Lecture on electro-metallurgy : delivered before the Bank of England Library and Literary Association, November 25th, 1851 / by Alfred Smee.

LECTURE

ON

ELECTRO-METALLURGY;

DELIVERED BEFORE

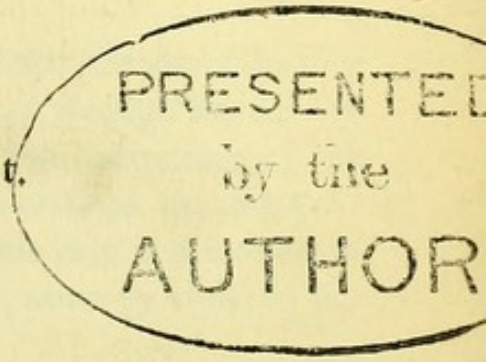
THE BANK OF ENGLAND LIBRARY AND LITERARY ASSOCIATION,

NOVEMBER 25TH, 1851.

BY ALFRED SMEE, F.R.S.,

SURGEON TO THE BANK OF ENGLAND,

&c.



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LECTURE ON ELECTRO-METALLURGY.

Mr. President, Ladies, and Gentlemen,—

My first duty this evening, is to return you my sincere thanks for the honour which you have conferred upon me, in having elected me an honorary member of the Bank of England Library and Literary Association. I cannot attribute this mark of consideration to any merit on my part, but believe that it is owing to kindly feelings, which have sprung up in our intercourse together. At all times it will afford me great pleasure to assist in any way the operations of the Association, and you may rely upon my cordial cooperation to the fullest extent which may lie in my power. On this evening the subject of the lecture will be the illustration of my little work on Electro-Metallurgy, which was written within these walls, and which was based upon experiments performed whilst I was residing within the Bank of England.

Meaning of Electro-Metallurgy. — The term electro-metallurgy was selected as indicating in the most complete manner the subject of the work, as it literally denotes, "The working of metals by the electric power."

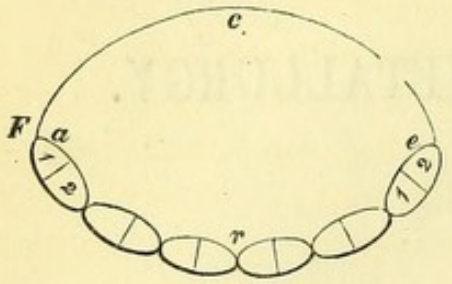
The Nature of the Process.—From the earliest periods of history men have been able to work in metals, by fusing them through the agency of heat; but it has been left to the present age to take advantage of the power of electricity. In all electro-metallurgic operations the metal is combined with other materials to form a salt. This salt is dissolved in water, and from this solution the metal is deposited, atom by atom, in the desired form.

Reduction from a Voltaic Circuit.—Whenever this deposition is effected from a metallic solution, the phenomena which are manifested take the character of a voltaic circuit, and are obedient to the laws of voltaic electricity.

Theory of a Voltaic Circuit. — A voltaic circuit is a circle, in which a compound body, formed of two elements, is being decomposed one element being abstracted by a substance bearing a strong affinity for it, and the second being evolved at another point, separated from the first

by a layer of the compound, the points of abstraction and evolution bein connected together by any conductin media. Thus in this diagram F marks th point of affinity by which the positiv pole takes one element of the electrolyt or water, *e* the point of evolution of th hydrogen or second element, *r* the cor necting particles of water, and *c*, the cor ducting wires between the point of evolutio and point of abstraction.

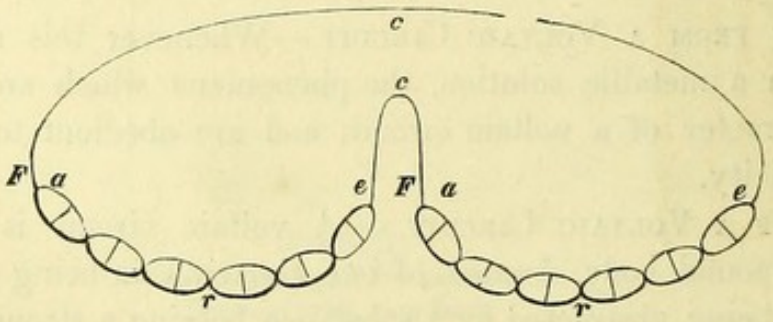
Fig. 1.



In arranging a voltaic circuit I would beg you always to think of thes several points, for all the phenomena of the circuit which has conferre upon man such wondrous powers depend upon the power which it afford us of extending the distance between the abstraction of one element of compound and the evolution of the second. I must stop one minute t show you an experiment of the effect of potassium on water, which, a many of you, doubtless, know, has the power of decomposing that fluid The energy of decomposition is so great that the hydrogen takes fire the metal moves about with disquietude, and nevertheless, notwithstandin this powerful exercise of affinity, no voltaic circuit is formed, because w have afforded no second point for the evolution of the second element In the present lecture time will not permit me to detail the various condi tions under which the voltaic circuit is determined by the exercise of th affinity; sometimes heat determines it, and then we have Thermo-voltai circuits, at others light is the exciting cause, and then we have Photo voltaic circuits. Again, electricity may be the cause, and then we hav Electro-voltaic circuits. Animal and vegetable substances may be th exciting body of a voltaic circuit, and almost all metals may be used as positive pole, though, practically, zinc is the metal which is almost exclu sively employed.

Compound Voltaic Battery.—By a curious arrangement we may have two points of affinity in a circuit, when we may add to our power

Fig. 2.



as you will readily see by the subjoined diagram. In this case we

have two affinities, two electrolytes, and by varying the degrees of affinity in the different cases we are enabled to augment or diminish our voltaic force.

