

ports from which the articles are hung in the depositing vat, of a gauge suited to the character of the work. Small articles will require but a very thin wire, while larger ones will require correspondingly thicker "slings wires." On the same point he cautions the operator that the difference of conductivity in the metals to be plated is to be considered, "for, whereas, a steel, brass, or copper article would become readily 'struck,' even if suspended from the conducting rod by a thin wire, articles of lead, britannia metal, pewter, or even cast iron would not receive the deposit so readily." It is obvious, therefore, that in suspending articles in the plating bath, the operator must be guided in the matter of the thickness of the "slings wires" by the nature of the articles as well as by their dimensions.

It cannot be too strongly impressed on the operator that the attainment of success in nickel plating depends very largely upon the perfect cleansing of the articles before they are immersed in the bath. Important as this operation is in plating with other metals, it is even more so in the case of nickel. Gilding, silvering, bronzing, etc., are usually effected with solutions having a decidedly alkaline character (reference is made here to the double cyanide solutions commonly used), and the presence of minute traces of oxide from careless exposure to the air after cleansing, or of grease from the fingers, etc., on the surface of the articles to be plated, is not necessarily fatal to the success of the work, as the free cyanide always present in those baths, being a solvent of greasy substances, and of metallic oxides, may remove trifling quantities of such impurities. With nickel, however, the case is different. The solutions employed for its deposition are either neutral or weakly alkaline or acid. Their chemical character is such, therefore, that they can have little or no solvent effect on the grease or oxide left on the articles by careless cleansing or improper handling or exposure before immersion; and if such articles are plated, the nickel coating at the unclean places will be found to have little or no adhesion to the metal beneath, and will almost certainly flake or strip at these places in the subsequent operation of buffing. Unless the surfaces to be coated are *chemically* clean, an adherent deposit of nickel is simply impossible.

On account of the hardness of the deposited metal, nickel-plated articles cannot be burnished. In order, therefore, to obtain upon the finished work that superb metallic luster which characterizes this metal, it is necessary to polish the surface of the articles upon the buffing-wheel before immersion in the plating bath, in order that the deposited metal may be as smooth as possible; thus reducing the amount of subsequent buffing, required to finish the plated articles, to a minimum.

The operation of cleansing articles differs somewhat in various establishments; the following methods, however, are those usually followed:

For copper, brass, britannia-metal, tin, pewter, etc., the articles are first steeped for a few minutes in boiling potash solution to remove greasy matter; they are then removed, dipped for an instant in cyanide of potassium solution of moderate strength, rinsed in water, again rinsed, then thoroughly brushed with the finest pumice powder (precipitated chalk and other fine powders are also used); again rinsed in water, dipped again for an instant in the cyanide, well rinsed, and then hung at once in the nickel bath. The time of immersion in the boiling potash solution will depend on the strength of the alkali and the amount of greasy matter present. Tin, britannia, pewter, however, should be left in it as short a time as possible, as the alkali exerts a solvent action on tin and alloys containing this metal. When rinsed in water after removal from the potash, the water should wet the surface uniformly; should any cloudy patches be visible, these indicate that the grease has not been completely removed, and the article must be immersed again in the boiling potash.

Steel articles are first treated to the potash bath; rinsed in water, scoured with pumice powder (or its equivalent), rinsed, dipped for a moment in dilute hydrochloric acid, again rinsed, and at once hung in the depositing vat.

Cast iron is first placed in the potash bath to remove greasy matter, well rinsed, then allowed to remain for some time in a pickle of dilute sulphuric acid to partially dissolve off and partially soften the scale that covers it, rinsed, then thoroughly brushed with pumice, rinsed, dipped for a moment in dilute hydrochloric acid, again rinsed and immediately placed in the nickel bath.

Many operators vary the above methods of cleansing somewhat, but they are followed substantially as given by the majority of nickel-platers. With britannia-metal, pewter, and other compositions of comparatively low conductive power, it is to be recommended to give them a preliminary coating of copper, for which purpose the cyanide bath is commonly employed. Many operators prefer also to copper articles of iron and steel preparatory to nickel plating. The advantages secured are a better conducting surface upon which to lay on the nickel, and a more tenacious deposit, having in the case of a heavy coating of nickel less tendency to flake. Where a substantial and durable nickel deposit is required on iron and steel, and especially where the articles are to be exposed to the atmosphere, or will be subject to much handling, a preparatory coating with copper is almost indispensable. In the earlier days of nickel plating it was the almost universal practice to first copper all iron and steel articles.

