by the same process you are going to use. By this method objects are copper-plated, silver-plated and gold-plated.

Besides its use in plating, the process is used in the purification of certain metals. Copper, for example, is separated from its impurities in this manner. At a recent chemical exhibit in New York there was placed on exhibition a slab of copper five feet square and six inches thick which had been purified not by removing impurities from the copper, but by removing the copper from the impurities.

In electroplating, the electrolyte or bath always consists of a solution of the salt of the metal to be deposited or plated on the object. Now, as to the action which takes place when an object is electroplated, let us first consider the nature of solutions of metallic salts when a current is passed through the solution. Salts are made up of metallic elements and non-metallic elements or groups. When in solution the metallic elements become ions and have positive electric charges. The non-metallic elements or groups on the other hand also become ions and have negative charges. Now suppose we pass a current through a solution of copper sulphate. The metallic copper ions which are positively charged are attracted to the negative pole to which is attached the object to be plated. On reaching the object to be plated the copper ions lose their charge, become atomic or metallic copper and as such are deposited in a smooth thin layer upon the object.

The non-metallic sulphate groups which are negatively charged are attracted to the positive pole to which in the case of copper-plating is attached a sheet or bar of copper. Upon reaching the positive copper pole the sulphate groups lose their charge, become molecular sulphate, having the properties of a strong acid grouping and dissolve the copper to form copper sulphate which goes into solution. The amount of copper which goes into solution in this way is exactly equal to the amount of copper which is deposited upon the object to be plated. You can see, therefore, that the concentration of the copper sulphate solution is always the same as long as there is any copper left at the positive pole.

The preceding action may be expressed a little more clearly in the form of an equation, thus:

Salt	electricity =	metal (of salt) goes to the object to be plated (cathode —)	non-metal (of salt) — goes to the metallic plate (anode +)

By using different kinds of salts and plates of different metals we can plate with almost any metal, although some metals plate easier than others.

EXPERIMENT 625—How to copper-plate

If you have any medals which you wish to copper-plate, proceed as outlined in this experiment. If not, use a nail, or other iron object.

The object to be plated must always be cleaned of oils, grease or varnish. This can easily be done by boiling the object in vinegar or a solution of sodium carbonate for several minutes. When cleaned the object must never be touched with the fingers, for if it is a film of grease will be left and the plating will not stick to the surface.

Dissolve one spoonful of copper sulphate in a tumbler half full of water. Now, using two or three dry cells connected up in series as outlined in previous experiment, attach the medal or iron object to be copper-plated to the wire from the zinc pole or negative wire in the manner illustrated (Figure 43.) To the wire from the carbon or positive pole of the battery attach the copper strip.

Now immerse the copper strip and the medal in the copper sulphate solution, being sure that the medal to be plated is below the surface of the solution. Do not allow the copper strip and medal to touch.

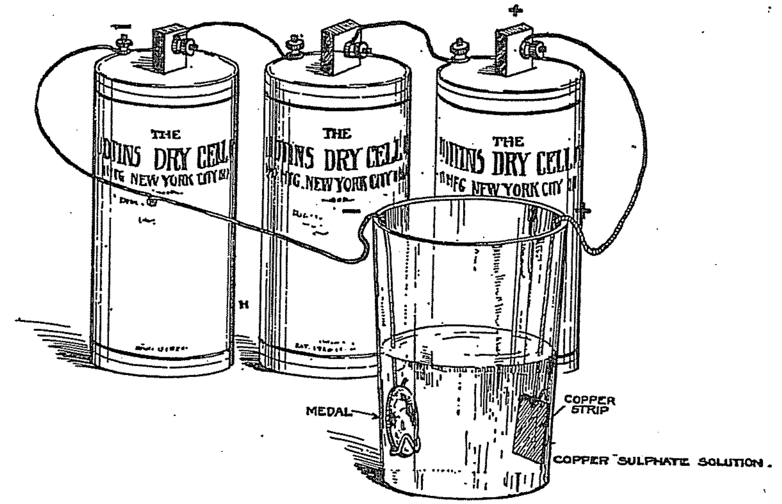

FIG. 43

In a few minutes you will note that the medal is covered with a deposit of copper. Leave the medal in the solution until an even coat is deposited. This should take from 10 minutes to one hour, depending upon the size of the object and the strength of the solution.

