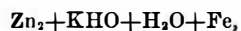


zinc. Trial proved the idea to be strictly correct; not only iron, but nickel and cobalt, as well as gold and silver, and the metals of the platinum group, were found to be practically as electro-negative to zinc as carbon itself. Carbon is at first a little more strongly electro-negative than iron, but owing to the absorption of hydrogen in its pores as soon as the circuit is closed, it is in practice in no wise superior.

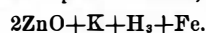
Silver is the most electro-negative of all the metals in these solutions. The use of iron, if practicable, has obviously several advantages. The cheapness of the metal and its freedom from liability to fracture as compared with carbon are strong points in its favor, and it affords besides the possibility of making a perfect and permanent connection on the negative plate for the binding screw, an end so difficult to attain when carbon is used. It was discovered, however, that a simple iron plate polarized very rapidly, the hydrogen set free by the action of the battery clinging to it and greatly increasing the resistance. By surrounding the plate with a packing of small fragments of iron, such as clean turnings or borings, in the same manner as the carbon plate in the original type of Leclanché, is surrounded by fragments of carbon and manganese dioxide, this deleterious action is considerably modified, and the cell acquires to a great extent the power of keeping up its electromotive force when working continuously through a low external resistance. The number of points presented by the turnings or borings is probably the cause of this, as it is well known that hydrogen escapes with much greater freedom from a rough than from a smooth surface. The packing of iron fragments is, in fact, the platinized silver plate of Smee in another form. The greatest efficiency is obtained when the iron fragments are thoroughly damped by the solution, but not immersed in it, the obstacles to the escape of the hydrogen being then at their minimum.

Although not quite constant when working through an external resistance of 20 ohms, the battery recovers its original electromotive force when allowed to rest with a rapidity sufficient to allow of its employment on the busiest telegraphic circuits and for most other practical purposes. The electromotive force of the iron battery varies somewhat with the nature of the iron and the purity of the exciting salt employed. Also with the degree to which the iron fragments are saturated or covered by the solution. The Daniell being 1, and the Leclanché at its best 1.30, the iron varies from 1.15 to 1.33. The last was an exceptionally good cell, and the average may be taken at 1.23, or 0.07 less than the best Leclanché. But after working for some days continuously through a low external resistance, the iron keeps up its electromotive force much better than the Leclanché. This was proved lately, at the suggestion of Mr. David Graham, who thought it likely to demonstrate the comparative capacities of the two batteries for actual work by setting a good specimen of each cell to ring an electro-magnetic trembling bell of precisely similar construction, and each of a resistance of 5 ohms, day and night, until they failed. They were started at 11.10 A.M. on December 23 last. After four or five days the Leclanché became very weak, and although it did not actually stop until January 12, it latterly simply vibrated the hammer of the bell without striking the gong. The iron cell rang the bell powerfully until January 15, and did not stop until January 23, exactly one month, or 744 hours, from the date of starting.

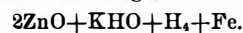
The chemical reaction of the iron battery is probably as follows: there being present when a solution of potassium hydroxide is used,



the closing of the circuit produces first,



That is to say, at the positive plate the oxygen of the potassium hydroxide and of the water is given off, and combines with two atoms of zinc to form zinc oxide. At the negative plate, the potassium and the hydrogen of the potassium hydroxide, and the hydrogen of the water are set free. The metallic potassium instantly decomposes an additional molecule of water in the negative portion of the cell, with the oxygen of which and with one of the free atoms of hydrogen it combines to reform potassium hydroxide, leaving the four atoms of hydrogen due to the decomposition of water free. This makes the final stage,



