as they are, and not mar what is well, by striving to better it. Considerable care is requisite in cleaning those specimens which " come off" soiled ; and those which are removed from wax and stearine moulds. They may be effectually prepared for gilding, &c., by rubbing them well with spirits of turpentine and rottenstone ; and then washing them with soap and water and a brush, rincing them, and afterwards polishing them with a leather free from dust. They should then be carefully examined to see that no accumulation of dust or dirt is concealed in the workmanship of the device ; for this, though little apparent on a burnished copper surface, is readily developed, when silver or gold is deposited upon it.

97. Nor is it enough only to prepare a clean and bright surface to receive the silver or gold ; though it is a fact to be borne in mind that the success of the result is very much *in proportion to the nature* of the surface. This fact is forcibly alluded to by Prof. de la Rive in his early experiments ; and also by Mr. Boettiger, in his account of gilding given in the *Annalen der Chimie und der Pharmacie.*[*] The latter says, speaking not of medals, but of articles generally, " It is very necessary to rub the metal according to circumstances, with extremely fine sand, moistened

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[*] Vol. xxxv. p. 350.

with hydrochloric acid mixed with a little chalk, so that there shall remain no trace of oxide of copper." But besides this, it will be well to take further precaution in order to ensure a permanent union between the copper and the gold or silver. For I have frequently observed, especially in the experiments on plating, when I have deposited a thick layer of silver, that the latter will present the exact appearance of a sheet of paper, badly pasted on a solid surface, containing little elevations, with air beneath them; and of course the silver, in such cases, readily is rubbed off. To guard against this, Mr. Spencer's mode of employing nitric acid should be adopted. He found that copper united to, and became one with, a copper surface, that had been touched with this acid. So, in like manner, if the electrotype medal be immersed for a second or two in dilute nitric acid, and afterwards thoroughly rinsed and dried, the surface will be in a condition to unite with the metal deposited upon it.

98. There is another way of inducing this perfect union, which depends upon the fact, that all metallic, &c. surfaces, after exposure to the air for some hours, become coated with a film of air so intimately, as to retain it even (as in electrotype cases) between themselves and any metal deposited upon them. In fact we are advised, in copying, by electrotype, large subjects, to take advantage of this; and to allow the film to arrange itself, before the plate is submitted to the action of the battery. For it is found that the presence of this natural film very materially operates in preventing adhesion between the plates, and the deposite. Whereas, in the absence of the film, the *two* will effectually become *one*, unless its place have been supplied by something else. (§ 81.) We are advised, after soldering a wire to a copper plate, to allow the latter to remain an entire day, to regain the film of air, which had been driven off by the heat. This fact

may be rendered subservient to plating and gilding; as it affords a simple and ready means of inducing on the surface a predisposition to unite permanently with the deposite. And hence it will be advisable at times to use this precaution, in addition to that of immersion in nitric acid;—before attempting to plate or gild, it will be enough to place the medal by the fire-side till it is well warmed.

99. As every grain of *gold* is of value, it is desirable to cover the back of the medals with a coat of copal varnish; it will dry, while the medal is being warmed for experiment; and forms a neat and effectual covering: indeed, I should recommend it in all cases, instead of the solution of shell-lac. (§ 26.) The value of the silver consumed in plating, (unless the object be very large or the deposite thick,) is very trifling, according to the mode I shall recommend; (§ 126.) the back may, therefore, be varnished or not at pleasure. Plated medals, with the backs *unvarnished*, possess so much the appearance of solid silver, that it requires almost demonstration to convince the uninitiated, that they are not so. To connect the medals with the wire, I either drill a hole, (if the extra rim (§ 74.) will permit it,) and hook them on; or bend the wire so as to hold the medal as in a pair of pliars.

100. CONSTRUCTION OF MOULDS.—A considerable space (§ 20-35.) was devoted, in the first part of this treatise, to mould-making; and with justice: for it is folly in the extreme, to work with bad and imperfect moulds; and good are not obtained without much care and patience. To the *fifth edition* (§ 79.) I added the results of recent experience, describing the method to be pursued in order to *preserve* the mould, when the plaister has adhered to it. But the subject is not exhausted. I have still to give the ingredients in a composition to be used instead of wax or stearine; and *an account* of the BEST mode of obtaining metal *moulds.*

101. *Composition moulds.*—The following mixture has been lately recommended,* as being very serviceable for mould-making —

Mutton suet, previously melted and strained	1¾ lbs.
White or virgin wax	1¾
Spermaceti	½

These are to be melted together, and used precisely in accordance with the directions given for wax, &c. (§ 28-34). With this, or wax, or stearine, I conceive that provision is made for every case, in which moulds, not metallic, are required. On metallic moulds I have some improvements to describe of the greatest importance; and of especial value when the object is to deposite *first* gold or silver, (§ 95.) and afterwards to deposite copper on it.

102. CLICHÉE MOULDS.—In a note to a paragraph (§ 25.) in the later editions of Part the First, allusion was made to a method, by which the best and *sharpest* moulds could be obtained from the fusible alloy described (§ 23.). Since that account was written, I have received a description of the method adopted on the Continent for obtaining the beautiful casts of the French medals, which are so much admired. These casts are in a fusible alloy, containing *antimony*, as well as the other ingredients. (§ 23.) On putting to the test of experiment, the instructions I obtained, the results were so satisfactory,—in fact, were so easily obtained, and so far exceeded in beauty any moulds, however good, that I had produced by other means, that I was led without hesitation to adopt this better mode of mould-making; and should recommend those of my readers, whose tastes are so far cultivated as to make them dissatisfied with imperfect specimens, to pursue the method I am about to describe. The alloy contains the following ingredients:†—

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* *Vide* "*The Chemist*," (No. xxii.) vol. ii. p. 308.

† *Vide Proceed.* Elec. Soc. part ii. p. 90, Aug. 17, 1841.

Bismuth	8 par
Tin	4
Lead	5
Type metal* . . .	1

These should be repeatedly melted and poured drops, until they are well mixed.

103. A block of wood is then turned into a s similar to that of a button-die, into one end of whi worked a cavity, the size of the medal to be co and *not quite so deep* as its thickness; in this c the medal is placed; should it not fit tightly, a c of paper is pressed in with it: the medal being firmly mounted, is to be copied in the follo manner:—

104. A sheet of smooth cartridge paper is fixe drawing pins or otherwise on a flat table; the pa be used is very slightly oiled with a single drop o on this is poured some of the prepared alloy, v should be removed from the fire as soon as me (§ 23.). The metal is then stirred together with until it assumes a pasty appearance, and is on th of crystallizing; if, at this stage, the surface sh appear defaced with dross, one of the cards mu passed over it lightly and speedily; should no appear, this part of the process may be omitted. die (§ 103.) containing the medal, must then be firmly in the right hand, and be struck gently steadily upon the solidifying metal. Should an tant be at hand to aid in this, it will be as well sometimes, during the brief interim, while the ca being exchanged for the die, the exact moment is and the mould is imperfect. When one stirs metal, and the other is prepared with the die, operation can be timed to a nicety. When an assi is not at hand, the experimentalist should place th

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* Type metal contains a considerable quantity of *antimony*, a *which expands* in cooling. Instead of following to the let *directions above*, I use one part of *antimony* itself.

within reach, at his right hand, with the medal downwards.