To give the medal a bright finish, rub it lightly with an ordinary pencil eraser.

EXPERIMENT 626—How to nickel-plate

The object to be nickel-plated must be free of oil, grease and varnish. This can be done by boiling it in vinegar or a solution of sodium carbonate.

Dissolve one spoonful of nickel ammonium sulphate in a tumbler half full of water. Now attach the iron, copper or brass object to be nickel-plated to the negative wire and an iron nail to the positive wire. Immerse these in the solution and notice that soon the object attached to the negative wire which goes to the zinc post is covered with a coating of nickel.

ELECTROTYPING

Electroplating with copper has been taken advantage of in the printing and publishing industry. Here it is called electrotyping. This process consists in making a mold of wax or plaster of Paris and the impression of the type of a book made by pressing the mold against the type. The wax is then dusted with graphite, which is a good conductor of electricity. It is then connected to the negative pole of a battery and immersed in a copper solution. The positive pole is a sheet of copper.

When a suitable thickness of copper is deposited on the impression, the thin sheet of metal is removed from the wax and "backed," that is, the reversed side is filled with a low melting substance such as solder or lead.

It is now affixed to a rotary, or flat press and used directly for printing. Besides its use in printing, this process may be used for making duplicates of medals.

Practically all books are now printed from electrotype plates. Without electrotype plates it would be necessary to set up new type every time a new edition of a book was printed. This would take much more time and would be much more expensive.

EXPERIMENT 627—How to reproduce a medal

Secure a medal, one as small as possible, or some foreign coin which you would like to reproduce in copper.

Prepare the molding wax by cutting a square piece of paraffin wax a little larger than the medal and about one-eighth of an inch in thickness. The wax may be molded flat by warming slightly and kneading it with the fingers. Now hold it under cold water until it becomes hard. Clean the medal and press it down upon the wax with considerable force. Then remove the medal with a knife point. If the wax sticks to the metal, oil the medal very, very slightly.

Now scrape some graphite or lead from a soft pencil upon the impression in the wax and rub the graphite to a fine finish with the brush included in the set. It is essential to give the impression a compact and smooth surface, therefore, rub with the brush as long as possible, even 15 minutes. Add more graphite if necessary until the whole impression is black and shining.

Set up two or three dry cells in series and attach the wire from the negative zinc post to the wax mold, making contact from the wire to the surface of the impression. (Figure 44.) The contact is best made by making a channel from the wire to the impression as shown in the illustration. Fill this channel with graphite and pack it tight with a pencil point.

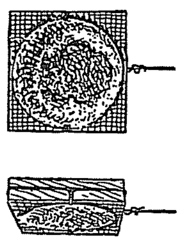

Fig. 44

To the other wire from the positive carbon post of the battery attach the copper strip. Now place the wax mold and the copper strip about one inch apart in a tumbler containing a solution of copper sulphate. The solution of copper sulphate is made by dissolving one spoonful of copper sulphate in a tumbler half full of water.

Allow the current to pass through the solution for several hours—over night, if necessary—and examine the wax mold carefully from time to time and notice that the copper-plate gradually creeps across the impression.

When the process is complete and you have a thin sheet of copper deposited on the impression, remove the wax mold from the solution, wash it with water and then remove the wax by melting it in a tin cover. The copper-plate then produced is an exact reproduction of the medal and can be preserved by pasting it on a piece of cardboard.

You may nickel-plate the copper reproduction by placing it in a solution of nickel ammonium sulphate as explained in the experiment, "How to nickel-plate."

EXPERIMENT 628—How to make a bronze statue from a plaster cast

This is a very interesting experiment in electroplating. Obtain a small white unpainted plaster statuette or cast and be sure that it is small enough to fit into a tumbler or pint jar.

Now paint the statuette with a little linseed oil or quick drying varnish and allow the oil to dry thoroughly. This makes the statuette waterproof and forms a skin upon which the powdered graphite will stick. When the oil is dry brush the statuette with

powdered graphite from your lead pencil. Brush until the surface is smooth and black.