The enormous extension of nickel plating of late years has caused its application to an endless variety of articles of trifling value merely to enhance their beauty, and this, together with the severe competition among those in the business has combined to cause a very general deterioration in the quality of nickel-plated work. The necessity of doing cheap work is responsible for the fact, therefore, that thousands of articles are turned out of the nickel-plating works with the merest wash of nickel. The want of durability exhibited by these inferior goods has had the consequence that many have formed a low estimate of the utility of nickel as a protective coating for metals, which it is far from deserving.

It is important that the work should be examined very shortly after it has gone into the nickel bath, to observe whether it has been "struck," and its general appearance. Should dark streaks exhibit themselves upon the work, they may indicate either that the current is too intense, or that the work has not been properly cleansed. Such streaks will often be observed, starting from joints, seams, or rivets, where the grease from the buffing-wheel may have secured lodgment, and from which it is difficult to perfectly remove it. In such cases the work must be removed and given another thorough pumice brushing and rinsing, and again immersed in the depositing vat.

As has already been briefly noticed, the hardness of electro-deposited nickel renders it impossible to finish the plated articles by burnishing. It is, therefore, necessary to prepare the

surfaces of the articles to receive the nickel deposited before they are plated, in order to reduce the subsequent finishing operations as much as possible. On this account it is customary to polish the surfaces of articles to be plated on buffing wheels. In case the surface is very rough, as is sometimes the case with articles of iron or steel, it may be necessary to grind it smooth upon the emery wheel. The work, when removed from the nickel bath, is dipped for a few moments into boiling water, and then rapidly dried in sawdust. It is now ready to be polished on the buffing wheels, when it is finished.

The length of time required to produce a sufficiently heavy deposit of nickel will depend on the strength of the current, the condition of the bath, and the character of the articles. Brass and copper articles usually receive a sufficiently heavy coating in half an hour; for wares on which an extra-heavy coating is desired the time of immersion is extended to an hour or even longer. Iron and steel, britannia-metal, pewter, etc., require a longer time of immersion than brass or copper, even though given a preparatory coating of copper, because of their comparatively inferior conductivity. A good coating of nickel, properly laid on, possesses great durability, and with ordinary usage will last for many years.

Old nickel-plated work which it is desired to replate should first be "stripped," as is found necessary with the precious metals. For this purpose a mixture of sulphuric and nitric acids is commonly employed. Watt* recommends the following mixture, which will be found very serviceable, viz.: "4 pounds strong sulphuric acid, 1 pound nitric acid, and about 1 pint of water." By volume, these proportions would be approximately: Strong sulphuric acid 2 parts, nitric acid 1 part, water 1 part. The acids should be added to the water under constant stirring. This stripping liquid may be used either cold or slightly warm. It acts promptly, removing a light coating of nickel in less than a minute, and a heavy one in a few minutes. To avoid contaminating the solution as little as possible with the metal of the wares, the operation should be closely watched, and the articles removed from the acid just as soon as the nickel has been dissolved. The preparation of the stripped articles for re-nickeling should be the same as for new work. Articles may be stripped in the nickel bath by the ordinary artifice of connecting them as anodes, but the practice is reprehensible, as the purity of the bath will thereby become impaired by the solution of the metals composing the wares. Where the current is used for the purpose, therefore, a separate solution should be used, and for this purpose Watt's suggestion to use as a stripping solution dilute sulphuric acid, which will dissolve nickel readily without appreciably affecting brass, may be recommended. Under all circumstances, however, the articles should be looked at from time to time, and removed as soon as they are free from nickel. It is important, however, that the old nickel be thoroughly cleaned off to prevent the peeling of the subsequent nickel deposit.

PLATING WITH NICKEL BY IMMERSION.