105. The beauty and perfection of moulds thus obtained will amply repay the trouble of producing them. Though I am not justified in using the word "trouble"—for it will be remembered, that by the old method, the operation is often to be repeated again and again, (§ 24.) before the requisite fidelity of transfer is obtained; and then, even after the most successful operation, the mould is wanting in that *sharpness* and *burnish*, which so especially characterise the results of the present process. By this mode, with ordinary care, two, out of every three casts, are perfect; besides, therefore, the economy of time, the saving in the oxydization of metal is thus of no inconsiderable importance.

106. This method of producing moulds is not confined to obtaining them from medals, which melt at a *high* temperature; they may be obtained from the common *soft*, *white* metal, without the least danger of damaging the original. They may also be obtained from the metallic casts (§ 102.) which are extant of the French medals of Andrieu, &c. Moreover, if the fusible mould itself (§ 105.) be cut round and fitted into the block (§ 103.) in place of the medal, it may be employed as a die; and casts, *perfect* casts, equal in all points, and similar to the original medal may be obtained. This is in fact the method by which the French medallions, some of which are in most cabinets, are obtained.

107. In concluding this description of the clichée process, I would remind my readers that the varieties in the size of medals are not *very* greatly extended. A dozen blocks, with cavities at *each* end, would be ample provision for a very large portion of the medals extant.

III.—VOLTAIC APPARATUS TO BE USED IN PLATING AND GILDING.

108. The medals prepared according to the foregoing directions, (§ 95, 97, 98.) and moulds, composed of the new alloy, (§ 102.) will be ready to receive deposites of gold and silver, either by the single cell, (§ 46, 112.) or by the battery (§ 48, 126.) process; either of which methods may be adopted, according to the will of the operator, or to the extent and nature of the operations. With respect to the process of gilding, and that of plating, the manipulation differs little: therefore, with little exception, one series of observations will apply in both cases.

109. *Preparation of Silver Solution.*—Take one pint of pure rain or distilled water; add to it two ounces of cyanide of potassium; shake them together occasionally, until the latter is entirely dissolved; and allow the liquid to become clear. Then add a quarter of an ounce of oxide of silver, which will very speedily dissolve: and, after a short time, a clear transparent solution will be obtained.

110. *Preparation of Gold Solution.*—*Warm* a pint of pure rain or distilled water, and dissolve in it two ounces of cyanide of potassium as before; (§ 109.) then add nearly a quarter of an ounce of oxide of gold. The solution will at first be yellowish, but will soon subside to white.

111. I by no means give these as *standard* proportions of the several ingredients required. They are the proportions which I employed with success in gilding and plating the series of medals, (submitted to the Electrical Society at their last meeting,*) by the battery process to be hereafter described. (§ 127.) When

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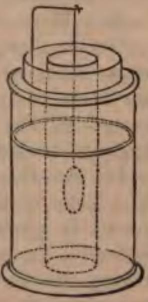
* *Vide* Proceed. Elec. Soc. Sept. 21, 1841, Part ii. p. 125.

the same object is effected by the employment of a single cell, it will be requisite to alter the degree of saturation according to circumstances ; to which, however, I shall have further to allude in the sequel. (§ 114.)

112. *Single Cell Process of Plating and Gilding.*— The necessity of economising solutions of such value as these, has led to certain modifications in the apparatus, contributing to that end. The porous cell, (§ 43.) which in all other arrangements contains the *zinc* and acid, and is surrounded by the copper, (§ 19.) or other negative element, in the present process, contains the *cyanide solution*, and the negative element or object to receive the deposite, and is surrounded by the zinc, &c.

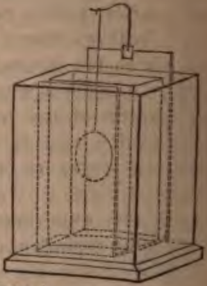


This arrangement will be readily understood by a glance at the annexed wood-cut, which represents a porcelain cell containing a cylinder of zinc ; and an inner porous tube filled with the solution of silver or gold ; connection is made between the zinc and medal (§ 96.) or mould (§ 104.) by a binding screw ; or by mere contact, as in the figure.

113. I must again dwell upon the philosophy of the action of this arrangement ; and return to first principles in order to impress them more firmly on the minds of those who read these pages with the intent to repeat the experiments. I should much regret, were any slight omission on my part to cause a single individual to fail in his attempts. For it is a matter of some importance, in employing the costly salts of the noble metals, to have the path of experiment traced out as distinctly as possible ; so that, with ordinary circumspection, the desired end may be looked forward for with at least moral certainty.

114. In the arrangement just described, the nature of the deposite will depend upon the principles elsewhere (§ 63, 64.) developed; and *a fortiori*, from the facility (§ 88.) with which the salts of silver or gold are decomposed, there will be a much *greater* chance of releasing hydrogen, and spoiling the experiment; in anticipation of, and to prevent which, therefore, ample provision must be made. For instance, if the silver solution is *weak* in proportion to the *energy* of action between the zinc and acid water, the electricity developed will be *more* than sufficient to release pure metal, (§ 63.) and hydrogen will be evolved, the result being a deposition of oxide. Or, if the balance between the strength of the solutions be duly adjusted, the relation between the size of the zinc and of the medal or mould may be such as to determine the same result. It is therefore requisite that the water which excites the zinc, should contain *but little acid;* a few drops, more or less in proportion as the cyanide solution contains more or less of the oxide; and that the strength of the latter should be maintained by a fresh supply of oxide from time to time.

115. Another and more convenient form for the single-cell apparatus is given in the annexed wood-cut; in principle it differs nothing from the former; the porous cell to contain the cyanide solution being flat, affords the means of immersing a large medal, without an extravagant supply of liquid. The zinc which envelopes the porous cell is flat too. The connections are made as before (§ 112.)