Set up two or three dry cells in series and wind the end of the wire from the negative zinc post around the statuette. Attach the copper strip to the wire from the positive carbon post. Now place the statuette and copper strip in a copper sulphate solution made by dissolving one spoonful of copper sulphate in a glass full of water. Allow the statuette to remain in the solution until it is evenly coated with copper. This is best done by leaving it to stand over night.

If you wish to nickel-plate the bronze cast, simply place it in a solution of nickel ammonium sulphate, as explained in the experiment on nickel-plating.

ETCHING BY MEANS OF ELECTRICITY

Pretty patterns or designs may be duplicated on sheet copper or steel very easily by means of the electric current. The designs will have the appearance of being etched.

EXPERIMENT 629—How to etch on copper

Take the copper strip and dip it into hot paraffin. When it is cold, trace the design you want and then with a toothpick remove the paraffin along the tracings. Also scrape off the paraffin where connection is to be made with the wire and copper strip.

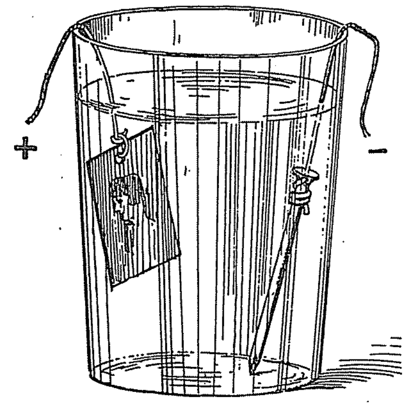

Fig. 45

Now connect two or three dry cells in series and attach the wire from the positive carbon post to the copper strip to be etched. (Figure 45.) To the wire from the negative zinc post attach a bright nail or other object of iron. Place the nail and copper strip in a copper sulphate solution made by dissolving one spoonful of copper sulphate in a tumbler half full of water.

While the iron nail is being plated with copper, the copper strip is being corroded. Since only the bare spaces are affected, the copper will be eaten along the lines of the tracing. After several hours, remove the copper strip, melt off the paraffin and notice that the etching is quite clear. It will look as though the design were directly engraved upon the copper.

EXPERIMENT 630—How to etch on steel

Steel or iron can be etched the same way as the copper in the preceding experiment. Procure a piece of sheet steel or iron and after coating it with paraffin trace the design upon it. Then connect it to the positive wire leading to the carbon post and attach a bright nail to the negative wire leading to the zinc post of the battery.

Now place the steel and the iron nail in a solution of nickel ammonium sulphate made by dissolving one spoonful of the compound in a tumbler half full of water. Allow the current to pass through the solution for several hours and then remove the steel and melt off the paraffin. Notice that the design is etched upon the steel.

EXPERIMENT 631—Copper-plating by immersion

Dissolve two measures of copper sulphate in a test tube half full of water and place into this solution a small strip of clean steel. Allow the steel to remain in the solution for half an hour and notice after this time that it is coated with copper.

The reason for this is as follows: Some metals, like iron, are more easily dissolved by acids than others, like copper. Therefore, when iron is placed in a copper sulphate solution some of the iron goes into solution to form iron sulphate and an equal amount of copper goes out of solution as metallic copper and is deposited on the iron.

EXPERIMENT 632—Tin-plating by contact

Dissolve six or eight measures of tartaric acid in a tin cup half full of water. Now place into this solution a penny which has been cleaned by boiling for several moments in a little vinegar.

Put the tin cup on the stove and allow the water to boil off. Notice that after several minutes the penny will gradually become coated with a bright silvery plating of tin.

EXPERIMENT 633—Nickel-plating by contact

Heat a test tube two-thirds full of water to boiling and dissolve in it five measures of nickel ammonium sulphate.

Put a clean penny in a small tumbler and pour the nickel solution upon it. Then place the strip of zinc included in the set in the tumbler so that it comes in contact with the penny. Allow the solution to stand for several minutes and notice after some time that the penny is gradually coated with nickel.