Stolba† describes the following simple process for nickel plating without the battery, which may be usefully applied in the case of small objects. He dilutes a concentrated solution of chloride of zinc with twice its volume of water. This mixture he boils in a copper vessel, adding a few drops of muriatic acid should there appear a precipitate of basic chloride of zinc. He thereupon adds a small quantity of powdered zinc. This addition causes a deposit of zinc upon the vessel. Thereupon sufficient chloride or sulphate of nickel is added to the bath to give it a distinctly green color, and the previously cleansed articles are then immersed in the liquid in contact with zinc, and allowed to remain there for about fifteen minutes, the temperature being maintained at boiling during the operation. If the coating is found to be insufficient, the articles are again immersed until a deposit of sufficient thickness is obtained. In this way, he claims to be able to coat satisfactorily articles of zinc, cast and wrought iron, steel, and copper.

By an analogous process described by C. Mene,‡ it is affirmed that metallic articles may be plated with nickel by immersing them, in contact with zinc, in a boiling neutral solution or chloride of zinc, in which is contained fragments of a plate of nickel. Should the solution be acid the plating, it is asserted, will be dull. By this procedure the author claims to be able to coat articles of iron, steel, copper, brass, zinc, and lead.

Where electrotypes of type or engravings are to be printed with colored inks that are disposed to become chemically affected by contact with the usual copper surface (as for example vermilion, which becomes brownish), it is customary to give the copper electrotype a thin coating of nickel in the usual manner. This nickel renders the electrotype proof against the above named difficulty that printers experience with electrotypes not so protected.

By methods and solutions analogous to those described for nickel, electro-deposits of cobalt may be obtained. The electro-deposits of this metal equal, if indeed they do not surpass, those of nickel in whiteness and brilliancy of luster. The costliness of the metal, however, prevents its use for this purpose.—*Franklin Journal*.

ON A METHOD OF MOUNTING ELECTRICAL RESISTANCES.

By ARTHUR W. WATERS, F.G.S., etc.

A SHORT time ago I came to the conclusion that there was a strong probability of the variations in the electrical resistances of the human body giving some indication as to how various climatic changes affected different constitutions. This idea forced itself on me in consequence of an investigation concerning the changes of the body temperature, as affected by meteorological conditions, having brought out the interesting fact that the average changes in the 5 to 6 P.M. clinical temperature of a sufficient number of invalids‡ follows the curve of the absolute moisture or of the temperature, both of which are very similar.

Dr. Stone's results, as published in *Nature*, gave a definite direction to the idea, and then, when considering how I could carry out what I proposed, I saw that I must first have an instrument by which measurements could be rapidly made and changes easily followed, and, if possible, the current should not be broken by altering the measure.

The ordinary resistance box with plugs cannot be used sufficiently rapidly, and is unsuitable. I therefore adopted

* Watt, *Electro-Metallurgy* (7th Ed.), 114, et seq.

† *Journal Chemical Society*, xi., 465.

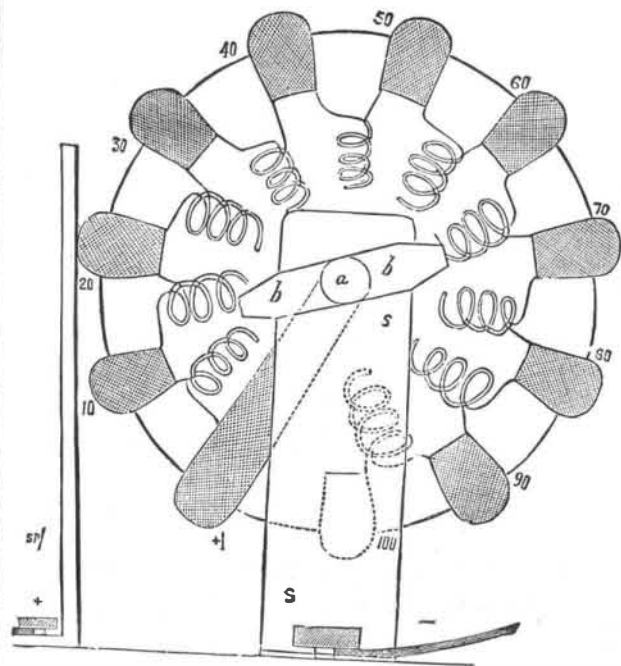
‡ *Chemical News*, xxv., 214.