116. *Plating by means of a single cell.*—Having charged either of these arrangements with the weak acid water (§ 114.) and the solution of silver (§ 111.), let it *remain for* a few minutes; in order that the porous

cell may be moistened through, and that action may commence as soon as the circuit is completed. Then attach a *thin*,* pliable wire to a medal (§ 96.) or mould, (§ 104.) and place its other end in contact with the wire attached to the zinc : complete the circuit by immersing the medal in the silver solution, and a deposition will *instantly* take place. It will present a *dead* whitish appearance. After a few seconds remove it; and, when dry, a little friction with a soft leather or piece of cotton will produce a bright silver surface; then connect the medal with the battery and immerse it again for a few seconds, and again polish it; sometimes it is advisable to repeat the operation a third time. And thus, in the course of a few seconds, the medal will be *perfectly* and effectually plated.

117. In the course of these operations, should the silver present a whitish surface, streaked with perpendicular *black* lines, it may be regarded as an indication that the action is attended with a development of hydrogen; this must be prevented by some of the means so often mentioned. (§ 63, &c.) If instead of plating medals the object is to deposite silver in a mould, (§ 104.) the same preparations (§ 116.) are to be made; but the mould should be allowed to remain for some minutes, (more or less according to the thickness required), subject to the action of the current. It may then be removed, and after being washed with water; and afterwards with water containing a few drops of nitric acid, may be placed with proper connections in a copper solution, (§ 46,48) to remain there till it is sufficiently backed up with this metal.

118. *Gilding by means of a single cell.*—With the exception of a variation in the duration of the experiment, the operation of gilding is conducted precisely in the

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* The principle, so often alluded to of retarding or restraining the energy of the action, is regarded in the employment of thin wire; it is a very valuable adjunct to the other means (§ 114, 63.) of obtaining *the same* end; and may often be adopted with advantage.

same manner as that of plating: gilding requiring a little longer time.

119. The operations of gilding and plating seem hitherto to have been effected by means of the single cell, in a manner more or less in accordance with the directions I have just given, as the nature of the case permitted. In fact, *plating* by this process has been adopted on a scale of some magnitude in the great manufacturing town of England; the strength of the solution being maintained by fresh supplies of the oxide of either gold or silver. And if attention be paid to the instructions given, there is little fear of failing.

120. Before describing a method which appears far superior to this, I would direct attention to the source whence the silver and gold are obtained, viz. from the *oxides*. For every ounce of these metals deposited, a quantity of the oxide must be furnished, which shall contain in it an ounce of *pure* metal: and hence for every ounce of *metal*, much *more* than an ounce of *oxide* is consumed. The time and trouble required to effect the combination between these metals and oxygen is by no means inconsiderable; and hence the expense of first producing the oxide of gold or silver and then releasing either from the after-combination (§ 109,110.) with cyanogen, far exceeds the actual cost of the metal employed: *how* far depends upon circumstances.

121. The object however may be accomplished with far more certainty, and at considerably less expense by means of an additional cell, (§ 48,126.) and a gold or silver anode.* And here it may not be uninstructive

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* I have used Dr. Faraday's term *anode*, because it conveys in one word what could not otherwise be expressed but by description. If I should have to repeat the term, as possibly I may, my readers will remember that in a decomposition cell (§ 48.) the plate or metal *connected* with the *copper* of a generating cell is called the *anode*,—*meaning* the path by or through which the electricity enters the solu-

to make a few observations on the nature of what are styled *secondary results*.

122. In the second initiatory experiment given (§ 12.) in illustration of electrolytic action, wherein a solution of copper was decomposed, by means of platinum wires, it was stated that oxygen is *given off* at the wire through which the electricity enters the solution, viz. at the *anode*. This would equally have been the case had the wire been of *gold*; but when, as in the third introductory experiment, (§ 13.) *copper* wire is used, no oxygen is *released*; but that, which is *developed* there, combines with a portion of the copper wire, and produces an oxide of copper: this immediately dissolves in the solution, and becomes a sulphate of copper. The *primary* result, or proper element liberated at the wire, is *oxygen*; the *secondary* result, or consequence of the affinity between copper in a positive electrical condition, and nascent oxygen, is *oxide of copper*.

123. These *secondary* results are often very complicated, nor do they always depend on a union between the terminal wire and the substance liberated, as in the instance given; for this element* not unfrequently assumes a new character by uniting with another element in the solution. As, for instance, the ordinary *copper* deposite is a *secondary* result: the element released by the direct action is *hydrogen*; but this combines with the oxygen of the solution, and the *copper* is set free.

124. The nature of these *secondary results* can

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tion. The metal connected with the zinc is called the *cathode* or path by which the electricity leaves the solution. The moulds therefore are *cathodes*, and the copper or gold, or silver plates, which furnish the metal are *anodes*.

* The word *element* is generally used to designate those simple substances, which have not been separated into constituent parts, and are hence assumed to be principles: as the metals, &c. The laws of the combination of elements with elements, are very interesting, but cannot be introduced here.

never be theoretically determined; because in any new case we cannot foresee what affinity will arise from the existing circumstances. We know that oxygen stands first in the list of those elements liberated at the *anode;* and we also know that it will not combine with *gold.* We, in like manner, know many other substances, which are liberated at the anode; but the secondary results of each, whether proceeding from a union with the anode or with an element in the solution, can only be determined by experiment. Amongst these substances is *cyanogen.* This is a very peculiar body; being a binary compound of carbon and nitrogen; but possessing the singular property of combining with *elementary* substances, as though it were elementary itself. It is an elastic fluid, and has received the termination—*gen,* in order to convey a notion of its intimate relation, in its *general* properties, with the other gases.

125. The result of a series of experiments,* with a solution of silver and gold in union with cyanogen, has shown that *cyanogen nascent at the anode* (§ 121.) *will combine with silver and also with gold.* This furnishes a means of gilding and plating, by the use of a generating cell to furnish the electricity; and a decomposition cell to contain the cyanide solution; in a manner similar to that recommended for obtaining deposites of copper. (§ 48.)

126. *Battery Process for Plating and Gilding.*—The generating cell for acting upon solutions of silver or gold need not be large. A pint Daniell, similar to that in the wood-cut, is sufficient for larger medals than can be placed in the decomposition cell attached. The latter is of porcelain or glass, four inches high, three inches wide, and will hold two-thirds of a pint of the cyanide solution. The zinc may be used unamalgamated, and excited with salt

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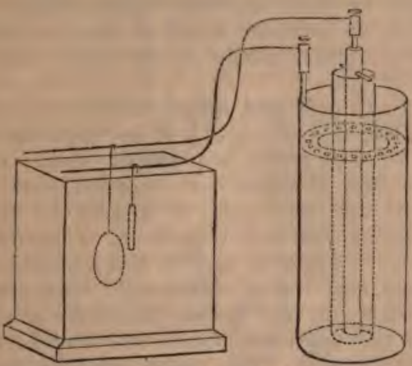
* *Vide Proceed.* Elec. Soc. Sept. 21, 1841, vol. i. p. 120.



and water; — the copper cell, as usual, contains a solution of the sulphate. (§ 19.)