EXPERIMENT 634—Formation of a current by contact of copper with zinc

Dissolve four measures of sodium bisulphate in a test tube full of water and pour this solution into a tumbler. Drop into the tumbler a clean penny and notice that the penny is unaffected by the solution. Then place in the solution the strip of zinc so that it touches the penny. Notice that bubbles of gas are formed on the copper penny.

The zinc went into the solution to form zinc ions and left the zinc plate negative. The hydrogen ions of the sodium hydrogen sulphate were attracted to the copper penny, where they lost their charges and became gaseous hydrogen and formed gas bubbles on the penny. Therefore, an electrical current was set up in the solution in which the strip of zinc became the negative electrode and the copper penny the positive electrode.

EXPERIMENT 635—Formation of a current by contact of silver with zinc

Using the same solution and zinc strip as in the preceding experiment, see if you can produce a current by means of a clean silver coin. Notice that in this case bubbles of gas are also formed on the silver coin, thereby setting up an electric current between the zinc and silver. The explanation is the same as in the preceding experiment.

ELECTROLYSIS

By electrolysis is meant the decomposition or breaking down of a chemical compound to form new substances by the aid of the electric current. Many important commercial industries depend upon this process for making and isolating different substances. For example, some metals like aluminum are prepared on a large scale by passing an electric current through a molten bath of certain aluminum compounds. Again, sodium hydroxide (caustic soda) and chlorine gas, used to a large degree in making bleaching powder, are made by passing an electric current through a solution of sodium chloride.

In the electrolysis of a solution of a chemical compound the positive ion of the compound is always attracted to the negative pole where it loses its charge and becomes an atomic substance. In this state it reacts with the water present to form a new compound and usually a gas, or is deposited on the negative pole as a metal.

The negative ion, on the other hand, is attracted to the positive pole, where it loses its charge and becomes atomic in nature. In this form it goes off as a gas or reacts with the water present to form a new compound and a gas.

EXPERIMENT 636—The electrolysis of sodium chloride

Dissolve one teaspoonful of common table salt (sodium chloride) in a tumbler one-third full of water and add two or three drops of phenolphthalein solution. Stir the solution a few times.

Now connect two or three dry cells in series and place the ends of the negative and positive wires in this solution about one-half inch apart. Do not let the wires touch. Notice that almost immediately bubbles of gas are formed at each wire in the solution. At the positive wire chlorine gas is formed, while at the negative wire hydrogen is given off. Notice also that the solution turns red, showing that a base of alkali is being formed. What really happened may be expressed a little more clearly as follows:

Negative wire	Sodium	water =	sodium hydroxide	hydrogen.
Positive wire	Chlorine gas.			

EXPERIMENT 637—The lemon electric cell

Procure a fresh, juicy lemon and cut two small slits, one on each side, as shown in the illustration.

Now clean the copper and zinc plates by scrubbing them. Insert the zinc and copper strips in the lemon as shown in the illustration. (Figure 46.) To prove the passage of an electric current, touch your tongue to the ends of the zinc and copper strips.

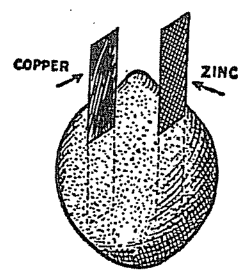

FIG. 46

Notice the slightly tingling sensation produced on the tongue. This proves that a current is passing from one metal to the other. When the external circuit is closed, the citric acid (lemon juice) attacks the zinc, forming citrate of zinc. By the separation of positive zinc from the zinc strip, the zinc strip is made negative.

The positively charged hydrogen ions of the citric acid, which is in the lemon, being displaced by the zinc, deliver their positive charge to the copper. Thus the copper is positively, and the zinc negatively, charged when the copper is joined to the zinc or when the circuit is closed. The flow of electricity externally is from the copper to the zinc.

The lemon cell polarizes quickly, so lift out the plates frequently to remove the hydrogen bubbles.