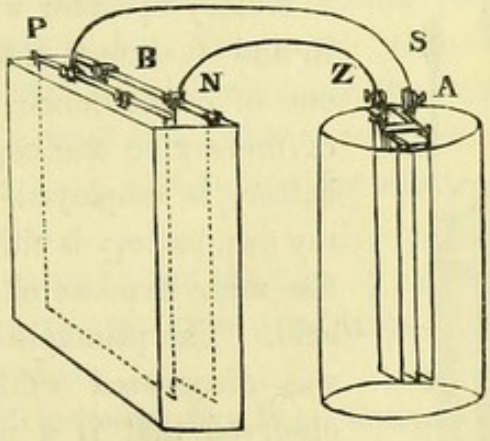
As my business this evening is to illustrate my assertions, I must show you how we prolong the distance between the abstraction of one element and the evolution of the second. I have here a series of batteries. To one end of these is attached a wire, which passes into the court-yard below, where there is a small break, connected by a thin layer of sulphuret of copper; the wire then returns to the room, and the moment the connection is made you hear a loud report from an explosion, which shows to you that electricity has passed; that the communicating portion of the circuit has been prolonged, and that the effects of the affinities in the batteries were exhibited in the court-yard below. It is upon the fact of this prolongation we are enabled to use the electric telegraphs, as we can surround the globe with our wires, and obtain the results instantaneously. The particular fusee which has been employed in these experiments is Brunton's fusee. That gentleman discovered that a spark would pass through sulphuret of copper with such readiness, that it might be conveniently employed instead of the platina wire used in the operations on the "Royal George," and in the blastings in the "River Thames," of which you have, doubtless, so frequently read accounts. Brunton's fusee requires a high series of batteries, but can be used with very thin wires at almost unlimited distances; and lately the newspapers have been filled with accounts of cannons fired through distances of sixty miles with the submarine telegraph.

Electro-Metallurgic Apparatus.—There are two general plans by which electro-metallurgic operations are conducted, the Single Cell, and the Battery apparatus.

Single Cell Apparatus.—The single cell apparatus has the point of affinity, or zinc, placed in a tube or cell formed of porous earthenware,

Fig. 3.

Fig. 4.



bladder, brown paper, or some such substance, fig. 3. This is filled with dilute acid, or some neutral salt; on the outer side of this a solution of some

convenient metallic salt, from which the reduction may be made, is placed and I here show a copper plate, formed by Mr. Barclay, which required seventy-seven pounds of crystals of sulphate of copper, in its formation.

Battery Apparatus.—In an early part of my experiments in electro-metallurgy, I saw great reason for separating the source of power from the vessel in which we reduce the metals, and recommended, for all practical operations, that we should use a voltaic battery, in which the power is generated, and a decomposition trough, in which we conduct several operations,—as in it we make our metallic salt at the positive pole, and reduce the metal at the negative. In our decomposition trough we place a positive pole of the metal on which we are operating, and which is dissolved in the process of formation of the salt, fig. 4.

As varieties of the battery process, we have the compound battery apparatus, where several cells of the battery are used; the compound trough process, in which several cells are connected with one battery, Fig. 5; and

Fig. 5.

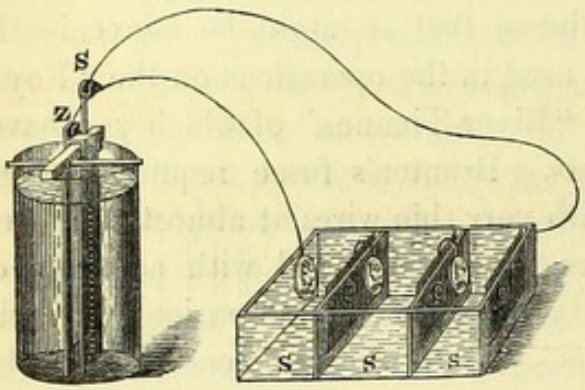
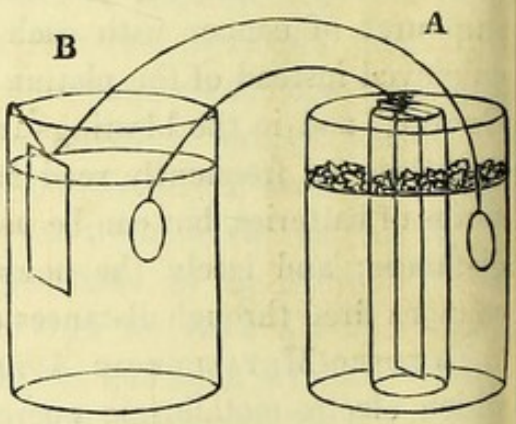
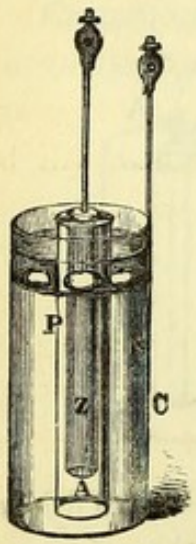


Fig. 6.



a union of the single-cell and battery process, where the power evolved in effecting an operation, is used to form a second deposit, fig. 6.

Fig. 7.



Sources of Power.—With regard to our choice of an instrument for the production of power, he really must be a clumsy operator who obtains a power and cannot apply it, and therefore, the question resolves itself simply into one of convenience and economy. Sometimes a battery of mere zinc and copper is used; at other times, Daniell's battery is employed, fig. 7. In most cases of heavy work my own battery is employed, as by it we obtain a power, with the mere expense of the waste of zinc in dilute sulphuric acid. The principle upon which this battery was founded was discovered whilst living within this building, as I observed that if a piece of smooth platinum, like this which I hold up, was placed in dilute sulphuric acid, and touched with a piece of zinc, the hydrogen separated

at its surface, adhered to the metal, and thus the heaviest substance in nature becomes lighter than water, and you see that it now rises to the top.

When a piece of spongy platinum, on the contrary, is touched with a piece of zinc, in the same dilute acid, the gas is instantly evolved in the remarkable manner which I now show you.

On first observing this experiment, I had but little doubt that a new principle was before me, and I instantly procured salts of palladium, iridium, and other metals, and I found that in all cases, not only did this finely divided metal favour the evolution of the gas, but that mere mechanical scratching was attended with somewhat similar results. Since that period my form of battery, made of either platinized silver, or platinized plated copper, has been most extensively employed, and many of the interesting objects which surround us, have been made by its operation.

Fig. 8.

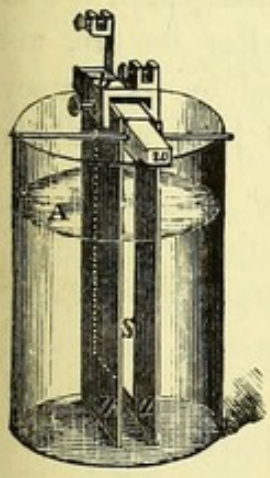
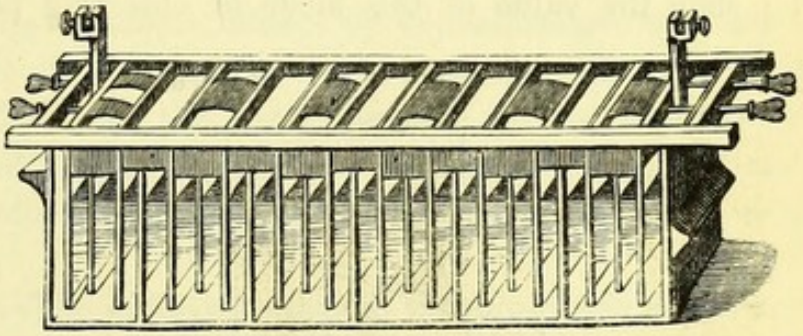


Fig. 9.