127. Connected with the copper of the Daniell's cell, is a *thin* wire terminating either in a plate or wire of silver or gold, dipping more or less into the solution, according to the size of the medal. The latter is attached to the zinc by a thin wire, and the circuit is completed by immersing it in the solution: it may remain there 10 or 12 seconds; and, after being treated as before described, (§ 116.) may be submitted to the action again and again, according to pleasure. By this method the deposition of oxide, and consequent waste of metal, is prevented; for if the eye detects the least appearance of black lines, (§ 117.) their further development may be instantly and effectually prevented, by merely raising a portion of the wire or plate out of the solution.

128. By this action the gold or silver of the anode combines gradually with the cyanogen, as the process of gilding and plating is effected at the cathode; and just so much metal is dissolved from the former as is obtained on the latter. So that the expense of the operation is not only simplified, but reduced to a

minimum; for when once the solution is made, it may be used for an indefinite length of time, and all further expense is confined merely to the actual value of the metal consumed.

129. PURE *gold and silver anodes.*—I must here observe that, in speaking of gold and silver for anodes, I allude to those metals in a state of *purity;* not such *silver* as that of which our household plate is constructed;* nor such gold as is used for jewellery. These are alloyed with copper: so is *standard* gold and silver. Copper is used to give a hardness to the metal, and enable it to "wear well." Anodes of this description would soon destroy the nature of the solution; for the copper would enter into it, and eventually alter its character. The metal may very readily be obtained pure.

130. *Gilding plated surfaces.*—I have already given directions for the preparation of medals to receive these deposites; (§ 96-98.) but, with respect to *gilding*, the electro-mode furnishes a means of providing for the gold a surface of the best possible character, namely, one of *silver*. Silver gilt is universally admired. Copper *plated*, and then *gilt* is equally beautiful; and as the operation is so readily effected, I should recommend that *every* article, to be gilt, be first plated. The specimens I have produced by this means, are very far superior to those in which the copper merely has been gilt; and are such that I shall always in my collection of medals adopt it.

131. In all that has hitherto been said, I have confined myself to the deposition of small quantities of

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* I mention this *particularly*, because the supply of silver for plating, which would present itself readily to the mind of my readers, would be a silver spoon. Now, this might be used as an anode, and plating would be perfectly effected; but it could not be used *long before* the copper with which it is alloyed, would enter into union *with some of* the constituents of the solution, and very speedily destroy its character.

gold and silver, quantities so small, that they can be obtained in a few seconds, and while the eye looks on. Some modification of arrangement is required, when the action is to be continued for any length of time, or when thick deposites are desired; for as it is absolutely necessary to expose to the liquid only a small portion of the wire (§ 116.) at one time, a constant attendant would be required, to furnish the wire as it is consumed. This may be obviated by using a small *ingot* of gold or silver, varnished at all parts but the end; so that *enough* metal will be furnished, and a *small* surface exposed.

132. But where it is not convenient to obtain the metal in the desired form, the same end may be attained by adopting what I have termed a *regulating apparatus.*[*] This consists in interposing, between the battery and the cyanide cell, a cell containing strong solution of sulphate of copper, and connected with the copper of the battery by means of a *stout* wire terminating in a spiral. The spiral should be well-varnished, with the exception of its extreme end; and thus the battery current will be retarded *there;* and, instead of a silver or *gold wire,* stout *plates* may be immersed in the cyanide solution with impunity.

133. *General observations on Electro-Gilding.*—The advantages, connected with the electro-method of obtaining a gold surface, are not a few. It is accomplished by the use of no costly apparatus, and by means within the reach of ordinary skill. It is effected at the expence of very little time; and, when carefully performed, is equal to any produced by the most skilled artificer. The thickness of gold deposited may be accurately adjusted; and the operation may be stopped at any stage of the process. It places within the grasp of thousands the means of

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[*] *Vide Proceed.* Elec. Soc. Vol. i. p. 123. Sep. 21. 1841.

protecting with the most costly of all coverin
(though by this process its cost is reduced to a
fraction,)—any metallic object whose surface is
preserving. And in a moral point, we must not
that it will entirely supersede the process of
gilding;—a process effected by an amalgam of
and mercury; the fumes of the latter being a c
source of premature death to those who are expo
them.

134. I have not thought it requisite to enter
detail of gilding other articles, because the prin
are the same in all instances. If the rules laid
are attended to, the application may be made
case that offers. I should, however, recommen
use of the additional cell on many accounts.
as my own experiments on the deposition of metal
extended, I am convinced that it is the *neate*
surest, and the *least wasteful* mode of gildin
plating.

135. *General observations on Electro-Plat*
This process has been carried on to a considera
tent, in furnishing the market with plated
though the single cell has been employed. It
my purpose to dwell upon plating as thus ap
but to convey clear instructions on the princip
the mode of effecting it in a few cases, which
applicable to all. There are two cases in w
will be found serviceable in the fields of scienc
one for producing Daguerréotype plates; an
other for fabricating the improved Smee's ba
(§ 137. 142.) on each of which a few obser
will not be misplaced.

136. *Daguerréotype Plates.*—Being quite a
the art of deciding upon the generic and specif
ferences, which form the barriers between one
and another, I am utterly unprepared to say w
we should be guilty of an act of infringeme
using for this purpose copper, plated by either

two methods described: (§ 112. 126.) but of this I am well assured, that the art of electro-plating will be very available in preparing such plates; and that many, who have been prevented by the expense of the plates used, will experiment now upon plates of their own preparation. They may be prepared in two ways: either by plating a burnished and prepared (§ 96.) copper plate; or by depositing silver on a burnished plate with due precautions, (§ 98.) and afterwards backing up with copper. The latter is the most effectual; especially to those who are not skilled in the plans adopted by the artizan, for the treatment of burnished surfaces.

137. *The improvements in Smee's Battery.*—I have elsewhere said (§ 58.) that a battery has been devised, consisting of platinized silver and amalgamated zinc; I purpose to enlarge upon that description, and enable the electrotypist to employ his art in constructing generating arrangements of the most efficient character. When a voltaic pair is excited by an acid solution, the zinc combines with the oxygen, and, being converted into an oxide, is gradually consumed; the copper, however, or other element, does not combine with the hydrogen, but, as it is liberated, parts with it in the form of gas. But, when the surface is *smooth*, there is a strong tendency, between the particles of gas and the copper, to adhere; and hence the surface of the latter becomes partially covered with minute bubbles, which effectually contract the limit of electric action. The case is different when the surface of the copper is rendered *rough by the deposition of copper from an acid solution;* (§ 76.) then the bubbles of gas rise to the surface as fast as they are formed, and a great increase of action is the result; or, those which do not rise, are disposed of in a manner effectually withdrawing them from all interference with the action.