The caustic solution is consequently used up in the positive half of the battery and reformed in the negative. It is to the polarizing action of the free hydrogen that the inconstancy of the electromotive force is due. It, however, as has already been stated, ascends between the iron fragments and rapidly escapes to the air. The author has attempted in many different ways to get rid of this obnoxious gas, but without permanent success. Mixing platinum black with the iron packing answers to some extent for a time, as the platinum absorbs the gas and leaves the iron free. Another plan is to place a chemical having a great affinity for oxygen, such as pyrogallol acid, nitrate of cobalt, permanganate of potassium or sodium at the negative plate. But the chemicals which absorb oxygen with sufficient avidity have little permanency and soon cease to act. The presence of a permanganate raises the electromotive force of the battery in addition to improving its constancy, but the effect is transient. A cell was placed in a jar of oxygen in hopes that this gas would find its way through the iron packing and combine with the hydrogen to form water. But the hydrogen would have nothing to say to the oxygen until it was clear of the battery. It then combined, and the cell being kept at work was, in a couple of weeks, drowned in water of its own creating. These are, however, at best complications which, besides being superfluous, are inadmissible on the score of expense in a cheap battery, which the one under consideration is specially designed to be. Its cheapness and the ease with which it can be made up are, indeed, its most remarkable features. There is here an old tinned iron can, which, as the legend upon it distinctly states, was originally packed with corned beef in Chicago. At that time there was little probability, it is to be presumed, of its making its appearance before such a learned assembly as the present. The beef having been consumed in Glasgow by some of Her Majesty's lieges, now unknown, the can was cast aside as useless, and was acquired without much difficulty or prolonged negotiation by the firm of Messrs. D. & G. Graham for the sum of one farthing sterling. There is also here a quantity of iron borings swept from the floor of an engineer's workshop, the cost being simply the time and trouble consumed in sweeping. There is also a strip of common zinc, cut from an old roof ventilator, a porous cell, and a bottle containing a solution of 4 oz. of commercial potassium hydroxide. The porous cell being placed in the tinned iron can and packed with borings, the solution is poured in, and the zinc strip immersed in it.

The tendency of the caustic alkalies to absorb carbonic acid from the air renders it desirable, although not absolutely necessary, to keep the porous cell which contains the solution tightly covered. On the other hand, the iron portion of the battery should be exposed as freely to the air as possible, to facilitate the escape of the hydrogen. These contrary conditions are rather vexatious, but by no means impossible of attainment. The most practicable mode of solving the difficulty appears to be the placing of the positive portion of the combination in an earthenware cell about 7 inches in height, but porous only for 4 inches from its bottom, which porous cell is fitted with an air-tight stopper, through which the zinc rod is brought and terminated by a binding screw. The earthenware cell is placed in an iron can 5 inches in height and of a like diameter, and packed in firmly with turnings or borings. The earthenware cell, having been filled with solution almost to overflowing, the air-tight stopper is fitted in, and the battery is ready for use. The advantages of this arrangement are the exclusion of carbonic acid from the caustic solution, while the iron is left exposed to the air; the prevention of evaporation, and the preservation of the packing from too profuse a wetting. There being no air pressure on the surface of the solution in the earthenware cell it can only percolate with extreme slowness, being opposed by the pressure of the air acting through the iron borings and the pores of the cell. The presence of carbonic acid in ordinary water renders it desirable to make the solution with distilled or newly-boiled water. If this is done, and the cell instantly closed with an air-tight stopper, the conditions necessary to secure the best results have been complied with. Instead of distilled or boiled, common water may be used if a portion of newly-slaked lime is added to the solution before closing the cell. For ordinary purposes, however, these precautions may be dispensed with.

Now, as to the cost: the tinned iron can may be used without detriment. The tin, being strongly electro-positive to iron, sets up a local action with the borings as soon as the solution reaches it, and, being small in quantity, is soon resolved into tin oxide without injury to the battery. The soldered joints of American preserve cans are but very little affected by the solution, and can be depended upon not to leak if tight in the first instance. Solders in which tin or zinc are present ought to be attacked, but copper and lead are but little acted upon. The joints of such cans are probably so carefully made in the first instance as to be mostly water-tight without the aid of solder. These cans may therefore be regarded as perfectly efficient although so ridiculously cheap. The cost of one, including the borings, which are by no means scarce in Glasgow, may safely be put down at one farthing. The borings never need renewal, as they do not rust and are not changed in any way by the action of the battery. The zinc may be of the commonest kind, as no local action of importance has been observed unless the caustic used is very impure. Amalgamation is therefore useless. Strips of common roofing zinc rolled into cylinders answer perfectly well. The porous cell is the most expensive item, but this can be dispensed with by the use of diaphragms of canvas or other fabric of vegetable origin. It must be remembered that the caustic alkalies destroy all animal tissues, so leather, bladders, etc., are not admissible. The author has tried cells of thin wood, such as willow boxes, with success; but the earthenware is more permanent, and, in spite of its prime cost, probably the most satisfactory in the end. Such as the one before you can be procured wholesale at 2d. each. A diaphragm of some kind is absolutely necessary. Caustic soda, in a state of reasonable purity, is made in the neighborhood of Glasgow, and can be obtained wholesale at a little over 1d. per lb. Whether this is sufficiently pure for long continued action has, however, yet to be determined. To sum up the cost of one cell in its simplest form, we have:

Can and borings .....	1/4d.
Porous cell .....	2
Zinc, say .....	1
Soda, 4 oz. ....	1 1/2
Soldered wires for connections .....	1
Labor .....	1 1/4
Total .....	6d.

which is quite a liberal allowance.

The battery is, consequently, probably the cheapest ever devised in proportion to its power and durability, when regarded in the light of prime cost, but it becomes even cheaper when it is considered that the chief product of its action is zinc oxide, known in the paint trade as zinc white, which is extensively used as a pigment, and as a substitute for white lead generally. It can easily be recovered in an approximately pure state from the used-up battery. From the cell which rang the bell for a month 1,458 grains, or 3.04 oz. troy, were recovered, the zinc consumed being 1170.7 grains, or 2.44 oz. troy. Some of it—one-sixth of the quantity recovered—is on the table before you. Its price in the market ranges from 6d. to 1s. 6d. per lb., according to purity. As this is by no means a bad example, containing only a very slight trace of iron, its value exceeds that of the zinc consumed. It has been said that voltaic batteries can never compete with dynamo machines, because the zinc used takes coal to reduce it from its ores to the metallic state, which coal would have produced the energy direct if burned in the furnace of a steam-engine driving a dynamo. But if the product of the consumption of zinc in a voltaic battery can be made to defray the cost of the zinc, that oft-quoted argument somewhat loses its force. However that may be, it is pretty evident that the man who can buy, borrow, or — otherwise become possessed of a few old preserve cans, a corresponding number of porous cells, a quantity of iron borings, with a few pounds of caustic potash or soda, and who has an old zinc chimney to cut up, can conjure up and render subservient to his wants or his pleasure in many ways that mysterious but beneficent force which we know as electricity. He may, perhaps, even light his library on a small scale, or drive his wife's sewing-machine; and, after all, when the battery ceases to work, he can take it to pieces and paint his house, or a part of it, with the products.

The battery, however, need not be made cheaply. It lends itself with equal facility to the taste of the sybarite as to the means of the working man. As before stated, nickel, cobalt, silver, gold, platinum, are all strongly electro-negative to zinc in caustic alkalies, and might all be used to good purpose. A golden goblet packed with half sovereigns, instead of a tinned can packed with iron borings, would ring an electric bell or work a telephone admirably; as would also a silver chalice packed with sixpences. So it is obvious that refinement is possible in voltaic batteries, as in everything else. It may be noted that copper also answers well instead of iron for a time, but a soluble salt of copper is

gradually formed, which is precipitated upon and stops the action of the zinc. On the table are various forms of the battery. In some, the negative plate, consisting of an old file, an old knife, or a spiral of iron wire, is packed with the borings in a porous cell, the positive portion of the battery in such cases being in a glass or earthenware jar.

#### MERCADIER'S SELENIUM PILE.

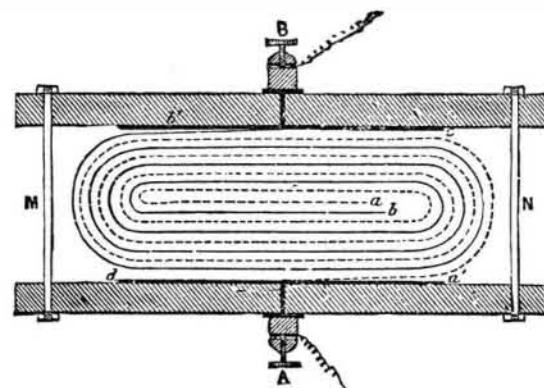
In speaking of the teleradiophone we have incidentally mentioned the selenium element employed by Mr. Mercadier in this apparatus, without having made its peculiar arrangements known.