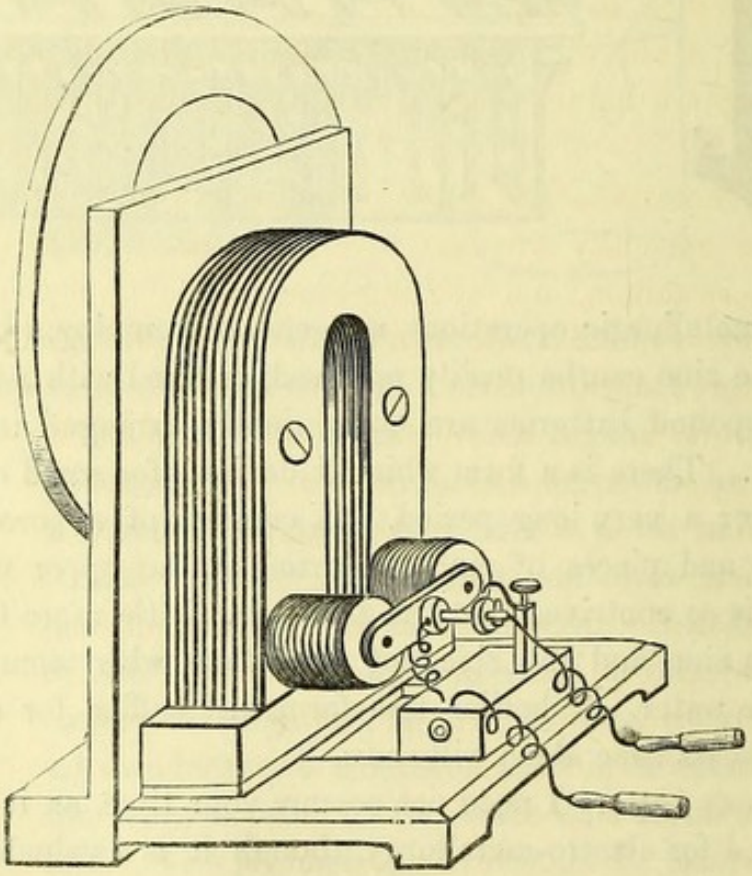
In electro-metallurgic operations, we generally employ a battery so contrived that the zinc can be readily removed, or fixed with a binding-screw, fig. 8. Compound batteries are conveniently arranged in many-celled troughs, fig. 9. There is a form which I devised for small currents, to be eliminated over a very long period. It consists of a porous pot with a little mercury and pieces of zinc supported at the upper part of a glass vessel, and it is so contrived that the acid is but little more than necessary to dissolve the zinc, and the zinc not more than, when combined, will be soluble in the water. Whether this form will suffice for electro-metallurgic experiments time alone will show.

With Groves's battery I need not occupy your time, as it is seldom or never employed for electro-metallurgy, though it is a valuable instrument, and well adapted for some other purposes.

Within the last few years, the electric power has been derived from an entirely different source, as it has been discovered that a spark could be drawn from a natural or artificial magnet. When I was a student, this

phenomenon was a mere philosopher's spark, but now it has been brought to practical account, and some of these exquisite candelabra have been silvered by Messrs. Elkington, through the agency of this power. Last summer, by the kindness of Mr. Lucy, the Mayor of Birmingham, I was one of an exhibition party who had an opportunity of witnessing the manufacturing triumphs of that great town. At Messrs. Elkington's we then saw a large magneto-electric machine, worked by a steam-engine, and which was computed to reduce fifty ounces of silver per day. You thus see that no one should ever despise a philosopher's spark, for it is impossible to foretell to what important conclusions it may lead. Mr. Henley, who makes the best magnets in England, and perhaps in the world, has contributed his beautiful Exhibition magnetic machine, to assist to exemplify the lecture, and when the armature is revolved before the magnet, a current of electricity is set free, which will freely reduce silver. As in this direction science is now progressing to benefit the manufacturer, I trust you will carefully examine that splendid instrument after lecture, and witness the decomposing powers which may be produced by its agency. To show the value of this mode of obtaining power, I have asked Mr.

Fig. 10.



Henley to send down a specimen of his magneto-electric telegraph, where the power from the magnet supersedes the necessity of employing a battery. In my judgment this telegraph, or some variety of it, will

entirely supersede every other form of electric telegraph now in use, and time will test the truth of my prophecy. The power obtained from the electro-magnet, although ample for the reduction of silver and gold, is not at present sufficient for the economical reduction of copper.

ELECTRO-METALLURGIC APPARATUS.—We must conduct our operations in certain vessels, and the choice of these is somewhat important. We find practically, that glass exceeds every other known material for chemical operations, and chemists owe a great deal to Sir Robert Peel, for having taken off the duty from glass, and enabled them to obtain glass vessels at so much cheaper a rate than at former periods. Next to glass, gutta percha has been found to resist the action of many chemicals, and for these purposes it is not only cheap, but exceedingly valuable. Troughs for batteries and metallic solutions are now extensively formed of gutta percha, and are found to answer their purpose most admirably. Many specimens are on the table for your inspection, which have been kindly lent to me by the Gutta Percha Company. Stone-ware, notwithstanding the apparent closeness of its texture, allows a certain quantity of the solution to penetrate into its substance, which, by crystallization, ultimately disintegrates it, and in this way some large stone-ware vessels, used in the manufacture of ink, in this establishment, are now destroyed. Wooden vessels, lined with cement or marine glue, are occasionally employed, but they are hardly as good as glass, gutta percha, or stone-ware vessels.

METALLIC DEPOSITS.—The different states in which metallic deposition occurs, I have generally grouped into three great divisions:—the pulverulent, the crystalline, and the reguline states. As a sample of the first state, I show you the finely divided platinum, as used in the construction of my battery; and the particles of the metal in this case are so small, that no microscope has yet revealed to us their form and appearance. We have the spongy states, consisting, in many instances, of the most beautiful interlacement of crystals. In the highest perfection of the reguline deposit, the particles of metal are aggregated together so that it is difficult to distinguish the deposit from metal manufactured in the ordinary manner, and which will bear rolling, hammering, or any other ordinary process. Lastly, we have numerous varieties of crystalline deposits, in which the particles of metal are aggregated together in crystalline masses, which, not thoroughly adhering together, always give more or less brittleness to its texture. Formerly, the deposits seemed to take place without apparent cause, but by watching the process most carefully, I found that the nature of the deposit depended upon the quantity of electricity passing in relation to the strength of the metallic solution. As a general rule, the black deposit occurs when hydrogen is freely evolved from the negative

pole; the reguline state when the deposition is so rapid that it exhausts the metallic solution as fast as it diffuses; and lastly, the crystalline, which occurs whenever the solution is very strong, in relation to the quantity of electricity passing.

