

water, and finely-divided gold remains. Dissolve this gold in aqua regia, and recover it, as in the first method, by precipitating it with ferrous sulphate.

§ 83. *Recovery of Silver from Old Solutions.*

Add hydrochloric acid in excess, syphon off the clear liquid, collect the precipitated silver chloride, dry and fuse in a clay crucible with twice its amount of sodium carbonate and a little nitre; pour into mould, allow to cool, and detach the slag by striking it with a hammer. Or the solution may be evaporated to dryness, the residue fused at a red heat, the soluble matter dissolved in water, and the finely-divided silver fused with carbonate of soda as before.

NICKEL.

Symbol Ni. Atomic weight 58.6. Chemical equivalent  $\frac{58.6}{2} = 29.3$ . Electro-chemical equivalent .0046944 grains. One ampère deposits 16.899 grains per hour. Pressure required = 5 volts, and when struck reduce to 2 volts. Current density—strike with 15 ampères per square foot of cathode surface and then reduce to 3 ampères per square foot of cathode.

§ 84. Dissolve 3 ounces of the double sulphate of nickel and ammonium in 1 quart of water, and test the solution with blue litmus paper; if acid, ammonia must be cautiously added until the solution is slightly alkaline.

The above double salt may be made by the battery method thus:—

Suspend a large plate of nickel in sulphuric acid, and connect it with the carbon pole of the battery. Place a small nickel plate in connection with the zinc. Pass the current until sufficient nickel has been dissolved from the anode, which is determined by weighing it before and

after the experiment. The solution is then neutralised with ammonia. To each ounce of nickel sulphate in solution, add 1 ounce of ammonium sulphate, and test with litmus paper as described above.

All articles to be nickel plated, must be clean and polished very bright.

§ 84A. A dry process of preparing work for receiving a deposit of nickel is in successful operation. After the work has been well polished, it is thoroughly rubbed over with dry whitening, which is afterwards rubbed off, and the article suspended in the nickeling solution. A strong current is used at first so that the work may be struck as quickly as possible.

Iron and steel articles are first coppered, then polished with a mop or "dolly" as it is sometimes termed, wiped quite clean with dry whitening and quickly covered with a deposit of nickel in the nickel vat. The work is then taken out, polished, wiped with whitening, and again put in the plating vat for the complete deposit.

Britannia metal articles are first brassed (see § 86), then treated as mentioned above for articles of iron and steel.

Tin-plate work is treated like Britannia metal, except that it is put through the brassing solution twice before being plated.

The advantages claimed for the above methods are—that they are much cleaner and healthier; that the work being less liable to receive scratches, has a better finish. The objections are—that the nickel is liable to crack and strip off if left too long in the vat; that the work is liable to tarnish and the deposit to strip if allowed to stand too long after wiping before being put into the vat. This method is only suitable for large work. Small work is better prepared in the wet way.

As nickel solutions are used in the concentrated state, the nickel salt begins to crystallise after a time, especially in a warm place; in which case water must be added.

It should also be borne in mind that the anode does not maintain the strength of the solution, so that it is necessary to add crystals of the double salt from time to time to replenish the weakened solution.

### PREPARATION OF SOLUTIONS FOR DEPOSITING ALLOYS.

#### BRASSING SOLUTION—PRELIMINARY EXERCISES.

§ 85. Exp. 240. Crush a crystal of copper sulphate about the size of a pea, in a porcelain or wedgwood ware mortar; transfer to a clean test tube; add water, and heat until dissolved. Filter if not clear. Allow to cool, and to the cold solution add a single drop of ammonia; the solution becomes turbid. Add more ammonia drop by drop, occasionally shaking the tube, until the turbidity disappears, and the solution assumes a beautiful blue colour.

Exp. 241. Take a lump of potassium cyanide about the size of a horse bean, dissolve it in a test tube half full of water, and filter if necessary. Add this solution drop by drop to the blue copper solution obtained in Experiment 240; shaking after every addition until the blue colour is resolved into a faint violet tint; then a few drops more will render the solution colourless. From such a solution copper alone could be deposited.

Exp. 242. Dissolve a small portion of sulphate of zinc in water placed in a test tube, and add a portion of ammonia solution drop by drop until the white precipitate which forms at first re-dissolves, and a clear, colourless solution results. Then, add to this ammoniacal zinc solution, the potassium cyanide solution obtained in Experiment 241, and observe that no visible change

occurs, so that there is no indication when sufficient of the cyanide has been added. From this solution, if the proper amount of potassium cyanide has been added, zinc alone could be deposited.

Exp. 243. Mix together the colourless cyanide solution of copper and the cyanide solution containing zinc, in about equal quantities of each, then such a combination would constitute a solution from which brass, which is an alloy of copper and zinc, could be deposited.

§ 86. Exp. 244. To prepare 1 quart of good brassing solution, proceed as follows:—

(a) Weigh out 400 grains each of copper sulphate and zinc sulphate. Dissolve both together in 12 ounces of hot water; allow to cool and decant the clear liquid; or pass it through a large filter paper fixed in a glass funnel into a quart bottle, then add liquid ammonia cautiously, shaking after each addition until the precipitate which forms at first re-dissolves, then add more liquid ammonia until the clear blue solution smells strongly of the gas.

(b) Dissolve 2000 grains of good commercial potassium cyanide in 16 ounces of water; allow to cool, filter, and transfer to a pint bottle.