138. I have said, rendered rough by a deposition of *copper; I* mean not, however, copper in the metallic

form, but in that state of *oxide*, with which we are familiar in our unsuccessful electrotype experiments: (§ 63.) it may be obtained by charging the decomposition cell (§ 48.) with acid water, containing a small quantity of sulphate of copper.* The opinion of Professor De la Rive,† with respect to some portion of the liberated hydrogen, is, that it unites with the oxygen of the oxide, forming water, and depositing the metal. This is an illustration too of secondary results. (§ 122.) But as silver and platinum both stand higher in the scale of negative metals, being both, especially the latter, farther removed from zinc than copper is, their combination with zinc, to form voltaic pairs, produces a more efficient arrangement. The process of platinization is to deposite on platinum or silver, not a *bright metallic* surface of platinum, (this has been termed platinating), but a deposition of pulverulent platinum, a state not much dissimilar to that of the copper deposite just mentioned.

139. *Platinization.*—The deposition is easily effected. A small quantity of the bi-chloride of platinum is mixed with water, and the solution is decomposed by the use of a platinum terminal in connection with the *copper* of the battery, and the substance to be platinized in connection with the *zinc*. A few minutes' action will suffice. Platinum is sometimes platinized; but, for all practical purposes, silver is equally serviceable.

140. These batteries require no diaphragms, and, if the zinc is well amalgamated and the acid pure, (§ 144.) are important acquisitions to the electrotypist. The characteristic of their action is, that they throw off complete streams of hydrogen, the liberation of which is attended with a hissing noise. These streams of hydrogen escape *between* the two plates constituting the pair; and, while in one sense they form a partial screen between the two plates, they, on the other hand,

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* *Copper* thus treated may be termed cuprized.

† *Vide* Arch. de l'Electricité, vol. i. p. 269.

prevent the plates being approximated within certain limits. A very ingenious modification of this arrangement has been *devised*,* by substituting platinized *silver gauze* in place of the *plate of silver;* as, by this means, a facility will be afforded to the hydrogen of escaping through the apertures of the gauze, and making its escape at the *outer* side instead of *between* the two plates, the latter may be brought much closer together, without having the action intercepted by the presence of the liberated and escaping hydrogen.

141. I say such an arrangement has been *devised;* because, up to the date of the communication which announced it, it had not been actually reduced to practice, on account of the difficulty of procuring silver gauze; and it is for this reason that I have entered thus fully on the subject, in order to prepare the way for applying electro-plating to the production of a battery, eminently adapted to electrotype purposes.

142. *New Electrotype Battery.*—This may be in two senses termed an electro-type battery; whether it is regarded as an apparatus *fitted for*, or as one *produced by*, electrotype. It is constructed in the following manner:—Take a sheet of copper-gauze, of the *exact* size required, (for it must not be cut afterwards,) and affix to it permanently the binding screw or wire, which is to be employed afterwards in making connections. Place it then in a decomposition cell, containing sulphate of copper, and submit each side to the action of the battery, until a bright deposite of *pure copper* is thrown down, of sufficient thickness to coat all the wires, and to unite them permanently into one. Then remove and wash it. Place it by the fireside till it becomes well heated; after which, *plate* it, by connecting it with the battery and immersing it, for some minutes, in the cell containing the *cyanide* solution of silver: during this process, expose alternately each side

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* *Vide Proceed.* Elec. Soc. vol. i. p. 117.—Sept. 21, 1841.

to the more direct action, in order that the deposite may be effectually obtained on both sides. A piece of *copper* gauze, thus prepared, will be even better fitted for the desired purpose, than if it were of *silver* wire; for the deposition of copper on it, and then plating this deposite, will have advanced one great step towards altering the character of the surface; and producing one better fitted to throw off the hydrogen. (§ 137.) The operation will be completed, by platinizing according to the directions given above. (§ 139.)

143. Having thus obtained a negative element, some little attention must be paid to its mechanical adjustment, in order to facilitate still further the great end in view, viz. the *ready disengagement* of hydrogen,—and its disengagement on the *outside*, and not on the *inside* of the platinized element. In the illustration of the platinized battery, (§ 58.) the two metals are represented *parallel* and *perpendicular;* but in the present arrangement, they must be placed *parallel*, and may be *very near to each other*, but must *deviate* a few degrees *from the perpendicular;* and in such a direction, that the platinized gauze shall be, as it were, *uppermost*. The reason of this is obvious. For, as the gas finds its way to the surface in perpendicular lines, such a disposition of the arrangement will at once admit it to pass through the interstices of the gauze, and readily to escape by the desired channel,—the outside of the gauze. A still more powerful apparatus may be constructed, by employing a gauze on each side of the zinc.[*] In this case, the zinc must be perpendicular;

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[*] With respect to the relation in size of surface, between the elements in a generating pair, a few words will not be here misplaced:—The most accurate experiments lean to the opinion, that equal surfaces of each are most fitted to obtain a maximum of action. When a plate of silver is placed between two plates of zinc, as in the common arrangement of the platinized battery, there is exposed to *each* side of the silver a *similar* surface of zinc; when a plate of zinc, *as in the* arrangement above given, is placed between two sheets of *platinized gauze, each* side of the zinc is exposed to a similar surface

and the gauze not *exactly* parallel, but rather *closer* at the top than below.

144. *Purity of sulphuric acid.*—As the great object of writing this treatise is to facilitate, to simplify, and to perfect in the minds of those who read it, the whole process of this art, I should feel that I had executed my task but partially, were I to leave unnoticed a fact which has lately been pressed upon my attention,* one which is of great practical importance. The necessity of employing *pure* sulphuric acid; I mean, so far pure, as to be free from *nitric* acid. Very commonly a small portion of nitric acid is present, and this operates in a most destructive manner upon the zinc, defying all care and trouble in amalgamation: for it attacks some of the mercury and leaves portions of the zinc exposed, giving rise to an amount of local action to no trifling extent. This will explain the cause of amalgamation failing far more effectually, than the assumption of the impurity of the zinc. The latter is effectually concealed by the mercury; but the nitric acid undermines the other precautionary means, and militates most effectually against the permanent preservation of the zinc.