Strength of Metallic Solution.—It is thus apparent that the proper maintenance of the strength of the metallic solution is a circumstance that requires our utmost vigilance. At one time it was thought, that when the positive pole was dissolved, and a metallic salt was there formed, that it would be thrust across to the negative pole by the voltaic force, but subsequent experience has shown that this view is not accurate. Then we have a law of diffusion, which Professor Graham has revealed to us, but that property even will not suffice for the manufacturer.

I must show you a very beautiful experiment which I discovered some years ago, and which demonstrates a principle worthy of our observation. When we take a red-hot cinder out of the fire, and quench it in dilute sulphuric acid, and afterwards bring it into contact with amalgamated zinc, hydrogen should be evolved; but, to my astonishment, none appeared for some time. I immediately conjectured that the hydrogen was kept in a state of adhesion; and my thought was confirmed, for, on placing the cinder in sulphate of copper, the metal was immediately reduced. The hydrogen will remain in this state for some time, and you will see that these cinders prepared this morning now show the phenomenon, as metallic copper is instantly thrown down. Without showing you all the varieties of this experiment, I may state at once that the theory which, in reality, is that originally propounded by Hisinger and Berzelius, which must guide our operations, is, that the metal is reduced by the hydrogen from the metallic solution at the negative pole, and the metallic salt is formed at the positive pole. The water containing the salt is heavier than the exhausted solution, so that the one rises and the other falls, and thus, by taking advantage of the power of gravitation, we can obtain the diffusion which is so urgently required. As a beautiful example of the application of these principles, I now show you two tall jars of solution of sulphate of copper, in one of which the positive pole is placed at the top; whilst in the second, the negative is placed in the same situation. When the positive pole is arranged at the upper part of the vessel, our manufactory of metallic salt is in the right place, and the salt falls to the bottom. When it is placed at the bottom, the salt does not diffuse, and ultimately, the pole becomes covered with crystals, and spongy copper is thrown down on the negative plate. At the Ordnance Map Office, Southampton, the diffusion is sustained by a pretty process: the negative pole is placed uppermost, and the equal diffusion of the fluid is maintained by an occasional jerk, given to the apparatus by a steam-engine. This

plan answers for the multiplication of those important national maps in the most satisfactory manner.

Rapid Deposition.—By proceeding in the above principles we may obtain very rapid deposition of several metals. Last spring some experiments were peformed for the proprietors of the "Illustrated London News' by Messrs. Horne and Thornthwaite under my superintendence, to ascertain how rapidly copper could be thrown down. Having a mould from a woodcut, we placed it in a solution, and it was covered with copper, obtaining a rapid deposit by two batteries arranged in series. It was then transferred to another vessel with a solution of sulphate of copper, containing dilute sulphuric acid and a little trace of nitric acid, and a series of copper plates well arranged about half an inch apart over it. In this way we ascertained that in about six hours it would be possible to form an electro duplicate. Those who are acquainted with metallurgic operations will at once perceive that this was an operation exceeding in rapidity anything which had heretofore been attempted. I have also lately tried a venetian blind positive pole, the plates being arranged at an angle of 45°, to throw off the heavy solution directly upon the negative pole. It appeared to be a valuable contrivance, but the excitement and bustle of the great Exhibition has totally stopped progress for this year, and we have not had sufficient experience to speak with that confidence which could be desired.

Reduction of Alloys.—We might easily imagine that, as no great difficulty occurs in the reduction of one metal, that the deposition of two or more at once might be similarly easily effected. The contrary, however, is the fact, for it is found that if a voltaic circuit has the choice of two or more roads it will take that course which opposes least resistance. I have here arranged a small platinized silver voltaic battery and decomposition trough. The silver is connected with a positive pole of copper, whilst to the zinc of the battery I have three platinum poles, two plain and one platinized, ready to be connected at a minute's notice. One I shall place in the porous cell which is filled with nitric acid, the second in a cell containing sulphate of copper, and the platinized pole in a third cell containing dilute sulphuric acid. Now the circuit will pass through the nitric acid exclusively, but if that pole be removed, then it will pass through the sulphate of copper, and when that is taken away the circuit will be completed by the platinized silver. In my work on Electro-Metallurgy I have given a table of the order of facility of passage, as far as I have determined it, and you must readily perceive that I have, by this knowledge, obtained a power of analysis which may prove to the chemist of the utmost value. You have seen the success of my experiment, and when I tell you that I have not rehearsed this delicate experiment before lecture, and that I have not repeated it for some years, I need hardly dwell upon

the extreme importance of understanding the principles of any operation; for when once we obtain the knowledge of a law of any of nature's operations, then we know that uniformity of action, will be maintained, and if our law is a true expression of the facts it will never be found wanting when we seek to apply it to any definite instance. This experiment shows how we are to reduce alloys, because we should have the various solutions of the metals sought to be deposited equally easy of decomposition. I will at once tell you that I have not reduced alloys, but Captain Ibbetson, to whom I am indebted for many very beautiful illustrations on the table, assures me that he has thrown down metals in equivalent proportions.

Regulation of the Quantity of Electricity.—As I have now described how we are to manage to maintain the strength of the metallic solution, it remains for us to consider how we should regulate the electrical power which acts upon it. The quantity of electricity passing will depend upon the strength of the battery, the state of its exciting fluid, the size of the plates of the battery, and the conducting power of the wire with which the battery is connected with the trough. By all these means the quantity of electricity may be regulated. In the trough itself the passage of electricity will depend upon the size of the positive pole, the care with which the newly made salt is dissolved, the power of conduction of the fluid, the distance between the positive and negative plates, the affinity of the positive pole for the oxygen of the water, and the facility with which the decomposition of the metallic salt can be effected. In all cases it is desirable that too low a temperature be not maintained, and for most practical purposes I think that a heat of between 60° and 100° Fahr. is to be preferred.