Make a paper scale, divided into inches and eighths, paste it on the bottle, and note the level of the solution. Pour the cyanide solution very gradually and with constant stirring or shaking into the ammoniacal zinc-copper solution until the colour is reduced to a very faint violet tint. Read off from the scale the quantity of cyanide solution used, and add one-sixth of that quantity to completely destroy the colour and to furnish the requisite quantity of "free" cyanide. Then fill up the bottle with water. This solution is a mixture of the potassio-cyanides of copper, zinc, and ammonium, to

gether with a small proportion of free potassium cyanide and free ammonia.

It should be worked at a temperature of about 55° C., using a good brass anode and a current equal to that produced by three or four Bunsen's cells, each 1 pint size. The student is enjoined to pay strict attention to the directions given in preparing the solution, especially with respect to the amount of potassium cyanide used. The writer has found that the first solution of this kind prepared by the majority of students fails to give a deposit on account of too much potassium cyanide having been used. It is more difficult to deposit copper and zinc simultaneously so as to constitute brass, than to deposit either metal separately, and a brass of good colour can only be obtained by nicely adjusting the strength of the current. If the current is too strong, either zinc alone will be deposited or the brass may be too pale in colour, whilst if the current be too weak, either copper only will appear, or a red brass will be deposited.

The first defect may be remedied by lifting the anode partly out of the solution, or by increasing the distance between the anode and the receiving surface. The latter defect, by immersing more of the anode, or by placing the anode and the work nearer together in the solution.

§ 87. *General Method of preparing Solutions of Alloys, as Brass, German Silver, etc.*

To make 1 quart of solution, dissolve  $\frac{1}{4}$  oz. of the alloy in a mixture of two measures of strong nitric acid with one measure of water. The acid mixture should be added to the alloy in successive small quantities, and heat applied until red fumes cease to come off, and just a small fragment of the metal is left undissolved. In this way all injurious excess of acid will be avoided. The solution thus obtained should be diluted with sufficient water to make up its bulk to 12 fluid ounces. Decant the clear solution into a quart bottle, add strong ammonia

until the precipitate formed at first re-dissolves, and then potassium cyanide solution until the blue colour is just removed. Finally add one-sixth more cyanide, then fill up the bottle with water.

In making an alloy solution in this way, observe the same precautions, and proceed exactly as prescribed for preparing the brassing solution. Use a strip of the same alloy for the anode, and work the solution hot, using a current strong enough to evolve hydrogen from the cathode.

§ 88. *Pickles, Dips, etc.*

To remove grease, -	-	$\left\{ \begin{array}{l} \frac{1}{2} \text{ lb. of common potash per} \\ \text{gallon of water. Used} \\ \text{hot.} \end{array} \right.$
To remove mere films of oxide from surface of work, - - - -	-	$\left\{ \begin{array}{l} \frac{1}{2} \text{ lb. of potassium cyanide} \\ \text{per gallon of water. Very} \\ \text{useful for preparing work} \\ \text{for nickel plating.} \end{array} \right.$
Pickle for cast iron,	-	$\left\{ \begin{array}{l} \frac{1}{2} \text{ lb. oil of vitriol per gallon} \\ \text{of water.} \end{array} \right.$
For brass (dead), -	-	$\left\{ \begin{array}{l} \text{Nitric acid, 2 measures; oil} \\ \text{of vitriol, 1 measure; and} \\ \text{a little common salt.} \end{array} \right.$
For brass (bright), -	-	$\left\{ \begin{array}{l} \text{Nitric acid, 1 measure; oil} \\ \text{of vitriol, 2 measures;} \\ \text{water, 2 measures.} \end{array} \right.$
For zinc, - - - -	-	$\left\{ \begin{array}{l} \text{Oil of vitriol, 1 measure;} \\ \text{water, 20 measures.} \end{array} \right.$

§ 89. *Stripping Liquids.*

For nickel, - - - -	-	$\left\{ \begin{array}{l} \text{Nitric acid, 4 lbs.; sulphuric} \\ \text{acid, 16 lbs.; water, 5 lbs.} \\ \text{Used cold.} \end{array} \right.$
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For silver,	{	Cover the work with sulphuric acid, and add nitre from time to time in small quantities Used hot.
Do.,	{	Sulphuric acid, 10 measures; nitric acid, 1 measure. Used cold Work must be dry before being dipped in this liquid.

All deposits may be stripped from work by making the articles the anode in a suitable liquid.

## PART II.

## ASSAYING BY DRY METHODS.

§ 90. Assaying (Fr. *essayer*; Lat. *exigo*, to examine, to weigh) was a term originally used to denote the estimation of a particular metal in an ore, alloy or other metallic compound by the dry way. At the present time the word has a far more extended signification, and assaying has become so identified with chemical analysis that the two terms are often used synonymously, and it is not unusual to call the determination of an *organic* constituent of a mixture 'an assay.' It should further be borne in mind, that analysis contemplates the determination of every constituent, while an assay only involves the estimation of one or more.

§ 91. Practical assaying may be conveniently classified under two heads, viz.—"Dry" and "Wet."

In the former, the operator effects the isolation of the metal by the agency of heat, generally following the methods, and even the sequence of the methods carried out on the large scale in the works, by which means he considers he will be able to discover the amount of metal a given ore will yield when treated in quantity. But the amount of metal obtained will often differ according to the plan pursued and the kind of apparatus used. Improvements now follow each other so rapidly that a larger yield is obtained from the same compound than formerly, so that many *dry* methods of assaying have been superseded by the more accurate although often tedious *wet* processes.