This small system is analogous in principle and design to the selenium element employed by Mr. Graham Bell in his photophone, it being an apparatus of variable resistance, under the influence of a luminous ray of more or less intensity, that falls on it. It differs therefrom, however, in certain points—its construction being much simpler and easier. It therefore deserves a description, since it may be applied equally well in all radiophonic researches.

The accompanying cut represents one of the selenium elements, actual size, which has been constructed in this form by Messrs. Mercadier & Humblot, so as to be afforded at small expense, and that it may be quickly put in good order again if it should deteriorate. In the construction of this element there are used two brass ribbons, *a* and *b*, of about a tenth of a millimeter in thickness, and of a centimeter in width. These are separated by two ribbons of parchment paper serving as an insulator, and the four ribbons are then rolled in spiral form as shown in the figure, where one of the brass ribbons is represented by a continuous line, the other by a broken line, and the paper by the blank interval separating them.

The block thus formed is held between two brass plates, *c* and *d*, which are in contact, respectively, with the extremities, *a'* and *b'*, of the metallic ribbons. The whole is tightly compressed between two blocks of hard wood held together by two cross-pieces, *M* and *N*. The element is connected with the circuit in which it is interposed, by means of two terminals, *A* and *B*, which are in metallic communication with the plates, *c* and *d*. One of the faces is then filed and afterwards carefully polished with emery paper. This done, and the perceptible absence of metallic communications having been ascertained by means of a galvanometer, the polished surface is covered with selenium in the following manner:

The apparatus is heated in a sand bath, or by laying it flat on a thick plate of copper heated by the flame of a Bunsen burner until the exact moment that a selenium crayon lying upon it begins to melt. Then the crayon is drawn along the surface in such a way as to cover it with as thin a coating as possible. If the temperature is not allowed



MERCADIER'S SELENIUM PILE.

to rise above this point the selenium takes the slaty tint which characterizes the state in which it is most sensitive to light. It is useless to heat it again, and, on allowing the apparatus to become cool it is ready to operate. In order to preserve the surface, it may be protected by a thin sheet of mica or covered with a layer of lac varnish laid on hot. If the apparatus happens to deteriorate, it is only necessary to file the surface again, repolish it, and add another coating of selenium, to put it in good order. The resistances of the elements vary greatly with the dimensions, the nature of the selenium, the mode of preparation, etc.

Constructed as we have described, the selenium receiver is adapted to all radiophonic and photophonic apparatus, as well as to the numerous experiments by means of which are demonstrated the singular electric properties of this body at present so little known. To obtain good results there are required about ten Leclanché elements mounted for tension, and very resistant telephones, that is to say, such as those whose very fine wire is wound a great many times around the magnetized core.

#### A NEW AND DELICATE TEST PAPER FOR AMMONIA WHEN IT IS IN THE FORM OF A GAS.

By GUSTAV KROUPA.

WHEN fuchsine is dissolved in water and dilute sulphuric acid added, its red color will be changed to a yellowish brown (the mono acid becomes converted into the di or tri sulphate). If stripes of unsized paper be dipped in a not too dilute solution of rosaniline and dried, they will appear—similar to turmeric—of a beautiful yellowish color.

Paper prepared in the above-described manner is permanently colored carmine by ammonia when it is in the form of a vapor. The action of the ammonia is to convert the polyacid—rosaniline into a monacid fuchsine. This paper is of use for the detection of ammonium salts when they are present in small quantities. The substance to be tested is placed in a bottle and moistened with calcium hydrate. The bottle is closed with a piece of the test attached to the lower part of the stopper. It is best to employ the paper when it is in a dry state, because when it is moistened it becomes bluish and its change to red is not so readily perceptible. In order to hasten the decomposition of the ammonium salts, the bottle with its contents may be warmed, as the paper is not affected by steam. By this means a beautiful red color may be produced with 0.0005 gramme ammonium chloride, and 0.0005 gramme ammonium carbonate in a very short while. When it is exposed to the air it is liable to be attacked by moisture, though only after some time; it is therefore best to preserve it in well closed vessels. It cannot, however, be kept indefinitely, as it is too fragile, whereupon it is best to prepare a fresh supply.—*Chemiker Zeitung*, v. 952.