Moulds and Negative Pole.—It appears almost unnecessary to enlarge upon the importance of considering upon what substance the deposit of metal may be effected. Substances applied for these purposes are of two kinds, conductors and non-conductors. All the metals are conductors, and any metal may be used for the reduction of any solution, provided it does not decompose spontaneously that solution. This is a rule so easy of trial in any particular case, that it will be unnecessary very fully to consider this subject. As to metallic moulds we generally use moulds of copper, fusible metal, type metal, and other compounds of lead, tin, bismuth, and antimony. Non-conductors consist of vegetable, animal, and earthy substances, and give us very valuable matrices. White wax and stearine are both well-adapted for moulds; sealing-wax is also an invaluable substance. Plaster of Paris is also of great service to the electro-metallurgist. Plaster casts, of themselves, would be disunited by being placed in the solution, but to prevent this result we fill the pores by soaking the cast in hot wax.

stearine, spermaceti, or those compounds known under the names of Price's and Palmer's metallic wick candles.

Since electro-metallurgy was first practised, a new material of great importance has been added to our list of substances capable of becoming moulds. I need hardly say that this is gutta percha. By it we are enabled to take the most perfect impressions. If the object is small the pressure of the thumb will suffice; if large a screw-press may be employed; and for very large objects the most powerful hydraulic presses are used, and you may judge of the size with which casts may be taken in this material, by the large casts which have been furnished by the Gutta Percha Company.

Before we use any of these substances, it is necessary to render their surface an efficient conductor. Professor Solly recommended nitrate of silver, exposed to the action of light, and Mr. Murray showed us that we had an invaluable friend in the housemaid's blacklead brush, for by giving the object a coating of that material it became a conductor sufficiently good to enable the metal to spread over it. I have great pleasure in showing you the first seal which he copied in this manner, and many works upon the table could not have been formed so efficiently without this invaluable discovery. Other conducting substances are sometimes used; here is one which appears to be a crystalline alloy pounded, which answers well. I am informed that Bessimere's best copper bronze may be used, but have never tried it; and Elkington has patented the process of obtaining a conducting medium by means of reducing silver through the agency of phosphorus, and by one or other of these means there is hardly any object, however delicate, which may not now be used to receive the metallic deposit. Connected with moulds I may mention the flexible moulds, formed of gelatine, and certain compounds of gelatine, which are at present kept secret, and which may be employed as moulds for works of art, which are undercut, or exhibit elaborate surfaces.

Mr. Charles Elkington informs me that he has lately discovered that by an addition of phosphorus to these moulds he is enabled to obtain a conducting surface by simply brushing them over with a solution of chloride of gold. This discovery of Mr. Charles Elkington's is one of immense importance to the practical electro-metallurgist, as it gives him a new power of operation for very delicate works of art, which he has not heretofore possessed. Very excellent results are obtained by the use of bisulphuret of carbon, which on being added to wax confers on it the power of reducing gold and silver, and thereby of becoming coated with a conducting surface to favour deposition.

Adhesion or Non-adhesion of Deposit.—Sometimes when we effect a metallic deposit we desire that it should adhere, at others we particularly

wish that no adhesion should ensue. When we desire adhesion we scour the surface of the metal; we dip it into dilute acid, and if it is thoroughly cleaned our wishes in that respect are complied with. When, however, we desire the other property, we leave the object for some hours in contact with the atmosphere, when apparently a film sticks to the metal, and prevents adhesion. When we seek non-adhesion we are very careful not to expose the plate for an instant without metallic deposition, but the best plan is to drop the plate into the solution, and thereby complete the circuit.

Bright Reduction of Metals.—Mr. Lyons accidentally discovered that the addition of a few drops of bi-sulphuret of carbon to a large quantity of solution of silver caused the reduction of the metal in a brilliant state, and in my various experiments I have occasionally seen this brilliant reduction under many circumstances, but at the present time no theory of the change is known. When this singular and interesting fact is rightly understood, I dare venture a confident opinion that it will tend to important practical results. Already the fact is of much importance, for the reduction is so perfect throughout, that spoons and other articles plated under such circumstances do not require the cost and labour of burnishing.

Cost of Electro-Metallurgy.—Before we enter upon any process we should reckon our cost; and I could tell you many curious stories of mistakes which have occurred by neglecting this precaution. In all electro-metallurgic operations we have, in addition to the value of the metal deposited, as a matter of necessity the cost of the power requisite for the reduction. When I tell you that the cost of this power for the reduction of silver is little more than a halfpenny an ounce, that gold may be thrown down at half that cost, you may say that this item is immaterial; but if we extend our examination to copper we cannot effect its reduction under a shilling a pound, which excludes this mode of operation from many manufactures, and the cost of production of hydrogen by electricity is so enormous as totally to prevent its adoption for economical considerations. In my work on Electro-metallurgy I have considered this subject in detail, but time will not permit its more extended consideration this evening.

Reduction of Copper.—After having given a rapid sketch of the principles to be followed in Electro-metallurgic operations, it may be useful to give a good commercial process for the reduction of the three principal metals, which are now ordinarily treated in this manner. The single cell process is occasionally used for copper, care being taken that an ample quantity of crystals are suspended at the upper part of the vessel to insure a saturation of the fluid. It is necessary that the sulphate of copper be placed at the upper part, or it would not as quickly dissolve as the nature of the case would require,

With the single cell apparatus it is important not to use too much zinc, or to excite the zinc with too strong a solution of acid, otherwise the deposit will take place too quickly, and it is found that with a porous pot only a few drops of acid will suffice. When bladder is employed the quantity of sulphuric acid may be stronger. I here show you two varieties (fig. 11, fig. 12), of this kind of apparatus, and a third I have exhibited at a

Fig. 11.

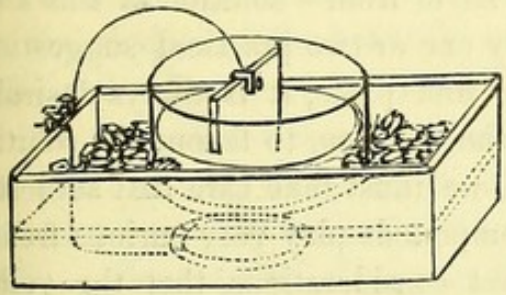
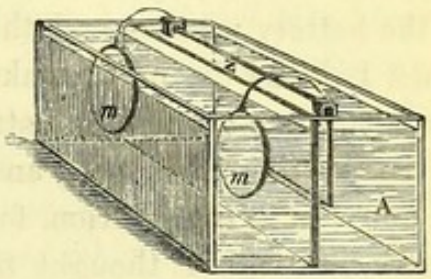
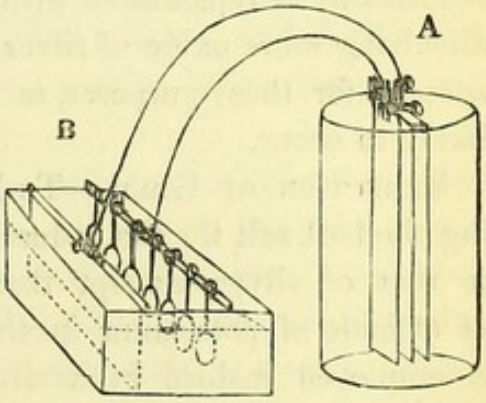


