

be attributed to the rival claimants for the invention of electro-metallurgy; for neither the English nor Russian philosopher revealed what had not been known before.

Yet to Jacobi and Spencer is due the merit of having called public attention to the subject; for in doing this, they have conferred benefits on the world greater, perhaps, than by making an original discovery.

After the publications of Jacobi and of Spencer had called the attention of the scientific world to the new art, the principles involved in it became the study of several eminent philosophers, who disclosed the methods to be followed for obtaining reguline metal. After this, several departments of electro-metallurgy rapidly advanced. Electro-plating, and the multiplication of pages of letter-press work, as pages of type, and wood-cuts (electro-stereotyping,) were soon extensively practised; but the copying of the delicate touches of the copper-plate engraver (the electrotype proper) was beset with difficulties. On account of the great value of the engraved plate, together with the risk of its being destroyed in the attempt to copy it, and the uncertainty as to whether the duplicate would have good metallic properties, even if the operator should have the good fortune to obtain one, this department of the art (the first and most beautiful of Spencer's suggestions) was allowed to rest as an experiment or be confined to articles of small size and value.

*Adhesion of Deposit to Matrix.*—Electro-metallurgy requires that the deposited metal should have all its cohesive properties. If such a deposit of copper is made on a clean plate of copper, it is obvious that the deposited metal will cohere with the plate on which it is made, and an elaborately engraved plate would thus be converted into a mere mass of metal. The electrotype art, therefore, cannot exist before means are provided for preventing this destructive adhesion.

Various plans for overcoming this difficulty have been proposed. All these, however, have a common feature, which is to prevent the deposit and matrix from touching by means of an intervening film of heterogeneous matter.

Mr. Smee proposes to use that coating of air which adheres so firmly to polished metals (so strikingly exhibited when the attempt is made to wet a polished knife-blade). To obtain the air coating, he directs that, after every attachment has been made to the plate, it be placed in a cool and moist cellar for a few days before introducing it into the electrotype vat.

Smoke, black lead, oils, and powders, and wax, have also been proposed for covering the face of the plate.

The method used in the British ordnance survey is perhaps the best of all these. This is conducted as follows: The plate is first well oiled, and the oil well wiped away with soft bread. The plate is then heated to above the temperature of melting wax, and a cake of white wax pressed against the edge. The oil having removed the air from the plate, the wax will flash over it in an extremely thin sheet or film. All excess of wax is then to be wiped away with a fine linen cloth, free from lint. The plate must be left to cool before introducing it into the vat.

To smear the face of the finely engraved plate is in opposition to the fundamental idea of the electrotype, which is that of atomic casting. In the process of Mr. Smee, air bubbles will be retained in the fine lines of the graving, thus mutilating the copy; moreover, the face of the new plate is waved from the agitation of the stratum of air when receiving the first portion of copper.

In the waxing process it is almost impossible to free every line from excess of wax. Even days of tedious application do not insure perfection. In addition to the coarseness of these va-

rious methods, they are extremely uncertain as to whether they effect the purpose for which they are applied.

It was always observed that if the deposited metal was not *deficient* in mechanical properties, it stuck very hard to the original, and the plates had to be subjected to violent jarring, heating and beating, to separate them. But if the deposited metal was of very fine quality, then most likely the deposit was *inseparably united to it*. From these circumstances attending the adhesion of the deposit, it occurred to me that, when the cohesive force was but feebly developed in the deposited metal, then the force of cohesion or homogeneous attraction could not extend the distance presented by the thickness of the film of heterogeneous matter between the plates; but that when these forces were well developed, the spheres of homogeneous attraction of each plate would extend through the wax or air film.

It may be proper here to remark that the above views of adhesion have been applied to another department of electro-metallurgy with the most gratifying success. In electro-plating the difficulty of obtaining a firm adhesion of the film of precious metal is entirely obviated by making such arrangements as insure a rapid deposition of highly ductile metal at the moment the article to be plated is immersed in the electrolyte.

In considering the sticking of the plates, after homogeneous attraction or cohesion, heterogeneous attraction or adhesion demands attention; for two similar bodies may be separated by a film of heterogeneous matter, which binds them more firmly together than their particles are held together by cohesion, as we see in the use of cements.

This force is very powerful between some bodies, while between others it is very slight. Air adheres very strongly to metals, as before referred to; hence a film of air may unite two copper plates, even though they are separated beyond the distance at which cohesive attraction takes place.

Wax is a common ingredient in cements; its adhesive properties have become proverbial; its use is evidently improper. Therefore a substance having a strong adhesive attraction for the plates must not be on the face, and the cohesive force of the surface particles must be suspended by other methods than making the deposited metal deficient in mechanical properties.

It was hoped that a substance could be found that would act uniformly and gently on the surface of the engraved plate, and which in destroying the homogeneous attraction of the surface particles, would, by chemical union with them, form an insoluble and friable compound, having but a slight adhesion to the plate. I was led to select iodine for the experiment on account of its sparing solubility in water, its high equivalent number, and innocuous qualities. A copper plate was well cleaned, exposed to the vapor of iodine, and electrotyped; the deposit separated from it readily. This was repeated some hundred times with invariable success.

It was found in cleaning large plates for the application of the iodine vapor, that while one part of the plate was being cleaned, another part would tarnish, and hence a uniform action of the iodine could not be obtained. This led to silvering the plates before iodizing, which facilitated the cleaning and exhibited the action of the halogen. A silvered plate was washed with an alcoholic solution of iodine and electrotyped; the electrotype separated from the matrix yet more readily than before, the iodid of silver serving better to prevent adhesion than the iodid of copper.

But it was soon observed that a plate prepared on a dull day did not separate so readily as one prepared under a bright sky, and on experimenting it was found that a plate iodized and ex-