145. *Test for Nitric in Sulphuric Acid.*—The presence of nitric acid may be determined by the following simple and effectual test.—Apply heat to a Florence flask, containing sulphuric acid, with which has been mixed some sulphate of indigo; if the blue colour disappears, nitric acid is present; if it remains, the acid is good and fit for use.—Besides exciting the batteries with the pure acid, it is also requisite to employ the same in the process of amalgamation. (§ 41.) When these precautions are taken, the common rolled or cast zinc may be employed with impunity, and a *perfect* action will be obtained.

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of silver. The relative amount of surface in action being, in both cases, about equal.

* *Vide Proceed.* Elec. Soc. vol. i. p. 112.

146. *Other applications of Electro-Gilding.*—On the Continent this art has been rendered available in gilding the springs and works of chronometers; and one experimentalist M. Perrot, has "undertaken to gild at the same time, all the movements of a watch, to gild them, not only in their places, but while in motion."* M. Boettiger, to whom I have already (§ 97.) alluded, has employed for gilding the bichloride of gold, and has prepared copper surfaces, by first depositing upon them platinum. M. Hamman, an engraver of Geneva, has deposited a coat of *gold* instead of one of *varnish* on plates intended for ordinary etching, and has traced the design most accurately, through this exceedingly delicate layer. This opens to our view, in connection with electro-etching, another most important application of this extended and extending art.

Electro-gilding has been successfully applied in protecting and permanently fixing Daguerréotype pictures. It is well known that thin films of gold are transparent. A thin film is therefore deposited upon the surface of the finished plate, and effectually secures the picture from destruction; while it does not in the least hide it from the eye; or detract from its beauty.

IV. ELECTRO-ETCHING.

147. The results which have been hitherto treated upon, as proceeding from the right application of the laws of electro-chemical affinities, have been all obtained at the *negative* metal, or as it is termed the cathode; (§ 121.) but there is a class of results of no inconsiderable importance to be obtained at the other terminal, the *anode;* (§ 121.) and to the brief description of these, I purpose devoting a few paragraphs.

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* Arch. de l'Electricité, No. I. p. 276.

The plates of copper, in the decomposition cell, in connection with the copper of the battery, have been described as combining gradually with the oxygen released there, and being eventually consumed; so likewise the plates of silver or gold, which occupy the same relative position when they form anodes, combine with the cyanogen, and are in a similar manner consumed. But as the varnish, (§ 26.) placed on moulds, effectually shields the parts protected by it, from the effects of electrolytic action, so also may the copper plates be protected, and the *destructive* action localised at pleasure.

148. If, for instance, the plates of copper be covered on any part of their surface with a stratum of varnish, that part will be excluded from the line of action, while all else is being consumed. Advantage has been taken of this, by coating plates with proper composition, and then tracing through it any design, of which an etching is required. The plate in this condition is submitted to the action of the nascent oxygen; (§ 122.) and the surfaces are readily, and effectually etched. There is some superiority too possessed by this method, over the ordinary etching by the use of nitric acid; for the operation can be conducted with considerable regularity; it can be rendered a slow or a speedy process; and the result can be taken out, from time to time, to be examined; and can be re-submitted in a moment. In fact, of so much importance has this mode of etching been deemed, that it is already one amongst the many applications of this principle, for which a patent has been obtained. (§ 164.)

149. To the amateur of science, it offers a channel in which to exercise his industry;—a little care and practice will readily enable him, especially if he possess the power of delineation, to produce sketches engraved thus by electricity. To those who have skill enough to delineate more accurately, and to trace through the delicate surface of gold mentioned above,

(§ 146.) a means is furnished of producing plates
very superior character; and I doubt not that r
who are lovers of the fine arts, will delight to ex
their genius in this novel and highly interesting
of engraving. A copper plate is to be well varn
on the back, and then submitted to the action c
cyanide of gold. (§ 126.) When a perfect coat
obtained, the plate is removed; and the desi
etched through the *gold film*, as in other cases
through the *varnish*. The plate is then submit
the action of the battery, as the *anode* in a soluti
sulphate of copper; and as the oxygen, released
combines with the *copper*, but not with the *gold*, (§
the design is permanently etched. This process i
speedily effected; and must, therefore, be very
fully attended to, lest, by proceeding too far, the
be spoiled. It is also necessary to oppose to the
another of equal size, and parallel to it.

150. *Electro-etching Daguerréotype Plates.*
the description last given, the *artist's* hand mus
trace the design, before the electric force will en
for him; but Mr. Grove has described a process
which the pencil of nature does *all* the work. H
taken Daguerréotype plates,—those beautiful pr
tions "drawn by light," and, having submitted
to the still further operation of Nature's laws, ha
ceeded in "engraving by electricity." (§ 83.)

151. Though this process has not been perfect
far as to produce plates fitted in *all* respects fo
printer, yet, as it is one most important applicat
the subject on which we treat, and as it furn
though not for the *printer*, yet for the *electrot*
plates from which *he* can obtain *perfect* impres
and these to any extent, it claims especial noti
this treatise.

152. *Nature of Daguerréotype Pictures.*—The

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* *Vide Proceed.* Elec. Soc., vol. i. p. 94. Aug. 17, 18

portions of these pictures are considered to be *silver*, and the light portions *mercury*; and hence, if they are placed as *anodes* in a solution, whose liberated element shall act as *one* of these metals, and not on the *other*, (as the oxygen in the last experiment, (§ 151.) which combines with the *copper*, and leaves the *gold* untouched;) or if they are submitted to a solution, the *anion** of which combines *more* with one than the other, the result will be an etching.

153. The point of first importance is *the nature of the solution* to be placed in the decomposition cell. And for this purpose hydrochloric acid, diluted with half its bulk of water, is to be employed. Then attention must be paid to the nature of the plate connected with the zinc of the battery, viz., the *cathode*, where hydrogen or metal is released, according to the nature of the solution. From hydrochloric acid hydrogen is released; and the great object is to dispose of it regularly, and as speedily as may be; for, if any hydrogen adheres to the surface of this plate, the surface of the plate to be etched, where it is *opposed* to this, will furnish an irregular result. The best plates for parting with the nascent hydrogen, are platinized silver, or platinum. Then the distance between the two plates, (which are, of course, placed parallel,) must be determined. The fifth of an inch is *near enough* to ensure uniformity of action, and *not so near* as to allow the escaping hydrogen to reach the anode, and interfere with the result.

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* The word *anion* signifies the element developed at the anode (§ 121.) I never felt more forcibly the value of Dr. Faraday's electro-chemical nomenclature, than in writing this treatise. I have endeavoured as much as possible to avoid scientific phraseology, and have done so at the expense often of no little circumlocution. When I have deviated from this course, I have explained the term employed; and as the term *anode* has now been so often introduced, my readers will readily understand that whatever is liberated there (as, for instance, *oxygen*) is an *anion*. The elements determined to *the cathode* are *cathions*; of these, hydrogen ranks first.