EXPERIMENT 638—How to clean silverware electrolytically

If you have any silverware which is stained dark by exposure to the air you can easily remove this stain, which is silver sulphide, by treating the silverware as follows:

Obtain an old aluminum pan and place the silver to be cleaned in the pan. Now cover the silver with a solution of common salt or baking soda made by dissolving two spoonfuls of the salt in each quart of water used. Now place the pan on the stove and allow the solution to boil for two minutes. Remove the silverware and wash it with fresh water. Notice that the black stains are removed and the silver is bright and clean.

The black stain or silver sulphide was reduced by the chemical action taking place in the solution. A feeble electric current was formed in which the aluminum pan acted as the negative pole and the silverware as the positive pole. The electrolyte in this case was the solution of common salt or baking soda.

The metal silver cleaners which you probably have seen advertised on the market are simply metals of aluminum or zinc. The process of cleaning silverware with these cleaners is the same as that used in this experiment.

EXPERIMENT 639—How to galvanize iron with zinc

Mix together on a sheet of paper four measures of powdered zinc, one measure of aluminum sulphate, one-half measure of powdered magnesium and three measures of calcium carbonate.

Now take a wet cloth and after touching it to the mixture rub the clean iron to be galvanized with some of the mixture. After thoroughly rubbing, wash the iron free of the paste with water and notice that it is coated with zinc.

Galvanized ironware is iron which has been treated with zinc compounds in a similar manner.

EXPERIMENT 640—How to galvanize iron with nickel

Mix together on a piece of paper three measures of calcium carbonate, one-half measure of powdered magnesium and five measures of nickel ammonium sulphate.

Now rub thoroughly by means of a wet cloth some of this mixture on the clean iron to be galvanized. Then wash off the paste with a little water and notice that the iron is now plated with nickel.

LIST OF CHEMICALS WITH THEIR FORMULA

1—Aluminum Sulphate $Al_2(SO_4)_3$	.10
2—Ammonium Chloride NH_4Cl	.10
3—Ammonium Nitrate NH_4NO_3	.10
4—Borax $Na_2B_4O_7.10H_2O$	.10
5—Boric Acid H_3BO_3	.10
6—Litmus Paper	.05
7—Calcium Hypochlorite $CaOCl_2$	.10
8—Calcium Chloride $CaCl_2.6H_2O$	.10
9—Calcium Carbonate $CaCO_3$	.10
10—Camphor Gum $C_{10}H_{16}O$	.10
11—Calcium Oxide CaO	.10
12—Calcium Monophosphate $Ca(H_2PO_4)_2H_2O$	.10
13—Calcium Sulphate $CaSO_4.2H_2O$	.10
14—Calcium Sulphide Paper	.10
15—Carbon Tetrachloride CCl_4	.10
16—Cobalt Chloride $CoCl_2.6H_2O$	.10
17—Cochineal	.10
18—Congo Red Paper	.05
19—Copper Strip Cu	.05
20—Copper Sulphate $CuSO_4.5H_2O$	.10
21—Ferrous Ammonium Sulphate $(NH_4)_2SO_4.FeSO_4.6H_2O$	.10
22—Ferric Ammonium Sulphate $(NH_4)_2SO_4.Fe_2(SO_4)_3.24H_2O$	.10
23—Gum Arabic	.10
24—Glycerine $CH_2OHCHOHCH_2OH$	.15
26—Nickel-Steel Wire	.10
27—Insulated Copper Wire	.10
28—Logwood	.10
29—Magnesium Sulphate $MgSO_4.7H_2O$	.10
30—Manganese Dioxide MnO_2	.10
31—Manganese Sulphate $MnSO_4.4H_2O$	.10
32—Nickel Ammonium Sulphate $(NH_4)_2SO_4.NiSO_4.6H_2O$	.15
33—Phenolphthalein $(C_6H_4OH)_2COC_6H_4CO$	.20
34—Potassium Nitrate KNO_3	.15
35—Potassium Permanganate $KMnO_4$	.10
36—Powdered Iron Sulphide FeS	.10
37—Powdered Charcoal C	.10
38—Powdered Iron Fe	.10
39—Powdered Magnesium Mg	.15
40—Powdered Zinc Zn	.10
42—Sodium Bicarbonate $NaHCO_3$	.10
43—Sodium Bisulphate $NaHSO_4$	.20
44—Sodium Bisulphite $NaHSO_3$	.15
45—Sodium Carbonate Na_2CO_3	.10
46—Sodium Ferrocyanide $Na_4Fe(CN)_6.12H_2O$	.10
47—Sodium Iodide Solution NaI	.10
48—Sodium Silicate Na_4SiO_4	.10
49—Sodium Sulphocyanate NaCNS	.15
50—Sodium Thiosulphate $Na_2S_2O_3.5H_2O$	.10
51—Strontium Nitrate $Sr(NO_3)_2$	.10
52—Sulphide Test Paper	.10
53—Sulphur S	.10
55—Tartaric Acid $COOH(CHOH)_2COOH$	.20