Fig. 12.



former part of the lecture (fig. 3). Commercially the single cell apparatus should always give way to the battery apparatus. The most convenient mode of proceeding is to use a battery with a surface of platinized silver, not less than that of the object to be copied. This should be charged with dilute sulphuric acid of the strength of one part, by measure, of acid to eight of water. The precipitating trough unless for reasons to the contrary, may be vertical and contain, a positive pole of sheet copper exposing a surface of twice that of the negative pole. The solution should consist of a saturated solution of as pure sulphate of copper as can be obtained, diluted with one third dilute sulphuric acid, similar to that used for charging the battery. A few drops of nitric acid may, from time to time, be added, taking care not to add so much as to cause bubbles to be formed on the negative pole; or otherwise this very slight addition of nitric acid improves the solution, and renders the deposition of copper much more rapid and of better quality. It is a good plan every day to wash the plate of copper which is being dissolved, and occasionally to filter the solution through tow. As the fluid loses by evaporation, the operator must add water, and after one week a little more dilute sulphuric acid. In the precipitating trough all the materials cannot be too pure, and perhaps it will be good economy to commence with pure sulphuric acid, properly diluted and galvanize it with a large positive pole of copper till it acquires sufficient strength.

Fig. 13.



Reduction of Silver.—To Elkington is due the honour of having given us the best solution for the reduction of silver, which unquestionably is that made with the cyanide of potassium. To prepare this solution the oxide of silver may be boiled in the solution of cyanide of potassium, or a large plate of silver may be connected with the silver of a battery, whilst a small wire is attached to the zinc, till sufficient silver is dissolved in the solution to render it fit for electro-metallurgic purposes. Nothing can be easier than the operation of reducing silver from a solution of this kind, by the battery process, and there is only one or two practical suggestions which I should desire to make. In the first place, it is always desirable to employ free cyanide of potassium in the solution, to favour the solution of the positive silver pole, and secondly, we must take care that sufficient silver exists in the solution, for these compounds play very curious freaks. Many years ago I thought from abstract considerations, that the yellow prussiate of potash might be converted into the red by galvanism, and on trying the experiment I succeeded in performing this curious metamorphosis. Now these cyanide compounds play a somewhat similar freak as they become a positive pole, and take oxygen, and the silver is not dissolved. And in this way the solution at last is unfit to perform its part and requires to be replenished with metal, either by the galvanic process or by dissolving more oxide of silver. The single cell apparatus should never be adopted for these purposes, on account of the waste of solution which is likely to occur.

Reduction of Gold.—To Elkington is also due the merit of discovering the best salt for the reduction of gold, which is similar in all respects to that of silver, except that oxide of gold is dissolved in a solution of cyanide of potassium in the place of oxide of silver, and a gold pole is employed instead of a silver pole. The battery process is that best adapted for this process also, the gold being connected with the silver of the battery, and the zinc with the object to be gilt. Practically it is found a good plan to keep this solution hot as the deposition generally takes place more favourably when warmth is applied.

Application of Electro-Metallurgy.—Having thus given you a rapid sketch of the theory of Electro-Metallurgy, I have now to pass over, in an equally rapid manner, its applications to the wants of man.

Electro-Medallions.—Electro-Metallurgy is extremely useful for the copying of coins and medallions. The casts of old coins are interesting to the public, and then more extensive diffusion cannot fail to exercise a beneficial influence over the community. You are all doubtless aware that the ordinary coins of the realm are struck from a die so rapidly and inexpensively, and upon both sides at once, that it will be useless for electro-metallurgy to compete with the moneyers. For the multiplication of

cast and chased medals, however, it is invaluable, as having an original carefully modelled, it can be multiplied to any extent. You will perceive that some of the medallions which I formerly executed are of surprising beauty and there is no more difficulty in the multiplication of these than there is in the multiplication of the most trumpery productions. I need hardly state that in the process of making a coin the artist first forms a design in wax. This is formed on a much larger scale than the subsequent medal formed therefrom, and by the kindness of Mr. Leonard Wyon, I am enabled to show you the original of the beautiful model of Prince Albert and Her Majesty used for the medals of the Great Exhibition. This charming production of his late lamented father is, as you see, electrotyped, and I should truly rejoice if we could but persuade Mr. Leonard Wyon to place the public in possession of such excellent portraits of those so justly dear to the English nation. The copying of coins is an amusement which may be followed by ladies, and I have seen fine collections formed in the drawing-room of the Numismatic enquirer. Connected with the subject, it is impossible to pass over Mr. Barclay's embossed works from electro moulds. I will now show his little work containing impressions of the coins mentioned in the Bible, which cannot fail to be of great interest. The Daric, the Mite, and other relics of antiquity, are there faithfully embossed. The larger works on the Syracusan and other coins are all of great interest, and show a very interesting application of electro-metallurgy to make known the works of our forefathers to the multitude.

Copies from Works of Art.—For the higher works of art electro-metallurgy is now lending its all-powerful aid. The very beautiful electro statues on the table, which have been contributed by Elkington, amply show to what use electricity may be applied. Whether we regard bas-relief, whether we observe the complete statue, or any analogous work, electro-metallurgy is paramount. If the artist has made a perfect design, our process multiplies it touch for touch, and stroke for stroke; but if on the contrary he has performed his work indifferently, our art will ever multiply the defect. I think we can hardly survey the exquisite works of art around me, and see the adaptations of high art to various domestic purposes, without feeling that by the electro-metallurgic process, the public taste will be improved, for it is impossible that persons can see, day after day, the productions of true artistic taste, and afterwards tolerate any aberration from those principles which give the charm to works of high art.