154. In a process so delicate as that of etching out the microscopic delineations on these plates, due regard must be paid to the relation between the size of generating pairs and the size of electrodes, or plates, by means of which the power generated enters into, and leaves a solution. Now, the *general* effect of an electrolyte or solution undergoing decomposition is to *retard* the electric action; and *à fortiori*, when the electrodes are *smaller* than the generating pair, the action is *further* retarded. This fact has been often exemplified in the employment of small anodes and fine wires. (§ 116.) The simplest, therefore, and the most rational mode is to have the generating pair and the decomposing pair of *one size*, or nearly so; and, as the solution employed will give up its elements with a feeble current, one generating cell is enough. Prof. Grove used a single pair of the *nitric acid battery;* but any other will produce the desired result. The *time* of action depends on the nature of the generating cell employed. With the nitric acid battery, (the energy of the action of which is great,) the effect was produced in from 25 to 30 seconds. With other arrangements it will be longer; and, possibly, as it is accomplished more slowly, the result will be more definite; and the experiment will be less liable to fail.

155. Having determined these several points, and shown the reasons on which they are based, (and I always wish to furnish *reasons* for all that is done: for when a man acts by mere directions, and arrives at ends he knows not *why*, I am well assured that his interest in the subject will soon be dissipated, and his path, instead of being pleasing and bright, will be dull and gloomy;) the next arrangement is to prepare a wooden frame with grooves, into which the two plates, viz. the Daguerréotype* and the platinized plate can slide, so as to remain firmly fixed in the required

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* *This plate* must be well varnished on its back and edges.

position. This frame is then immersed in the solution, (§ 153.) and contact is made with the generating cell by touching with the ends of the connecting wires, the edges* of the plates; and retaining them in contact for the given time. "The plate is then removed, and well rinsed in distilled water, and if the silver be homogeneous,†" will "present a beautiful sienna-coloured drawing of the original design, produced by a film of the oxychloride‡ formed; it is now placed in an open dish, containing a very weak solution of ammonia, and the surface gently rubbed with very soft cotton, until all the deposite is dissolved; as soon as this is effected, it should be instantly removed, and plunged into distilled water, and carefully dried. The process is now complete, and a perfect etching of the original design will be observed; this, when printed from, gives a *positive* picture, or one which has its lights and shadows as in nature; and which is in this respect, more correct than the original Daguerréotype, as the sides are not inverted: printing can therefore be *directly* read; and in portraits thus taken, the right and left sides of the face are in their proper position."

156. "There is, however, *ex necessitate rei*, this difficulty with respect to *engravings* from Daguerréotypes; if the plates be etched to a depth sufficient to produce a good impression, some of the finer lines of the original must inevitably run into each other; and

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* A small portion of varnish is removed from the Daguerréotype for this purpose.

† "It is very necessary that the silver of plates subjected to this process be homogeneous. Striæ, imperceptible in the original Daguerréotype, are instantly brought out by the nascent anion; probably silver, formed by Voltaic precipitation, would be found the most advantageous."—PROF. GROVE. This extract, illustrated as it was by the condition of the prints from some of the etched plates, indicates that the application of electro-plating, before described, (§ 136,) will eventually be found of some service.

‡ *Oxygen from* the water, and chlorine from the acid, are released *at the anode.*

thus the chief beauty of these exquisite images be destroyed. If, on the other hand, the process be only continued long enough to leave an exact etching of the original design, which *can* be done to the minutest perfection, the very cleaning of the plate by the printer destroys its beauty; and the molecules of the printer's ink being larger than the depth of the etchings, a very imperfect impression is produced."*

157. But though these mechanical difficulties exist with respect to *printing* from an etched plate, yet "for all that" the etching is *perfect*. The action of the anions has produced perhaps the most delicate piece of workmanship ever seen; and though many practical difficulties will ever exist against successfully printing from such plates, yet the electrotypist possesses the means of multiplying the most faithfully and elaborately executed among them, with undeviating certainty; and of obtaining in metal as many perfect copies of the original as he may think fit to take. "To give an idea of the perfect accuracy of these, I may mention that in one I have taken," writes Mr. Grove, "on which is a sign-board, measuring, on the electrotype plate $\frac{1}{10}$th by $\frac{6}{100}$ths of an inch, *five* lines of inscription can, with a microscope, be distinctly read."

158. I may conceive, therefore, that among those into whose hands these pages may fall, are some, who are interested in M. Daguerre's invention, and that possibly many possess specimens of those beautiful productions. By them especially will this discovery be admired, which furnishes a means of multiplying readily these treasures of ART, I was about to say; and possibly *art* is the fittest designation to give to this process which has arisen at the magic touch of science. It is true no living *artist* can produce pencillings so true and faithful, but science has called into action the finger of nature, who is ever faithful

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* Vide Proceed. Elect. Soc. vol. i. p. 98.

and ever true; and has inscribed upon her productions, not the words "drawn by Landseer, and engraved by Cousins," but "drawn by Light, and engraved by Electricity."*

159. There is one class of Daguerréotype pictures, in which every circle feels an especial interest, I allude to portraits; these are now obtained, with singular truth. They may be very easily submitted to the action of the battery; and from the etched plate copies can be obtained.

V. APPLICATIONS OF ELECTROTYPE.

160. In conclusion, I purpose giving a brief review of the branches of art in which electrotype has been profitably employed. I say *profitably;* because, it is fair to assume, that a patent is based upon the principle of *cui bono;* and that all who avail themselves of its protection, anticipate a *quid pro quo.* In reviewing the patents taken out, (and there are not a few,) I have felt some degree of difficulty in tracing the features by which the right of one is distinct from the right of another; (§ 136.) and have almost doubted whether the patents are not based rather upon the nature of the *moulds*, than of the *power* employed. To one is allowed the peculiar privilege of making a wax model of a *stew-pan*, and despositing copper upon this; (§ 168.) to another, the peculiar right of making the model of a *seal* by uniting some *printer's type*, and depositing copper upon this. (§ 167.) I shall best succeed in conveying an idea of the extent to which this art has been patented, by extracting from the several specifications the general summaries on which the claims are based. I shall thus furnish my readers with a mass of general information on the subject, and

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* Vide Prof. Grove's paper on this subject.

enable them to know how far they may tread without infringing the rights and claims of others. And I doubt not they will be somewhat surprised, when they find how the *principle* of electro-chemical decomposition,—for it is but a general *principle*,—has been seized upon and appropriated.