§ A paper read before the Manchester Literary and Philosophical Society, January 23, 1884.—*Chem. News*.

¶ The measurements were made for the purpose by consumptive people in Davos.

the plan of mounting the resistance reels on an ebonite disk, with a metal axis, *a*, running at each end in brass supports, *S*. This support has a binding screw at the base, and the current is thus led away from the axis. Round the border of this disk German silver flanges* or bosses are attached, and one of these, *x*, is connected by a stout strip of copper to the axle. Between this and the next boss a resistance coil of fine German silver wire wound double on a small reel is attached, and between each of the other bosses a similar coil is placed, and the two ends severally soldered to the adjoining German silver projection. The disk is revolved by means of a bone or ebonite handle, *b*, and these bosses are thus brought against a strong spring, *s*, *p*, up which the current is led. If the flange connected with the axle is brought against this spring, then there is practically no resistance; but if any other flange is against this spring, then the current must pass through one or more reels of resistance. As figured it would go through two reels of 10 ohms each, and if it went through all the reels we get a total of 100 ohms. As arranged, one boss does not leave the spring until the next is in contact.

The complete instrument consists of four such disks similarly mounted and put into connection, and on the first disk the reels are 1 ohm, on the second 10, and on the other two 100 and 1,000 respectively, so that they are read off like a gas meter, and thus a resistance from 1 ohm to 11,110 ohms can be read directly; and by mounting the commutator and the permanent arms of the Wheatstone bridge on one board, we get a very compact instrument, and have all the handles within easy reach for rapid change. About 7 centimeters will be found ample for the diameter of the disk, and the whole apparatus may be mounted on a board about 45 centims. long and 10 centims. wide.



The arrangement of resistances is much the same as in slide resistances, and the plan of arranging these in a circle has been used for medical purposes, but I am not aware of the resistances themselves being made to revolve, though I have not had any opportunity of investigating all the plans previously adopted. It seems to me, however, that, in cases where only amateur or imperfect workmanship is available, this will be found the simplest plan, and also I think that when compactness and rapidity of action are important this form may often be found useful, and, therefore, describe it, although there is no new principle involved.

One such disk may also be used when a galvanic current is being applied for medical purposes, in which case the current is made to first pass through a high resistance of several reels, and then without contact being broken the resistance is brought down to null. In such cases it may be found advisable to make the first resistance much lower than the last.

LIQUEFACTION OF HYDROGEN.

By S. WROBLEWSKI.

THE author subjected hydrogen to a pressure of 100 atmospheres in a glass tube, arranged perpendicularly, of 2 mm. external diameter, and of 0.2 to 0.4 mm. internal diameter. By means of a screw the compressed gas can be released instantaneously. The tube was surrounded with liquid oxygen and refrigerated by means of a series of ebullitions of this body. At the moment of releasing the hydrogen there appeared in the tube an ebullition quite analogous to that observed by M. Caillietet in oxygen in his experiments in 1882.

The phenomenon is produced in the same manner at a certain distance from the bottom of the tube. It lasts for a much shorter time, is less decided, and much less easy to perceive. The reason of this difficulty may perhaps be explained by the very low density of liquid hydrogen. MM. Caillietet and Hautefeuille, in their researches on the densities of oxygen, hydrogen, and nitrogen liquefied in presence of a liquid without chemical action upon these elementary bodies, have inferred for liquid hydrogen the number 0.033. Since the same method yielded, under the same conditions, the number 0.89 for the density of oxygen, and since this latter number agrees entirely with the author's direct determinations, it may be admitted that the density assigned by MM. Caillietet and Hautefeuille for hydrogen will not be far from the truth. On the other hand, gaseous hydrogen reaches this same density, 0.033, at a low temperature, under inconsiderable pressures. Hence arises the optical difficulty of distinguishing the liquid from the gaseous portions of the hydrogen. This difficulty has probably prevented the author from reproducing M. Caillietet's experiment on hydrogen. The analogy between the phenomenon described and those presented by oxygen permits us to suppose that the temperature necessary for the complete liquefaction of hydrogen is not far from that which may be obtained by means of boiling oxygen.

* These flanges overlap on each side, and therefore present to the spring a continuous surface the width of the disk.