56—Turmeric Paper		.05
57—Zinc Strip		.15
59—Nigrosine		.10
61—Red Saunders		.05
63—Gum Benzoin		.15
65—Acetic Acid CH_3COOH		.10
68—Denatured Alcohol C_2H_5OH		.05
69—Ammonia NH_4OH		.05
73—Strontium Chloride $SrCl_2.6H_2O$		.10
74—Acetone $(CH_3)_2CO$		.10
75—Chrome Alum $Cr_2(SO_4)_3.K_2SO_4.24H_2O$		.10

MINERALS

X1500-A	Galena	.10
X1500-B	Stibnite	.10
X1500-C	Chalcopyrite	.15
X1500-D	Pyrite	.10
X1500-E	Magnetite	.10
X1500-F	Pyrolusite	.10
X1500-G	Sphalerite	.15
X1500-H	Malachite	.10
X1500-J	Calcite	.05
X1500-K	Fluorite	.10
X1500-L	Halite	.05
X1500-M	Orthoclase	.10
X1500-N	Talc	.10
X1500-O	Apatite	.10
X1500-P	Muscovite	.05
X1500-Q	Garnet	.10
X1500-R	Quartz	.10

APPARATUS AND EQUIPMENT

X861-B	Wand	.05
X1547	Thermometer	.15
X1555-A	Scale—Complete	.50
X1557	Test Tube Rack—Medium	.20
X1570	Test Tube Rack—Small	.15
*X1584	Gas Generating Bottle—Glass	.10
X1584-A	Alcohol Lamp	.20
P-57-A	Rod	.02
P859	Ring for Ink Trick	.05
P860	Black Cloth for Ink Trick	.05
P1502	Test Tube	.05
P1503	Glass Rod	.05
*P1504	Glass Tubes 4½"	.05
P1518	Spoon	.05
P1522	Filter Paper Disc	6 for .05
[illegible]	Test Tube Brush	.10
	Flask	.50
P1544	Self Generating Torch with Swab and Cleaning Wire	.75
P1549	Beaker	.50
*P1560	Right Angle Tube—Long	.05
P1563	Test Tube Holder	.10
P1574	Charcoal Block	.20
P1577	Short Right Angle Tube	.05
*P1578	Glass Funnel	.15
P1580	Small Shovel	.02
P1582	Metal Test Tube Rack	.10
P1583	Carbon Electrodes	.10
P1589	Porcelain Pestle	.15
P1593	Glass Mortar	.10
P1598-A	Cork with Hole	2 for .05
P1599	Candle	.03
*P3308	Rubber Coupling	.01
P3309-A	Rubber Tubing 2 ft.	.35
*P3310	No. 2 Rubber Stopper—2 holes	.05
P3312	No. 1 One Hole Rubber Stopper	.05
P4727	Horseshoe Magnet	.10
P5607	Glass Blowers Pipe	.25
P6704	Quill Brush	.03
M1706	Small Chemical Manual	.25
M1710	Large Chemical Manual	.35
M1735	Medium Chemical Manual	.35
	Chemical Magic Manual	.25
	Mineralogy Manual	.25
	Glass Blowing Manual	.25

The parts marked * are necessary to make the Gas Generating Apparatus. Kindly enclose check, money-order or stamps with your order.

THE A. C. GILBERT COMPANY
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