161. One has accomplished certain "improvements which have for their object the coating or covering manufactured articles composed of wrought or cast iron, lead and copper and its alloys, with copper or nickel; such coating being effected by means of galvanic electricity." Nor does he "confine himself to any particular arrangement of apparatus, but claims the mode of treating manufactured articles, of the metal and alloys above stated, so as to obtain a permanent coating or covering of copper or nickel."

162. With respect to plating, patentees claim "the use of a solution* of silver, in prussiate of potash,† or other analogous salt, or in pure ammonia, in combination with a galvanic current;" and "the use of a solution of silver in acid, so as to constitute a neutral salt, in connection with a galvanic current; the articles in this (the latter) case having been previously coated with silver." Under the head of gilding is claimed, "the use of a solution, for the purpose of gilding, formed of oxide of gold, dissolved in prussiate of potash or soda or any other analagous salt, and combining the action of a galvanic current with the use of a salt of gold as above, preferring the solution of gold formed by dissolving the oxide of gold in prussiate of potash; and, further, the patentees claim, with reference to the two last heads of their invention, the application of a galvanic current, in combination with solutions of gold or silver for coating or plating with gold or silver,

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* It is stated "that it will be found necessary *to add from time to time, a fresh supply of the* oxide to the solution, in order *that it may be kept saturated with that* salt."

† *Cyanide of* potassium.

whether the articles to be so coated are formed entirely of metal or only partly so."

163. The same parties prepare surfaces of iron to receive a coating of copper or other metal, by connecting them with a piece of zinc and placing them in acid, so as to form a voltaic pair; "after a short time, the scales and dirt will fall from the iron, leaving its surface perfectly clean and bright;" and fit to receive a coating of copper, and then one of silver or gold.

164. The right is claimed of etching on *iron or steel* by the electrolysis of a solution of common salt, and an iron or steel cathode (§ 121); on *silver* by a solution of sulphate of soda or sulphate of silver and a silver cathode: on *gold*, with hydrochloric acid, and a gold cathode; on *copper*, sulphate of copper and a copper cathode; nor do the patentees limit their claim to the metals named, but "claim the use or application of voltaic electricity for engraving on metals generally; and hence, I presume, within this COMPREHENSIVE clause is included the etching of Daguerréotype plates; although the latter process was not discovered until months *after* the patent was enrolled.

165. The notice from which I abstract this last application of the art still further convinces me of the value of Dr. Faraday's nomenclature; (§ 121.) the want of some such definite terms is continually producing confusion. For instance, the plates to be etched are directed "to be immersed in a solution" "and connected to the *negative* POLE of a voltaic battery." The fact is, they must be connected with the *positive* POLE, viz. the *copper*. This is the *negative* METAL of the battery, viz. the metal *toward* which the electricity comes from the zinc; but it is the *positive* END, or POLE, if that term must be used, of the battery, viz., the end *from* which the electricity passes, in its progress *toward* the decomposition cell. (vide §7, 8, & 9.) I suppose the steel and gold and silver plates for *cathodes* are not deemed as being included within the

range of the patent; for at these only metal or hydrogen is released, neither of which affect, or are affected by the nature of the plates on which they are developed.

166. Another application of the art is to form rollers of copper for printing or embossing calicos, &c., by making a model of a roller, and, after rendering it a conductor by any of the ordinary means, (§ 32.) depositing copper upon it;* also for thickening old cylinders, rollers, &c., for the same purpose; and for filling up portions of patterns that are to be obliterated.

167. Other applications of this process are described: "1st, in the production of a printing, embossing, or impressing metallic cylinder, plate, or block, having a device or pattern formed thereon, suitable for the above purposes; such device or pattern constituting *one perfect* or *connected* design, produced from an originally engraved or otherwise executed *portion* of the said design; 2nd, in a mode of *joining* together engraved or otherwise executed metallic plates, so as to form *one connected* surface; 3rd, in obtaining an *extended* plain surface to an engraved metallic plate, whereon a continuation of or an addition to the subject already formed may be engraved; 4th, in certain modes of producing *suitable* surfaces, as aforesaid, such modes not requiring the ordinary original process of engraving;† 5th, in a mode of producing surfaces, as aforesaid, such surfaces being suitable for printing, or printing or embossing in various colours;‡ 6th, in

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* This is merely a variation in the *form* of the mould. (§ 160.)

† A flat metal surface is covered with varnish; the design is traced by removing the varnish; the whole is then covered with plumbago, (§ 32.) or rendered conductible by other means; and is placed as a mould (§ 105.) or cathode in connection with the battery; or a lithographic stone is prepared and treated in a similar manner; or the design is punched in sheet-lead, and this is united to *other metal*, and then deposited upon.

‡ *Two or more* moulds, according to the number of colours, are *obtained* from the *same* original; and from each is removed those

the application and use of dies, formed by the agency of voltaic electricity, for the purpose of embossing or impressing horn, hoof, or tortoise-shell, in the manufacture of buttons; 7th, in the mode of mounting or attaching seals, book-binders' tools, or *other such* instruments used for impressing, such instruments or tools being produced by the agency aforesaid; and lastly, in a mode of producing seals,* for impressing on wax or other such substances."

168. The object of another "*invention* is to produce pipes, boilers, stew-pans, or other vessels of copper, through the agency of Voltaic Electricity;" by depositing copper on moulds of "clay, wax, plaister, or other like substances; or of lead or other metal, fusible at a lower temperature than copper." "Another part of the invention relates to the joining together of several pieces, so as to form vessels; and by which means stop-cocks, or other such parts, may be added to boilers, &c., formed by the above process."

169. With this necessarily brief abstract, I will conclude the present treatise. I have not space to make any lengthened comments upon the extensive applications of electrotype just detailed; I leave my readers to think for themselves, and from the several channels into which it has already flowed, to conceive the thousand others yet unopened. I can fancy that scarcely one will read this treatise with attention, and reflect on the uses to which the art *has been* applied, without figuring to himself many others to which it *may be* applied. The science on which the whole of what we have treated is based, reminds one of that little cloud, dimly seen at first in the distance, no bigger than a man's hand, which gradually developes itself, until it enfolds within its spacious mantle the whole of the visible face of nature. Every day is

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portions which are *not* to be printed by the colour to which it will be confined.

* *Vide § 160.*

bringing fresh evidence of the vast extent of the operations of electric agency; although each fresh acquisition of knowledge only teaches us how *little* we really *know*. Scarcely do we elucidate one series of problems, than another, and another, and another, presents itself to our earnest gaze; and we are compelled, in summing up the results of even our most successful labours, to confess with the great philosopher, that we are like children on the sea-shore, who pick up occasionally one pebble of better value than the rest.

CHARLES V. WALKER.

Kennington, Oct. 15*th*, 1841.

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