Electrotype.—The electro processes are of considerable utility to printing in a variety of ways. For the multiplication of type the formation of the mould is so difficult that the process is but seldom adopted. Nevertheless, when the electro-stereotype is formed we obtain a surface

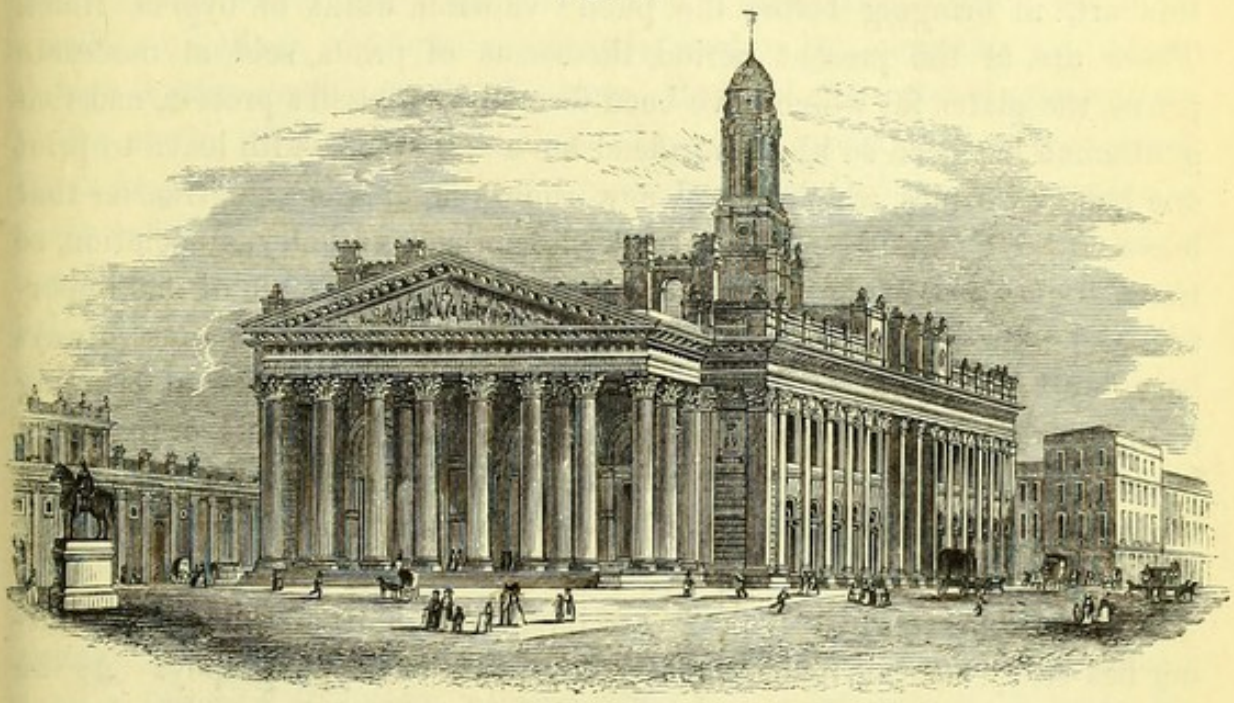
for printing of the first excellence, and as very long numbers may be printed therefrom, the process may sometimes be desirable. Copper is found to print far better than the metal of ordinary stereotype. For the multiplication of woodcuts, electro-metallurgy is of higher importance. A mould is taken of the block in gutta percha, which is black-leaded and copied in the usual manner. The gutta percha cut of the coat of arms

Fig. 14.

which was placed in the solution, when speaking of the reduction of copper, has already become coated with metal, and after due time will become sufficiently thick for our purposes. This is backed by some alloy of lead, and fixed upon a block of wood, when experience demonstrates that not less than three millions of impressions may be printed therefrom (fig. 14). I have ascertained that the frontispiece of "Punch," the title of "Chambers's Information," and the headings of the "Illustrated London News," publications of enormous circulation, have actually had that number printed from them. I have borrowed from Messrs. De La Rue a small electro cast of the Royal Exchange, which Mr. Coe has been so good as to place in a small printing press, and will take an impression for any of my hearers, who may like to possess it. By the multiplication of a single block, several impressions may be pulled at once; and here we have a power of production which enables better works to be introduced into the ordinary operations of life. We are enabled, moreover, from the original design to form two devices, one to print in one colour, one in a second, and I now

show you an example of Messrs. De La Rue's operations in this manner. You may think this a trifling matter, but I can assure you that part of the business of their very curious and extensive manufactory is to print labels for certain woven manufactured goods. In foreign countries these are arranged round the stores ornamentally, and, *cæteris paribus*, the sale is

Fig. 15.



secured by the beauty of the ornamental envelope. You thus see that by printing in two colours, and varying their patterns, our exportations in other directions are favoured, and by that mutual exchange, in which consists the true character of commerce, the whole country is benefited by the modern discoveries of electro-metallurgy. The electro-multiplication of wood-cuts is not so cheap as the ordinary mode of stereotyping, nevertheless, the cast when formed is far more durable and better adapted for the purposes of the printer. I have here an example of a novel mode of the multiplication of blocks by bituminous casts, but nothing can be considered equal to the electrotype for these purposes.

The multiplication of engraved plates is also an important feature of electro-metallurgic operations. The Ordnance maps are multiplied in this manner, and by the admirable skill exemplified in this department of the public service, plates are joined together, or separated, or an original, by a little manual labour, is enabled to become the parent of many offspring, all varying to the extent required. The multiplication of engravings is hardly as frequently adopted as formerly was considered probable, because steel plates are more commonly used, and these print a large number of impressions. When an engraved plate is copied, a matrix is taken, like this, which has been lent me by Messrs. Horne and Thorn-

thwaite, this is again multiplied, and is ready for printing. Another process, however, has come into use, which has much tended to lessen the value of electro-metallurgy for engraved plates; for Mr. Russell has succeeded in forming steel plates at a very moderate rate, from the simple impression on paper. In this way, many of these beautiful engravings around me have been multiplied; and I need hardly mention the value of this art, in bringing before the public valuable works of bygone times. There are, at the present period, thousands of prints, sold at moderate prices, the plates for which have been formed by Russell's process, and that gentleman has been so kind as to lend me a steel plate, with leave to print one hundred copies, which plate I now show you, and beg to transfer that leave to the Committee of the Bank of England Literary Association, so that the members of the association may possess an example of this important and interesting process. Connected with this subject we must always bear in mind the Anastatic printing, so called, from its power of bringing forth, or raising a former impression. In this way, lost sheets or pages of works are printed; and by the kindness of Mr. Appell, I am enabled to show you a very beautiful print of Albert Durer's which has been copied by the Anastatic process.

Electro-Glyphography.—A very important addition to surface printing has lately been introduced under the name of Glyphography. As the art is now practised, a copper-plate is etched, and from this copper plate, a surface block is formed. This process confers upon the engraver a new power of operation, as it is the best and cheapest mode now known for the formation of blocks from which maps can be printed. Already the public have the advantage of this addition to our manufacturing operations as very excellent maps are now being sold at one penny a-piece; and we can hardly estimate the effect of this cheap circulation upon the education of the people. This process also admits of small maps being introduced into the text of books, which are now being extensively used in the valuable Gazetteer published by Messrs. Blackie and Co.; and you may observe, placed upon the table various Glyphographic blocks of maps, writing, &c., for which I am indebted to Mr. Hawkins.

Electro Casts of Natural Substances.—I have now to show you casts taken from natural bodies, such as flowers, leaves, birds, &c. The case of leaves, which I show, was, I believe amongst the earliest, if not the earliest works of this kind. Since the period they were formed, others have executed specimens of far higher beauty. To Captain Ibbetson I am indebted for the splendid castings of humming-birds, and other natural objects which are placed upon the table, and to Mr. Elkington, for the pretty little rose-bud made into a brooch, which I now show you. Some of these objects are formed by covering the object with black-lead,

others, by covering them with a fine layer of wax and phosphorus, which, as I have already told you, deposits metals from their solution, and produces a metallic coating, which renders it a conductor for the metallic deposit to travel over.

ELECTRO SILVER PLATING.—In no department of electro-metallurgy does the benefit conferred by electricity more strikingly shine forth, than in the results which have been obtained by silver-plating. By it we obtain a surface of silver, which, to appearance, renders the object as valuable as though it were made entirely of silver. Formerly the plated articles used to be made of copper, with a thin layer of silver, and when struck the most prominent part being the most extended, had the least portion of silver to resist the greatest friction. At the present time a white metal is used, and Mr. Elkington has furnished me with a waiter silvered on one half its surface, whilst the other is in its natural state. Though you can now see a notable difference between the two halves, it is manifest, that if a portion of silver should, in process of time, wear off, nevertheless, it will not be an eye-sore, like the difference of colour which is afforded by the protrusion of copper. There is no difficulty in plating. The object to be coated is simply to be placed in the silver decomposition apparatus, which I before described, and you have only to be careful to deposit enough metal. In buying plated articles it is necessary to select a respectable vendor, for, as a thin layer of silver looks as good as a thick layer, you must trust to the character of the manufacturer as to the quality of your purchase. I need hardly call your attention to the manifest advantages which result from the power of replating articles, nor to the comparatively speaking economical manner in which articles of elaborate design may be manufactured, a fact which is well illustrated by the candelabra upon the table. The effects produced by the oxidized silver, and by partially plated articles, immediately show the value of these processes to the observer.

ELECTRO-GILDING.—The gilding of metallic surfaces is almost exclusively conducted by the electro process. Formerly a very pernicious mode of proceeding was adopted for gilding, as a large quantity of mercury was employed, which made great havoc with the health of the workpeople employed in this trade. At this late hour it would be almost impossible to recount the extensive application of electro-gilding; suffice it to say, that no other process is now required for coating metallic surfaces with this precious metal. The operation is conducted in the manner which you have already seen, when the reduction of gold was under consideration. The effect of partial gilding and plating as a means of increasing artistic power, is beautifully demonstrated in some of the specimens which Mr. Elkington has sent.

I have now, gentlemen, taken a rapid sketch of the leading principles

which must guide electro-metallurgic operations, and also given you a cursory glance of some of the principal applications of this power to the arts and manufactures. It would be impossible to detail all the purposes for which electro metallurgy is now employed, and though I have been led, by the interest of the subject, to extend my lecture beyond all the bounds of lecturing precedents, I have been unable to bring before your notice all the points which appear to me worthy of attention. Before I close the subject, I must call your attention to part of the model of the Britannia Bridge, which was made by Mr. James, as it is a very beautiful application of the electro deposition. I would also point to Shepherd's magnetic clock, which is kept in motion by the voltaic power. The pendulum is the same which regulated the time of the clock at the Great Exhibition, and has therefore obtained for itself an historic importance which should have prevented its removal from the Crystal Palace. The power which Mr. Shepherd obtains is amply sufficient for the largest clocks, and the contrivance is specially interesting, from its being one of the very few practical applications of electricity as a motive power. Electricity has only but partially been brought to bear for a motive power, because the cost of zinc is so much higher than the cost of coals, but if ever a battery should be discovered, in which coke can effectively take the part of zinc, then will the steam engine give way to the electro-magnetic machine. You may readily infer that I have tried to make a battery with an effective positive pole of coke, or similar matter. Hitherto the attempt has been in vain; but who shall say, that hereafter the desideratum will not be accomplished ?

Perhaps it may be expected, that on the first lecture of the season I should make a few observations upon the advantage of scientific knowledge to members of the Association. To those who would venture to apply the hackneyed "cui bono?" I would point to the beautiful collection of objects around me, and ask whether the kindly feelings which have prompted so many distinguished electro-metallurgists to assist in illustrating the subject this evening, are not of themselves an ample recompense for scientific inquiry.

In former times, "Sutor ne supra crepidam" was the unworthy proverb by which the innate desire for knowledge was sought to be repressed; but now, when we observe a Lord Chief Baron to be as eminent for mathematical attainments as for legal knowledge; when we find one of our ornaments on the woolsack to be as eminent for his literature and science as for his law; when we have as President of the College of Physicians the author of "Philosophy in Sport;" when the Prince Consort becomes the active President of the Industrial Exhibition; when, moreover, restricting our inquiries to the members of this establishment, we find that we have an

historian, a painter, a musical composer, a florist, and an entomologist amongst us; when we find our chief cashier delights in microscopical pursuits, and our chief accountant finds amusement in numismatics; when we further observe that a former governor of this House was, notwithstanding his arduous and responsible duties, the inventor of one of the choicest pieces of mechanism ever devised, we are led to suppose that the mind will no longer be kept under the dominion of narrow-minded prejudices, but with the expanded ideas engendered in the natural progress of human development we may confidently predict that in future ages the proverb will be substantially varied, and posterity will be taught that "the cobbler who sticks to his last, will be more fit for a last than a cobbler."

There are potential reasons for the study of nature and nature's laws; for however difficult and manifold may be the duties by which a man obtains his bread, nevertheless by use and custom his business becomes, to a certain degree, monotonous, and requires variation. By a variation of occupation, other faculties of the mind are called into play, and whilst we rest from our business, and have the pleasure of exercising our other powers of thought, our entire mental faculties are improved and strengthened, and we are rewarded by becoming a higher individual, with increased capability to perform our ordinary duties.

In every station of life, experience amply indicates that to possess knowledge is to possess a priceless jewel which gains nothing from its rarity, a light which brightens as it shines, a fire which grows hotter as it burns, a power which gains by exercise, and an inexhaustible treasure which never can be spent.

LIST OF WOOD-ENGRAVINGS.

LONDON:
Printed by SAMUEL BENTLEY and Co.,
Bangor House, Shoe Lane.